

PART 2 – Employer's Requirements

A. Scope of Supply of Plant & Installation Services by the Contractor

(Extension of 132/33kV Rumuruti and 132/33kV Kabarnet Substations)

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1. GENERAL

1.1 Scope of Work

The scope of this EPC Project includes engineering, procurement, and supply of all equipment and materials, erection, construction, testing and commissioning of equipment. The scope also includes civil works, all structural and architectural works, construction of buildings, boundary walls, fences, internal access roads, access road to substation, construction of cable duct and cable trenches, transformer foundations with fire protection / blast walls and oil collection pits, outdoor equipment foundations, etc. with all the necessary facilities provided for a fully functional substation.

The Contractor shall be fully responsible to study this document and existing practices of KETRACO and assess the works by visiting the site and collecting the necessary data required to establish the satisfactory implementation and operation of the systems. The Cost required for any such study is construed to be included in the Contract price. Notwithstanding that any details, works, equipment, accessories, etc. required for the complete installation and satisfactory operation are not specifically mentioned in the principal drawings, outline specifications, or price schedules, the cost required to collect such details is considered to be included in the Contract price. The substation shall fully meet the requirements of KETRACO & relevant applicable standards.

All the bid drawings are only principal and indicative. The Tenderer shall visit the Substations' sites before preparing his drawings and documents, foresee all eventualities that may arise during execution and taking into account of availability of labor, machineries, equipment and materials required and should make sure that the project works can be fulfilled and equipment, panels and etc. can be installed and commissioned for satisfactory operation of the Substations. The design documents shall be supported with comprehensive calculations and the drawings prepared by the Contractor shall contain all dimensions in detail ensuring that there are adequate clearances as per KETRACO practice and international standards.

Note: The Tenderer/Contractor must provide a comprehensive outage plan (according to KETRACO General Guidelines for Outages during EPC), before commencement of executive works in site to minimize the shutdown time for implementation of the required activities for each substation extension or OHL connection (including destructions, displacements and new erections/installations), for the Client/Consultant review and approval.

The following items are included in the scope of work of the EPC contractor:

- Soil investigation studies (Geotechnical, geo-electrical, and resistivity)
- Site clearance, site surfacing, excavation, backfilling, leveling and all concrete works.
- All buildings to be constructed as reinforced concrete frames with masonry walling,
- Concrete cable trenches/ducts
- Supply, installation, test and commissioning of switchyards' equipment

- Outdoor galvanized steel apparatus support structures and foundations, grading and leveling of the site and spreading of crushed aggregates over all unpaved areas.
- Supply, installation, test and commissioning of main and auxiliary transformers
- Foundations, concrete firewalls and oil pits for main transformers and auxiliary transformers. Oil pit sizing shall be based on approved calculations. In addition, burnt oil-containment tank common for both transformers shall be provided and its sizing shall be subject to approved calculations.
- Interconnection between the OPGW and fiber optic cable and final ODF-ODF testing
- Extension of Substation Control Building, Civil works (including Excavation, concrete works, backfilling, and roofing) together with building services such as Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand-held capsule fire extinguishers, Eyewash facility and access control
- Substation Guard House to be combined with the Telecom Collocation Room. Civil works (including Excavation, concrete works, backfilling etc.) together with building services such as Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand-held capsule fire extinguishers, Eyewash facility and access control
- Substation Diesel generator house Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services (e.g. Lighting, Small Power System, Fire Detection and hand-held fire extinguishers)
- Substation Storage Warehouse Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g., Lighting, Small Power System, HVAC, Fire Detection and hand-held capsule fire extinguishers, Eyewash facility and access control.
- Integrated Closed Circuit Television (CCTV) System for the substation buildings and outdoor area
- Technical staff Housing Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g., Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand-held capsule fire extinguishers, furniture and furnishing
- Security staff housing Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g., Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand-held capsule fire extinguishers, furniture and furnishing
- Regional office building Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g., Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand-held capsule fire extinguishers, furniture and furnishing
- Water supply system shall be improved. The contractor shall be required to connect to the existing water distribution system around the substation area. A borehole shall be sunk at Rumuruti Substation. The water supply for the control building and guard house is via an overhead tank. Main pressed steel water reservoir of 30,000 litres (as minimum) capacity to be provided at Rumuruti SS , adequate to serve requirements of control building, staff housing, Regional office and guard houses, automatic level controls shall be provided. Also, 10,000 litres elevated pressed steel water tanks shall be considered near the control building, Regional office and staff housing with required pumps to be fed from the main water reservoir. For Kabarnet substation additional 10,000 liters pressed steel

water tank shall be provided and interconnected with the existing water supply system. It is to be noted that water pumps to be solar powered.

- Integration of the existing drainage system with the new drainage system for the extension scope.
- Complete sewerage system (including pipes, Vent Pipes, Floor Drain, Toilet, Septic Tank with sufficient size) and other Mechanical Installations (including Shower with Faucet, Basin Faucet, Basin, Kitchen Sink, Pedestal Eye Wash), etc
- For water heating in staff housing, solar heaters and backup electric heating elements shall be considered and the design shall be subjected to approval of Client/Engineer.
- HVAC system shall include Dual Split Units and shall be considered in the control building, guard house and telecom collocation room, staff housing according to KETRACO requirements. These should be adequately sized to ensure the room temperature is ideal for the optimal performance of equipment. The refrigerant should comply to KEBS standards. The individual HVAC units will be sized according to the dimensions of the particular room for approval by the client/consultant. In addition, the HVAC system is to be designed to fit the particular local conditions of the substation.
- Fire protection system for transformers,
- Chain-link fence with barbed wire equipped with electric shock facilities for the substation plot, switchyard fencing, and staff housing shall be constructed, which their design shall be subjected to approval of Client/Engineer.
- Internal access roads to switchyards and to buildings should be implemented to match existing road standards. Necessary warnings / signage shall also be fixed. Suitable slopes / drains / manholes shall be provided for water to flow to the substation drainage system. The road shall have adequate lighting which is automatically controlled based on the ambient light intensity.
- External access road from main road to substation shall be implemented to bituminous standard and according to Kenya roads regulations. Necessary warnings / signage shall also be fixed. Suitable slopes / drains / manholes shall be provided for water to flow to the drainage system.
- Shaded car parking
- Machineries, tools, appliances, instruments and test equipment
- Temporary works, mobilization and de-mobilization

1.2 Site Location

1.2.1 Existing Kabarnet 132/33kV Substation

The coordinates of the existing Kabarnet substation land are as detailed below

Point No.	SS coordinates (ARC 1960 UTM ZONE 36 N)	
	Easting (m)	Northing (m)
1	807999	53083
2	808060	52964
3	808030	52965
4	808023	52935

5	808016	52935
6	808015	52902
7	807925	52912
8	807926	52952
9	807901	52952
10	807870	53023

The boundaries of Kabarnet substation land has been shown in the below figure.



Figure 3: Existing Kabarnet Substation Location.

1.2.2 Existing Rumuruti 132/33kV Substation

The coordinates of existing Rumuruti substation land are mentioned in the below table.

Point No.	SS coordinates (ARC 1960 UTM ZONE 37 N)	
	Easting (m)	Northing (m)
1	222067	27460
2	222362	27570
3	222427	27446
4	222122	27310
5	222067	27460

The boundaries of Rumuruti substation land has been shown in the below figure.

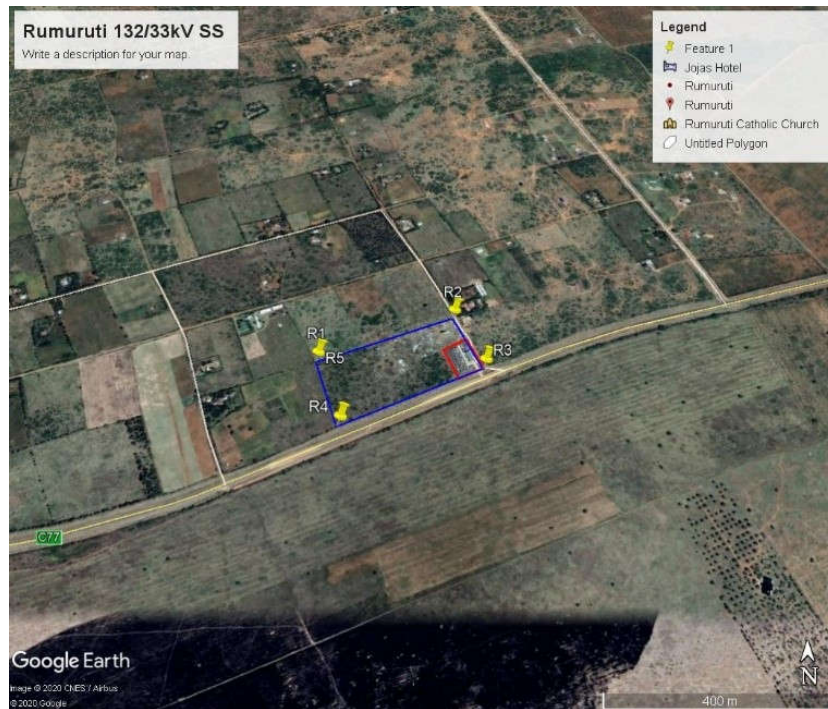


Figure 4: Existing Rumuruti Substation.

1.3 Substation Works

The bidder/contractor is responsible for the satisfactory design, supply, transportation, test, installation, commissioning and successful energization of substations, subject to Client/Engineer's approval.

All the bid drawings included in the tender documents are only conceptual drawings and intended for the guidance of the Bidder. The bidder is responsible to provide the detailed design drawings to finally obtain the Client/Engineer's approval on "For Construction/ As-Built" documents (the As-Built documents shall be resubmitted once again after final takeover for Client/Engineer's approval including all equipment, material, design drawings, modification and calculations). All submissions shall be provided in both un-editable and editable versions (e.g. Pdf, Word, AutoCAD, Excel, etc). Drawings provided for brownfield sites must also show the existing/old infrastructure in addition to the new. The substation layout and all other designs shall satisfy the following requirements:

- a) The layout and all other designs shall comply with latest KETRACO Standards and regulations of other concerned Authorities, Organizations and so on.
- b) The Bidder shall ensure that satisfactory and safe access for maintenance, inspection, and operation is provided to all equipment and measurement points. Further, considerations for future expansion of the substation shall be taken into account and foreseen. Road access for unloading, loading and transportation of equipment shall be considered especially for heavy equipment such as transformer.
- c) Equipment Vendor's recommendation for minimum all-around clearances, arrangements, etc. shall be also considered. Minimum clearances shall comply with all local regulations, KETRACO standards, international standards, and maintenance access requirements as applicable.
- d) The Bidder shall include provisions in his tender proposal for any works necessary to relocate buried services, pipes and associated equipment to avoid unidentified hazards in advance.

- e) The bidder shall maintain not only the civil requirements given in this tender but also any local requirements/present practices during the civil design/construction works subject to Client /Engineer's approval.

Note: The Contractor shall provide a comprehensive outage plan for each substation (according to KETRACO General Guidelines for Outages during EPC), before commencement of executive works in site to minimize the shutdown time for implementation of the required activities for each substation extension or OHL connection (including destructions, displacements and new erections/installations), which shall be approved by the Client/Consultant. No outage should last longer than 8 hours.

1.3.1 Extension Works at Rumuruti 132/33 kV Substation

Refer to bid drawings for proposed SLDs, Equipment layout and other drawings (attached for bidder's reference) for scope of works of extension of Rumuruti substation with 132kV and 33kV air-insulated switchyards (including supply and installation of 1 x 23MVA 132/33kV Power Transformer).

The works include the following but not limited to:

- a) Extension and modification work at 132kV AIS switchyard:
- Demolishing of existing Nanyuki line bay.
 - Busbar modification from single bus to 132kV double busbar configuration with bus coupler. This shall include the replacement of existing current transformers to provide sufficient dedicated cores as per the designed busbar protection scheme. Bay current transformers shall ensure provision of dedicated two (2) cores for busbar 1 and busbar 2 respectively having the same class as per the client design drawings. The scope shall also include integration, testing, and commissioning of the busbar protection scheme to achieve full functionality.
 - 1 No. 132kV bay for bus Coupler
 - 2 No. 132kV overhead line (OHL) bay for Kabarnet Line
 - Include space for 2 (two) future line bays for 132kV OHL Maralal Lines
 - Include space for 2 (two) future line bays for 132kV OHL Olkalau Lines
 - 1 No. Reconstruction of demolished 132kV Nanyuki Line-1bay
 - Include space for a future line bay for the second 132kV OHL to Nanyuki
 - Include space for 2(two) future line bays for two 132kV OHL to Rumuruti Solar Power Plant
 - 1 No. 132kV transformer bay and associated foundations and civil works.
 - Equipment and other support structures installations and associated foundations
 - Gantry structures installations and associated foundations
 - Supply, installation, test and commissioning of one (1) No. 132/33kV, 18/23MVA ONAN/ONAF Power Transformer, Dyn1, with OLTC in steps of 1.67%, 17 Steps are required and shall feed into the 33kV switchyard. The new power transformer shall be capable of operating in parallel with the existing power transformer.
- b) Extension and modification works at 33kV AIS switchyard:
- 1 No. 33kV transformer bay
 - 1 No. 33kV bus section with bus VT
 - 2 No. 33kV line feeders
 - Associated foundations and civil works.
 - Equipment and other support structures installations and associated foundations
 - Gantry structures installations and associated foundations

- c) Supply and installation of Two (2) No. 33/0.415kV, 315kVA and, ONAN auxiliary transformer, Dyn11, with 5 taps in step of 2.5% and $z=4.5\%$. The existing transformer (100kVA) shall be decommissioned and delivered to the Client and the new one (315kVA) shall be installed in its place. Changeover facilities with the generator to be provided. All related modifications/replacement/relocation/completion testing and commissioning works included in the scope of work.
- d) Supply, installation, test and commissioning of One (1) 0.415kV, 315kVA Diesel Generator. Separate Diesel Generator Control panel interfaced to the Substation Control System, daily and Bulk fuel storage tanks, pipework, pumps and dedicated battery charger and associated batteries. Diesel Generator shall be installed in its own generator house.
- e) Required facility for interconnection between the OPGW and fiber optic cable (including joint box, splicing, termination at the gantry) and final, end to end (ODF-ODF) OTDR and core-matching testing and preparing as-built documents
- f) Extension/modification of control room building and SCADA as per tender drawings, including required building services (e.g. Lighting, Small Power System, HVAC.)
- g) Modification of the HMI systems, software and its computers to incorporate the new scope of works.
- h) Other electrical, mechanical and civil works including complete equipment as per technical requirements and tender drawings:
 - i. Construction of new Emergency diesel generator house
 - ii. Construction of new Storage warehouse measuring approximately 24m X 60m X 8m and as per the tender drawings. The storage warehouse should be equipped with an Electric Overhead Travelling (EOT) of a minimum of 5tons
 - iii. Construction of Internal Access Roads within substation to match existing road standard
 - iv. Construction of technical staff housing (4 units) and security housing (3 units) as per tender drawings
 - v. Removal, Modification and Completion of existing Boundary Wall / Fencing
 - vi. Construction of new Firefighting Pump Houses
 - vii. Extension of control room building to accommodate additional panels
 - viii. Extension of guard house to include collocation room
- i) Extension of existing earth mat to cover the entire substation, including the fence and the warehouse.(For new and existing equipment).
- j) Test, commissioning and training
- k) Protection and control, telecoms end to end tests with RCC and NCC Dispatching Centers
- l) Submission of Revised As-built documents approved by the Client/Consultant
- m) Complete and functional system integration to existing grid
- n) Modification of the 132kV and 33kV busbar protection scheme from HIGH impedance to centralized LOW impedance type considering the number of 132kV and 33kV bays including the new and existing 132kV and 33kV bays.
- o) Decommissioning of existing 132kV and 33kV high impedance busbar protection scheme and handing over the protection panels with its accessories and delivering to KETRACO's Warehouse.
- p) Modification of the existing protection and control systems including commissioning and testing to achieve protection coordination and grading.
- q) Validation of existing protection settings to achieve the necessary grading with existing system
- r) Development of new protection settings for extension scope.
- s) Upgrade/replacement of the entire SCADA SAS system to include the existing bays and new (extension) bays. Design, supply, test, commission two new redundant Gateways for Integrating the new scope to the existing. The new Gateways to have a spare 40% signal capacity after the commissioning. The supplied Gateways to have 110VDC supply. The existing gateway needs to be recovered and handed over to KETRACO.

- i. The supplied gateways to be capable of transmitting Integrated Total values for the Energy meters
- ii. Integrate, Test and Commissioning the combined SCOPE to the National Control Center including the necessary Data Engineering at the National Control Servers.
- iii. The existing SCADA installed in the NCC shall be modified accordingly if needed, within the scope of this project.
- iv. Old and new Scopes to be integrated to the same redundant HMIs. The servers shall be industrial computers. The testing and commissioning of the HMIs to be done.
- v. The new network communication protocols to match the existing.
- vi. All signals of each substation required for the control and monitoring from the remote-control centers shall be made available for data transmission via gateways.
- vii. A fault on a Central Processing Unit (station server computer) of SCMS or the substation database shall not restrict the function of the NCC (National Control Centers). The information from and to the NCC shall be available as well as remote control from the NCC.
- viii. Supply and Installation of a pure sine wave Inverter to supply the HMIs.
- ix. Design, Supply, Install new LAN network equipment including LAN Switches for the new SCOPE.
- x. The extension/modification scope for protection and control, SCADA and Telecoms shall match the existing systems.
- xi. The Contractor's scope of supply shall include the design, manufacturing, supply, installation and commissioning of the new telecommunication system equipment, accessories and panels at 132/33kV Rumuruti and 132/33kV Kabarnet substations. Upgrade existing Telecommunications Equipment in both substations to achieve the following:
 - i. Upgrade the link to STM-4/ 2.5 G MPLS-TP with associated functionalities, eg WAN etc
 - ii. Supply and installation of new cards for Tele-protection signalling for distance protection and differential protection for the three new line bays.
 - iii. Create redundancy on exiting communications links
 - iv. Substation CCTV System as specified in this Specification with dedicated battery bank and UPS for the entire Substation and fully integrated with the existing centralized CCTV system at KETRACO Headquarters (National Control Centre).
- v. Modification/extension of the remote end station protection, control and telecommunication and SCADA systems including commissioning and testing to achieve full system functionality
- vi. Development of new protection settings for extension scope.
- vii. Upgrade of the drainage system including flood protection, storm water channels and storm drains shall be implemented around the whole substation perimeter, including the existing substation area, for complete dewatering of the compound. The existing drainage within the substation shall be upgraded to completely dewater the switchyard, and the existing transformer oil pit as well as protect against the current backflow of storm water towards the control building through the cable trench. Channels shall be surfaced by stone pitching or any other method as per the approval of the Client.
- t) Provision of an additional battery bank with at least 400Ah capacity together with 100A battery charger. Extension/modification works to be done to integrate the new battery bank and battery charger into the existing auxiliary system to form a complete system as per the employer technical requirements.
- u) Demolition and recovery of existing 132kV busbar. Recovery of existing 132kV line bay CT and Transformer Bay CT.
- v) Relocation of Nanyuki line to the new gantry to be constructed under this project. This includes all conductors, fittings and necessary hardware items.
- w) Modification of existing lightning protection and lighting system to cover the entire switchyard
- x) Update and provide the As-built approved drawings in A3 printed hard copies and softcopies in PDF and editable format. The hard copies shall be submitted to the CLIENT in triplicate.

- y) Normal lighting as per this Specification in extended substation buildings, switchgear bays, indoor and outdoor panels, switchyard areas and along substation; access road, internal roads, internal fence and acquired land perimeter fence. Emergency lighting shall also be provided in all substation buildings powered using UPS connected to the 110V DC system. Lamps in battery room shall be explosion proof.
- z) Lightning Protection System for extended Substation shall be fully integrated into the Lightning Protection System of the existing Rumurutu 132/33kV Substation.
- aa) 50 Mbps symmetric internet bandwidth for scalable and future-proof connectivity to support basic IT Functions (Email, ERP access, VoIP, Patch Management) and Video Surveillance Streaming and Remote Support Capabilities. Design should allow easy upgrades of bandwidth and hardware as needs evolve.

Note: A solar power plant is being developed in Rumuruti near the Substation. To avoid changes during the construction phase of the Rumuruti substation extension, a bay space shall be reserved in a manner to prevent line crossings between the Solar plant line and the Menengai (Olkalau)- Rumuruti or Nanyuki-Rumuruti transmission lines.

1.3.2 Extension Works at Kabarnet 132/33 kV Substation

Refer to bid drawings for proposed SLDs, Equipment layout and other basic drawings (attached for bidder's reference) for scope of works of extension of Kabarnet substation with 132kV and 33kV air-insulated switchyards (including supply and installation of 1 x 23MVA 132/33kV Power Transformer).

The works include the following but not limited to:

- a) Extension and modification work at 132kV AIS switchyard:
 - 132kV busbar modification from single bus to double busbar configuration. This shall include replacement of existing current transformers to provide sufficient dedicated cores as per the designed busbar protection scheme. Bay current transformers shall ensure provision of dedicated two(2) cores for busbar 1 and busbar 2 respectively having the same class as per the client design drawings. The scope shall also include integration, testing, and commissioning of the busbar protection scheme to achieve full functionality.
 - 1 No. 132kV bus coupler bay
 - 2 No. 132kV OHL bay to Rumuruti
 - Demolishing of existing Lessos line bay.
 - 1 No. Reconstruction of demolished 132kV Lessos Line bay
 - Considering free space for the 2nd bay of Lessos 132kV OHL
 - One (1) No. 132kV transformer bay
 - Replacement of CT of existing 132kV bays to comply with the busbar protection
 - Supply, installation, test and commissioning of one (1) No. 132/33kV, 18/23MVA ONAN/ONAF Power Transformer, Dyn11, with OLTC in steps of 1.67%, 17 Steps are required and shall feed into the 33kV switchyard.
 - Associated foundations and civil works.
 - Equipment and other support structures installations and associated foundations
 - Gantry structures installations and associated foundations
- b) Extension and modification works at 33kV AIS switchyard:
 - 1 No. 33kV transformer bay
 - 1 No. 33kV bus section with bus VT
 - 2 No. 33kV Line Feeders

- Associated equipment foundations and civil works.
 - Equipment and other support structures installations and associated foundations
 - Gantry structures installations and associated foundations
- c) Supply and installation of Two (2) No. 33/0.415kV, 250VA and, ONAN auxiliary transformer, Dyn11, with 5 taps in step of 2.5% and $z=4.5\%$. The existing transformer (100KVA) shall be decommissioned and delivered to the Client and the new one(250KVA) shall be installed in its place. Changeover facilities with the emergency diesel generator to be provided. All related modifications/replacement/relocation/completion works included in the scope of work.
- d) Supply, installation, test and commissioning of One (1) 0.415kV, 250kVA Diesel Generator. Separate Diesel Generator Control panel interfaced to the Substation Control System, daily and Bulk fuel storage tanks, pipework, pumps and dedicated battery charger and associated batteries. Diesel Generator shall be installed in its own generator house.
- e) Other electrical, mechanical and civil works as per technical requirements and tender drawings:
- Internal Access Roads to match existing road standards
 - Removal, Modification and Completion of existing Boundary Wall / Fencing
 - Extension and required repair works of switchyard retaining walls
 - Extension of control room building to accommodate additional panels
 - Extension of guard house to include collocation room
 - Construction of Emergency diesel generator house
- f) Extension of existing earth mat to cover the entire switchyard. (for new and existing equipment).
- g) Required facility for interconnection between the OPGW and fiber optic cable (including joint box, splicing, termination at the gantry, etc.) and final end to end (ODF-ODF) OTDR and core-matching testing and preparing as-built documents
- h) Extension/modification of control room building and SCADA
- i) Test, commissioning and training
- j) Protection and control, telecoms end-to-end tests with Dispatching Centers
- k) Submission of Revised As-built documents approved by the Client/Consultant
- l) Complete and functional system integration to existing grid
- m) The LVAC/LVDC systems shall be modified/extended to ensure adequate capacity for the loads associated with the extension works.
- n) Modification of the 132kV and 33kV busbar protection scheme from HIGH impedance to centralized LOW impedance type considering the number of 132kV and 33kV bays including the new and existing 132kV and 33kV bays.
- o) Decommissioning of existing 132kV and 33kV high impedance busbar protection scheme and handing over the protection panels with its accessories and delivering to KETRACO central stores or Employer's designated place.
- p) Modification of the existing protection and control systems including commissioning and testing to achieve protection coordination and grading.
- q) The extension/modification scope for protection and control, SCADA and Telecoms shall match the existing systems.
- r) Modification/extension of the remote end station protection, control and telecommunication and SCADA systems including commissioning and testing to achieve full system functionality.
- s) Validation of existing protection settings to achieve the necessary grading with existing systems.
- t) Development of new protection settings for extension scope. Upgrade/replacement of the entire SCADA SAS system to include the existing bays and new (extension) bays.
- i. Design, supply, test, commission two new redundant Gateways for Integrating the new scope to the existing. The new Gateways to have a spare 40% signal capacity after the commissioning. The

- supplied Gateways to have 110VDC supply. The existing gateway needs to be recovered and handed over to KETRACO.
- ii. The supplied gateways to be capable of transmitting Integrated Total values for the Energy meters
 - iii. Integrate, test and Commissioning the combined SCOPE to the National Control Center including the necessary Data Engineering at the National Control Servers.
 - iv. The existing SCADA installed in the NCC shall be modified accordingly if needed, within the scope of this project.
 - v. Old and new Scopes to be integrated to the same redundant HMIs. The servers shall be industrial computers. The testing and commissioning of the HMIs to be done.
 - vi. Supply and Installation of a pure sine wave Inverter to supply the HMIs.
 - vii. The new network communication protocols to match the existing.
 - viii. All signals of each substation required for the control and monitoring from the remote-control centers shall be made available for data transmission via gateways.
 - ix. A fault on a Central Processing Unit (station server computer) of SCMS or the substation database shall not restrict the function of the NCC (National Control Centers). The information from and to the NCC shall be available as well as remote control from the NCC.
 - x. Design, Supply, Install new LAN network equipment including LAN Switches for the new SCOPE.
 - xi. The Contractor's scope of supply shall include the design, manufacturing, supply, installation and commissioning of the new telecommunication system equipment, accessories and panels at 132/33kV Rumuruti and 132/33kV Kabarnet substations. Upgrade existing Telecommunications Equipment in both substations to achieve the following:
 - i. Upgrade the link to STM-4/ 2.5 G MPLS-TP with associated functionalities, eg WAN etc
 - ii. Supply and installation of new cards for Tele-protection signalling for distance protection and differential protection for the one new line bay.
 - iii. Create redundancy on exiting communications links
 - iv. Substation CCTV System as specified in this Specification with dedicated battery bank and UPS for the entire Substation and fully integrated with the existing centralized CCTV system at KETRACO Headquarters (National Control Centre).
 - v. Modification/extension of the remote end station protection, control and telecommunication and SCADA systems including commissioning and testing to achieve full system functionality
 - vi. Development of new protection settings for extension scope.
- u) Update and provide the As-built approved drawings in A3 printed hard copies and softcopies in PDF and editable format. The hard copies shall be submitted to the CLIENT in triplicate.
 - v) Provision of additional battery bank with at least 400Ah capacity together with 100A battery charger. Extension/modification works to be done to integrate the new battery bank and battery charger into the existing auxiliary system to form a complete system as per the employer technical requirements.
 - w) Demolition and recovery of existing 132kV busbar. Recovery of existing 132kV line bay CT and Transformer Bay CT.
 - x) Relocation of Lessos line at Kabarnet to the new gantry to be constructed under this project. This includes all conductors, fittings and necessary hardware items.
 - y) Modification of existing lightning protection and lighting system to cover the entire switchyard
 - z) Normal lighting as per this Specification in extended substation buildings, switchgear bays, indoor and outdoor panels, switchyard areas and along substation; access road, internal roads, internal fence and acquired land perimeter fence. Emergency lighting shall also be provided in all substation buildings powered using UPS connected to the 110V DC system. Lamps in battery room shall be explosion proof.
 - aa) Lightning Protection System for extended Substation shall be fully integrated into the Lightning Protection System of the existing Rumuruti 132/33kV Substation.

- bb) 50 Mbps symmetric internet bandwidth for scalable and future-proof connectivity to support basic IT Functions (Email, ERP access, VoIP, Patch Management) and Video Surveillance Streaming and Remote Support Capabilities. Design should allow easy upgrades of bandwidth and hardware as needs evolve.

2. Extent of Works

The Contract Works to be supplied shall include all works (at Kabarnet, Rumuruti) incidental thereto whether specified in detail or not and shall be carried out by the Contractor in accordance with the Specification and Conditions of Contract.

The extent of work is described below in subsequent sections of this document. The Contract is of the 'Turnkey' type for the Substation and associated works in which the Contractor is responsible for ensuring that all items of work required for the safe, efficient and satisfactory completion and functioning of the works over expected plant life, are included in the tender's price whether or not they have been specifically described in the related section or specification.

Details of the requirements and the technical specifications have been referred to in the relevant Bid drawings and documents.

Bidder to note the following:

- a) Project scope of work (Part 2-A, current section), technical specifications (Part 2-B), drawings (Part 2-D), technical data sheets (Part 2-E) and KETRACO Standard Operating Procedures are applicable for the project (also KEBS standards, Kenya building code and applicable Kenya regulations).
- b) Any shutdown requirements for modification/ Installation work(s) to be carried out under this project shall be submitted to the KETRACO/Project Manager for approval before starting the work clearly indicating the activities to be carried out and the duration required for completion of each activity. Bidders are required to develop detailed method statement to minimize the shutdown.
- c) Shutdown will be given only one circuit at one time. All temporary works required for arranging the shutdown with Client and National Control Center are included in Contractor's scope of work. Shutdown that results in total station outages for more than one day will not be possible.
- d) All the major equipment shall be installed and tested under the direct supervision of vendor's supervisor(s) at each stage of installation and testing which then would be verified/approved by KETRACO/ Project Manager.
- e) All the Substation equipment and systems shall include necessary contacts/signals and other facilitation required for future extensions. Spare margins in capacities, feeders, contacts, etc. shall be over and above future provisions. LVAC, DC System, Inverter, Fire Water System, building's openings, etc. shall have provisions for future expansion.

2.1 Definite Work

The supply and services to be performed by the Contractor shall comprise of the design, manufacture, factory testing, packing, transport, insurance, demurrage, delivery to and off-loading at site, storage, erection, site testing, commissioning, training of KETRACO personnel and warranty of all the necessary plant and materials for the complete works.

2.2 Terminal Points

The terminal points for the project are the interfaces with existing infrastructure for extensions. So, the EPC contractor shall carry out scope of connection to the existing parts.

The terminal points of Kabarnet 132/33kV and Rumuruti 132/33kV, Substations have been generally described in Clause 1 ("scope of work"). Also, regarding the electrical connection of the transmission line and substation, the substation contractor shall supply the relevant clamps and fittings with the suitable conductor and jumper to allow complete termination of the overhead lines from the terminal towers to the gantries and terminal equipment.

The detail of terminal points of:

- Extension Substations (i.e., Kabarnet 132/33kV and Rumuruti 132/33kV) are boundary limit of SOW, making connection and completing all the interfaces to the existing parts/systems in the Substation (including construction, erection, test and commissioning works), and making connection to the upstream/downstream Substations, and Dispatching Centers.

The following 132kV transmission line are planned to be constructed under another project:

- 132kV Kabarnet - Rumuruti OHL (94km)

The Relocation of Lessos lines at Kabarnet to the new gantry to be constructed under this project

The programme for work, arrangements for any necessary outages and work at all the terminal points are required to be coordinated with others at no additional cost to KETRACO.

The contractor shall be responsible for getting necessary information of existing system. However, the employer shall facilitate this activity.

Division of Work between OHL contractor and Substation Contractor:

Division of Work	Substation	Transmission Line
Dead-End Tower		X
Conductors down to the gantry, including dead-end clamp, U-bolt as well as insulator strings with adjustable spark gaps, is required.	X	X
OPGW and conversion/earth wire down to the gantry, including clamps	X	X

Division of Work	Substation	Transmission Line
Splice box including console	X	X
Substation Gantry	X	
Conductors from gantries to the switchyard	X	
Conductor jumpers to the transmission line conductor	X	
Earth wire from gantry to the switchyard	X	
Optical cable from splice box, including splicing and commissioning	X	
Fence	X	
Testing of OPGW and rectification of defects hindering compliance to the Employer's Requirements in the strung OPGW outside substations	X	X
Testing of Optical Telecommunication equipment inside the substation	X	X

Both contractors are required to coordinate and define in advance the conditions of works for the transmission line Contractor inside the substation.

2.3 Details of Transmission Line

As specified in section OHL (part2-b- clause 25. Overhead Line Termination) as part of the Employers Requirements.

2.4 Service Conditions

(a) Rainfall

The annual rainfall is approximately 500-2500 mm.

(b) Temperatures

Minimum temperature	1°C
Maximum temperature	40°C
Max. Conductor temperature	80°C
Annual average temperature	25°C

(c) Humidity

Mean relative humidity (max/average)	95% / 60%
Relative humidity	70%

(d) Isokeraunic Level

An isokeraunic level (TD/Y) of 40 thunderstorm days/year shall be considered for substation design purposes.

(e) Maximum Solar Radiation

For substation design purposes, an average annual sum solar radiation of 1500-1800 kWh/m² shall be considered (as per each substation technical data sheet).

(f) Earthquake loading

For substation design purposes, an earthquake loading of > 0.25g shall be assumed.

(g) Wind load

For design purposes, the following basic wind velocities (3s gust) shall be adopted: 36 m/s for Rumuruti substation and 45m/s for Kabarnet substation respectively.

(h) Altitude

The height above sea level shall be considered 2000-2500 m (as per each substation technical data sheet). Here for 132/33kV Rumuruti and 132/33kV Kabarnet substation, the Altitude considered is 2000m (as per substation technical data sheet).

The insulation levels of external insulation shall be determined in accordance with IEC 62271-1, Clause 2.2.1.

Important Note: All main and spare equipment shall be provided for proper operation in four altitude categories (to optimize main equipment/ spare parts and achieve interchangeability at country level), including 1000, 1500, 2000 and 2500 meter above sea level. In case of other range may has been mentioned in the schedules of technical information (Part 2-E), the higher altitude category shall be considered.

(i) Pollution

External insulation shall be designed to Pollution Level IV (Very Heavy) in accordance with IEC60071-2, Table 1.

2.5 Transport

The Contractor shall provide a site-specific transportation plan to ensure equipment is delivered to the relevant substation site safely and on time. This should include as a minimum: -

- Freight instructions/specifications
- Pro-forma packing lists
- Nominated freighting and forwarding companies
- Procedures for shipping release
- Route of land transportation / transport survey
- Unloading procedures
- Heavy lifting plan for bulky consignments / cargo
- Timing of freight and delivery

As part of the transportation plan the Contractor shall conduct a pre-road survey for the delivery of the respective power transformers from the dock to site. This survey should identify the entire route of transportation, any traffic restrictions for movement of large trailers, obstacles such as gantries, overhead lines and bridges, limitation of road and bridge widths, limitation of allowable axle load on bridges and the requirement of temporary road constructions at site. The survey shall be issued to KETRACO for approval prior to the completion of the transformer design.

All transport costs including road widening or bridge strengthening are deemed to be included in the contract price.

The Contractor shall inform himself fully as to all available transport facilities, road width, and axle load limitations, loading gauges and any other requirements and shall ensure that equipment as packed for transport shall conform to the relevant limitations. Any cost arising from the use of roads or tracks, including tolls, shall be borne by the Contractor.

The Contractor shall ensure by his own enquiries that the facilities available for unloading and bearing capacity of wharfs at ports are adequate for his proposed plant and equipment.

The Contractor shall take reasonable steps to prevent any highways or bridges from being damaged by his traffic and shall select routes, choose and use vehicles and restrict and distribute load so that the risk of damage shall be limited as far as is reasonably possible. The Contractor shall immediately report to the Project Manager any claims made against him arising out of alleged damage to a highway or bridge.

The Contractor shall be responsible for all costs including those incurred by KETRACO or the Project Manager, arising from repair or replacement due to damage to equipment or materials during transport, off-loading or erection on site, until take-over by KETRACO.

The Contractor shall be responsible for obtaining from the relevant authorities all permissions necessary to use docking, off-loading, highway, and bridge facilities required for the transportation of contract materials and plant.

For proper supervision and expediting of the works, the Contractor shall provide transportation facilities for the Employer's exclusive use. The cost of the cars, their maintenance, fuel cost, operation, and the driver shall be included in the contract price. The vehicles shall be provided 3 weeks after receipt of advance payment at the latest.

3. Environment, Social and Health - Safety Requirement

3.1 General

The Contractor shall always carry out its business and operations in compliance with all applicable national environmental, occupational health & safety and social laws and regulations in Kenya for both temporary and permanent works including consideration for sensitivity to gender and persons with disabilities.

In addition, the Contractor and all subcontractors shall comply with and adhere to:

- Environmental, Health and Social guidelines and Safeguards of the; African Development Bank Group (AfDB), the World Bank (WB), the International Finance Corporation (IFC) on Power Transmission and Distribution.
- International Labor Organization (ILO) Core Labor Conventions and IFC Performance Standard 2: Labor and Working Conditions (IFC PS 2);
- Provisions of the Environmental and Social Management Plan (ESMP).

The ESMP and all sub-plans are part of the contracts and binding for the Contractor and all sub- contractors. The Contractor shall monitor and report on the E&S performance of the subcontractors. The Contractor will ensure that provisions regarding construction health & safety and labour conditions in the contracts with the sub-contractors shall be consistent.

The Contractor will further be required to customize the overall ESMP and to develop a site- and works-specific Construction Environmental and Social Management- and Monitoring Plan, including all necessary sub-plans as indicated below:

- Environmental Management Plan.
- Hygiene/Health/Safety Plan.
- Emergency Plan.
- Traffic and access road Management Plan.
- Closure and Rehabilitation plan.
- Cultural Heritage Conservation Plan.
- Bird protection measures.
- Employment Plan Community relation management plan.
- Waste Management Plan.
- Hazardous Materials Management Plan.
- Stakeholder Engagement Management Plan.
- Labor Force Management Plan

The Contractor shall submit a methodology statement on his general and planned procedures on the requirement listed above during the bidding stage, submit work method statements with reference to the requirements of the ESMP and the sub-plans as listed above, outlining the Construction Environmental and Social Management and Monitoring Plan (CESMMP) with sub-plans; submit a work plan for the establishment of the CESMMP during bidding stage; submit CESMMP including all required sub-plans not later than 60 days after contract effectiveness.

Relevant management plans to be provided by the Employer for the construction phases are:

- Overall ESMP and ESIA (part of the Bidding Documents)
- Resettlement Policy Framework (RPF)
- Chance Find Procedure

The Contractor will be responsible for ensuring that all sub-contractors receive an EHS induction prior to starting work, a work-site orientation and on-the-job or formal training prior to being assigned for a job. The Contractor shall apply best practice international standards to occupational safety with regard to use of personal protective equipment, work procedures (for tower erection and maintenance) and equipment movement. All employees will be provided with the necessary training and safety equipment as required for their respective responsibilities and duties.

The contractor is required to comply with the management plans provided by the Employer as listed above and to integrate the provisions into the overall Construction Environmental and Social Management- and Monitoring Plan.

Regarding land acquisition and compensation, it is the Employer's responsibility to establish and to implement the RAP. However, it will be the Contractor's responsibility to compensate affected parties for any damage and losses related to construction works in line with the provisions of the RAP, e.g. for temporary land take for lay down areas or workers' camps, for any crop damage due to construction works or any damage from construction activities to physical structures.

The Construction ESMP and all Sub-Plans will be subject to no-objection from the Employer and the donor. The Implementation of the Construction ESMP will be subject to supervision and monitoring by the Employer/Implementation Consultant.

The Contractor shall provide a monthly report, which includes detailed information on the implementation of the Construction Environmental and Social Management- and Monitoring Plan including monitoring results, covering amongst other issues, safety issues, incidents/accidents, need for corrective measures, conflicts amongst construction workforce or with local residents, grievances of workforce or stakeholders, any other details related to the social and environmental management and performance. Subcontractor-related issues shall also be included.

In its Bid Proposal the Contractor shall provide evidence that he has an Environmental and Social Management System established and ready for operation in order to implement the Construction Environmental and Social Management and Monitoring Plan (i.e. appropriate staff, procedures, routines and processes).

3.2 Management Plans

Contractor Environmental and Social Management Plan

The Contractor shall prepare an Environmental Management Plan (C-ESMP) which will comply with National regulations and International Standards and more specifically with the IFC's Performance Standard 1 (IFC PS1) relating to the assessment and management of environmental risks and impacts.

The aim of the Contractor's ESMP is to define applicable regulations and standards, roles, and responsibilities of the Contractor and its subcontractors with regards to the implementation of environmental management on various construction sites. The C-ESMP will also define the measures to be implemented in compliance with the environmental and social impact assessment for the project.

In particular, the Contractor shall, as part of environmental protection:

- Set up a team dedicated to the supervision of environmental aspects on the site.
- Take all necessary measures to avoid accidental water, air, and ground pollution during the construction work, including:

- Clean and empty vehicles and construction machinery in areas provided for that purpose.
- Store chemicals in suitable containers, placed in bunds at a safe distance from the local watercourse.
- The Contractor shall, at his own cost and under the Employer's supervision, clean and remove all types of pollution resulting from his activities (when discharging from a vehicle for example), remove all contaminated materials, carry out all necessary repairs (removal/treatment of contaminated land and plants) and compensate those who have suffered from the effects of this pollution.
- Minimize airborne dust from quarries, mixing areas, moving or vibrating equipment, and access roads to protect the local population and the environment.
- Implement abatement measures when airborne dust reaches a threshold that is considered a nuisance to workers and local populations and measured by the environmental team.
- Identify and protect areas subject to erosion.
- Limit the clearing to the area planned for the site and preserve useful or large trees (those with a diameter greater than 20 cm, measured at 1 m from the ground) outside the right of way.
- Check that equipment sound levels remain below permitted levels to protect the health of workers, surrounding communities, and biodiversity.
- Encourage construction workers not to hunt and fish.
- Provide enough waste bins, waste containers, and site toilets.

Night work on a construction site shall be subject to the approval of the Project Manager. If the Contractor has been given the go-ahead to carry out work during the night, he agrees to do so without disturbance to residents and businesses. The lighting mode shall be approved by the Engineer.

Regarding the layout and management of borrow pits as well as the construction and site facilities, the Contractor shall be required to:

- Provide the layout for the deposits (quarries, borrow pits) and areas for stockpiling material to minimize all negative environmental impacts. Get the layout validated by the Main Contractor before the start of the operations.
- Provide the layout for construction and site facilities to minimize all negative environmental impacts. Get the layout validated by the Main Contractor before their implementation.
- Areas used by the Contractor for its facilities and/or storage areas shall be located at a minimum distance of 500 m from all wetlands. If this is not the case, a system must be set up to avoid all pollution or sedimentation from these areas and
- The establishment of construction facilities (mechanical area, offices, and storage of material, equipment parking, coating plant) shall be prohibited in wooded areas and close to streams.
- Rehabilitate all deposit sites and storage of materials as well as construction and site facilities. As part of this rehabilitation, the land which was previously used for agricultural purposes shall be returned to cultivation.

The use of water needed for road construction must ensure the needs of the local population, livestock and wildlife are met, either using surface water or groundwater. The end of the construction work, wells, boreholes and ponds created for the purpose of the work will be given to the population with customary usufruct rights in their actual state.

The ESMP prepared by the Contractor shall include a Management Plan for the construction waste and waste from site facilities. The Waste Management Plan shall meet national regulations as well as the requirements of funding agencies:

- The Waste Management Plan shall list the various waste streams from the site as well as the appropriate storage, transportation and treatment methods provided for different types of waste.
- With regards to waste management, the Contractor shall at least include:

- Containers to receive household waste (no hazardous waste) distributed throughout the various facilities.
- The regular emptying of these containers following a method approved by local regulations in accordance with national regulations and international standards.
- All solid and liquid waste generated by the construction site, including rubble, packaging, food waste shall be collected and stored in a suitable location (e.g. industrial or controlled landfill). If landfilling is chosen, the storage or landfill area must be located at a minimum distance of 100 meters from a watercourse or a body of water. At the end of the construction work, the pit should be backfilled with soil up to the natural ground level. If these landfill sites are not available locally, the waste shall be temporarily stored before transport to approved sites for their appropriate treatment in accordance with national regulations and international standards.
- All surplus aggregates as well as unused mortar or concrete shall be recovered and disposed of in an appropriate location.

Stockpiling of waste material from demolition work as well as the disposal of equipment and wrecks along the road shall be banned.

Hygiene/Health/Safety Plan

The Contractor shall prepare a Hygiene/Health/Safety Plan which will comply with national regulations and international standards and more specifically to the IFC PS4 standard relating to community health safety and security.

With regards to hygiene, the Contractor shall provide more specifically:

- Internal rules listing the procedures to be adopted with regard to hygiene and waste management in the living facilities.
- Enough toilets showers and washbasins in the living facilities (at least one of each 12 people), cleaned on a daily basis and replaced if needed.
- A drinking water supply on all sites.
- Organize an annual health check for each employee.
- With regards to health, the Contractor shall provide a routine and emergency medical service in the living facilities as well as in the construction facilities, appropriate for the size of the workforce.
- Establish a register as well as a complaint management system for all employees.

With regards to safety, the Contractor shall provide more specifically:

- A risk analysis for each type of work. This analysis will determine the PPE (personal protective equipment) to be used (e.g. for the head, the face, for hearing, for hand and arms, feet and legs, for breathing, protective clothing, and against falls);
- PPE shall be compulsory for all workers on site. The Contractor shall ensure the equipment is available and check worker wear their PPE.
- Regular checks of the exhausts from vehicles and machinery as well as regular engine tuning
- Load protection (tarpaulins, nets, etc.) on transport vehicles.
- The provision of systems for "earthing" each tower to ensure lightning current flows to the ground.
- Storage materials such as gravel, cement, sand, timber shuttering, etc. in predetermined locations according to the recommendations made by local supervisors so that the construction site nearby is free from any object which may cause an accident.
- Enough fire extinguishers for the type of risk (more specifically electric fires) installed in the buildings (one per building).
- Staff training for the use of extinguishers.
- At the substations in a location known by all members of staff working on the power line, display the following contact details: fire services, Ambulance, Site operators, Environmental Authority, Police.

- Easy access to the site for emergency services in the event of an intervention.
- Day and night surveillance of stock with access is restricted.
- No trench shall be left open overnight before 6 p.m. and 6 a.m. without appropriate road signs agreed by the Employer.
- Raising awareness of communities and workers regarding the risk of accidents due to material on site.

With regards to health, the Contractor shall provide a routine and emergency medical service in the living facilities as well as in the construction facilities, appropriate for the size of the workforce. Additionally, a safety coordinator shall be included in the team. That person shall ensure maximum safety in the living and construction facilities for workers and for the population and other people in contact with the site.

Emergency Plan

The Contractor shall prepare an Emergency Plan which complies with national regulations and international standards.

This plan shall specifically include a section identifying potential sources of external aggression (natural and anthropogenic risk) to electrical substations and power lines. This section shall also include adequate preventive measures. Operating instructions shall be issued to and signed by all members of staff working on the substations and overhead power line. In the event of an accident, general fire and rescue instructions shall be applied. These instructions shall be permanently displayed and indicate:

- Available extinguishing and rescue equipment, including their location.
- Procedure in event of an accident.
- People who need to be informed.

Post-accident management: After having managed an emergency, more precise post-accident management shall be implemented. Amongst other points, this shall include the identification of the root causes of the accident and, if possible, the implementation of means to prevent this accident from happening again.

Traffic and Access Road Management Plan

The Contractor shall prepare a Traffic and access road management plan which will comply with national regulations.

For each section of work, this plan must include summary maps to be validated by the Employer before the work begins. These maps shall be updated according to the work progress and indicate the following information:

- The full road marking used.
- Road marking when approaching the construction sites.
- Temporary diversions.
- Temporary marking.
- Traffic directions.
- Speed limits on site and in urban and other areas.
- The delimitation of parking areas in towns and villages.
- Areas for parking and emptying vehicles.
- Location of borrow pits and quarries as well entrances and exits for villages and hamlets.

This Plan shall also include:

- Contact details of the person in charge of road signs on the site.
- Staff list.
- List of equipment and vehicles used.
- Working method for installing and removing road signs.
- Working hours, including periods when no working is taking place.

- Changes and measures provided for road signs during periods of inactivity.
- Planned changes to speed limits according to the times and phasing of the construction work.
- Maintenance of access roads.
- Maintenance and surveillance patrols.
- Assessment of the state of access roads and unpaved tracks before and after the construction work.
- Modalities for the rehabilitation of access routes used by site vehicles.

Deviations, the opening of new access roads and temporary closure of roads are to be submitted to the Consultant before any implementation and construction work. The cost of building new tracks, deviations, their maintenance as well as associated environmental protection measures are to be included in unit prices in the price schedule.

In the event of crop destruction or damage to property not discussed in the impact assessment, the Contractor shall bear compensation costs.

The detailed route of transporting different parts for abnormal loads (12 axles) shall be presented to and validated by the Employer. The convoy shall be accompanied by signalling vehicles.

Rehabilitation and Closure Plan

The Contractor shall prepare a Rehabilitation and Closure Plan which will cover all of its temporary facilities: borrow pits, quarries, and construction and living facilities. This plan must be approved by the Employer before the end of the work.

In this plan, the Contractor shall include a period during which the changes in the site after rehabilitation shall be monitored to prevent any disruptions from occurring after his departure.

The plan will evolve according to the project evolution (choice of new borrow sites, site extension, etc.).

This plan will specify the Contractor's constraints and any potential contributions from populations with customary usufruct rights to agricultural and forestry productivity improvements they may have requested.

The Contractor shall, at least, remodel the topography of the site to be rehabilitated as needed to control the risk of erosion and allow the implementation or restoration of clavipectoral vegetation compatible with the local soil and climate.

Cultural Heritage Conservation Plan

The management of impacts on the cultural and religious heritage has been avoided in the route of the line identified in the Environmental and Social Impact Assessment is included in the Project's Action and Recovery Plan. However, these works may reveal further cultural or religious heritage. To prepare for this potential development, the Contractor shall prepare a Cultural Heritage Conservation Plan which shall comply with national regulations and international standards, more specifically with the IFC Performance Standard PS8 on Cultural heritage.

The Plan shall be prepared by the Contractor and approved by the Employer before the start of work. More specifically, it shall define procedures for managing incidental findings which will be applied if cultural or religious heritage is discovered during the construction.

This protocol shall describe the measures to be taken in the event of the discovery of a previously unknown cultural heritage.

In the event of an archaeological discovery during the work, all activities shall be suspended in the area involved which will be then closed. Competent authorities shall be notified immediately. Necessary measures for recording the data and if possible, for organizing excavations shall be implemented in collaboration with renowned archaeologists.

In the event the Contractor unearths cultural or religious heritage which is not essential and potentially reproducible, mitigation or compensation measures shall be defined in collaboration with local authorities and populations.

Any planned or unexpected discovery during the work shall be recorded in a register of cultural, religious, or heritage discoveries.

Bird Protection Measures

The Contractor shall mark out the ground wire protecting the conductors against atmospheric surges. These markers will be placed along the ground wire every 20 meters on the range line which passes through each "hotspot" (e.g. crossing of rivers). White and red markers may be placed alternately on the cables: red for diurnal birds and white for nocturnal birds.

Employment Plan

The Contractor shall prepare an Employment Plan in compliance with national regulations and international standard PS2 relating to labour and working conditions.

In particular, the Contractor shall agree to implement the following measures during the works:

- Primarily recruiting the workforce in cities and villages crossed by the project.
- Involve community organizations including youth organizations or cultural social services from the municipalities concerned to organize recruitment.
- Use communication channels (media, billboards) to disseminate information about the project and recruitment needs.
- Include a recruitment criterion prohibiting the recruitment of people equipped with non-compatible pacemakers.
- Establish employment contracts for every worker and those recruited by subcontractors.
- Keep registers of construction workers up to date (direct and indirect employees) including name and marital status of the worker, a record of hours worked, overtime, wages paid.
- Daily monitoring of working conditions in compliance with local regulations and international standards via the assignment of a supervisor in charge of monitoring the workforce management as well as the worker's health and safety aspects. This supervisor included in the Contractor's team shall also oversee checking the way the Contractor's subcontractors operate in terms of employment.
- Implementation of a system to monitor the age of the workers.
- Creating risk assessments for workers under the age of 18.
- Team training on health and safety aspects at work.
- Implementation of a complaints management system for the workers and keeping a register of ongoing proceedings up to date.
- Implementation of an internal communication system with the Main Contractor and the funding agencies in the event of serious incidents and
- Provide copies of pay slips for workers used on-site (employees and subcontractors).

Community Relation Management Plan

The contractor shall prepare a Community Relation Management Plan which will comply with national regulations and international standards and more specifically with the IFC performance standards 1 (IFC PS1) relating to the assessment and management of environmental and social risks and impacts.

The aim of this plan is to define applicable regulations and standards, roles and responsibilities of the Contractor and its subcontractors with regards to the implementation of social management on various construction sites. The plan will also define the measures to be implemented in compliance with the environmental and social impact assessment for the project.

With regards to surrounding communities, the contractor shall at least:

- Implement a communication and control system to limit health and safety risks to local communities due to the construction work (traffic, access to construction areas, etc.).
- Check there are no populations remaining in the construction area and report to the Employer non-compliance with regards to the displacement of affected populations.
- Keep a record of cultural or religious sites disturbed by the construction works.
- Implement a communication system aimed at local communities to provide information on the site and more specifically on its environmental and social aspects (billboards, advertisements in the media).
- Support local purchases and subcontracting, while supporting these suppliers in improving their environmental and social management.
- More specifically, promote the creation of economic interest groups in order to make their application more credible.
- Define and implement local development programs (youth training, hiring, assistance to development with local authorities and community representatives.
- Establish a register as well as a complaint management systems.
- Organize campaigns to raise awareness to the impacts of poaching and feeling sensitive species.
- Implement measures to avoid Gender Based Violence and Violence against children.
- Establish a Community Grievance Redress facility.

3.3 Safety Measures

Generals

The Contractor shall be responsible for the safety of all workmen and other persons entering the Works and shall, at his own expense (where not otherwise stated) and to the approval of the Consultant, take all measures necessary to ensure their safety; no worker will be allowed on site without the required safety gear. Reference in these respects is made to statutory requirements and Conditions of the Contract, but such measures shall include, but not be limited to, the following:

- Provision of proper safety and emergency regulation; fire, gas, and electric shock prevention, stretchers, and first aid boxes, together with rescue facilities generally, for each place of work.
- Safe shoring of all excavations.
- General good housekeeping to prevent the spread of diseases including the provision of safe drinking water.
- Provision of efficient safety helmets for all personnel including the Employer and the Consultant and each of their staff and any authorized visitors to the Site.
- Provision of safety shoes, glasses, belts, and other protection adapted to the risks encountered for all personnel including the Employer and the Consultant and each of their staff and any authorized visitors to the Site.
- Safe control of water.
- Provision and maintenance of suitable lighting to provide adequate illumination of the Works with appropriate spares and standby equipment.
- Provision of safe Contractor's equipment and temporary works.
- Provision of good and safe access to any part of the Works.
- Provision of notices written in English language to be erected at points likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

Safety Plan

The Contractor shall submit to the Consultant, within four months before the start of work, the safety plan and hygiene applicable throughout the Site. The plan, intended to integrate security against major risks to staff, shows:

- The measures provided for this purpose in both procedures in their definition in the different phases of Works. It will clarify, depending on the method of construction and the materials used how to prevent falls for personnel, materials and equipment, vertical and horizontal circulation gear, fire hazards, and drowning, and electrical hazards, especially while working in the vicinity of live parts.
- The measures for first aid to the injured and sick.
- The measures that contribute to healthy work, including the consistency and quality of the staff rooms.

Terms of health and safety will be maintained by the Contractor who will report changes to the Consultant.

The Contractor shall submit in due time and not later than 4 months after receiving the Order to Commence, for the approval of the Consultant his detailed safety regulations and plan.

The Contractor shall ensure that all his employees are fully conversant with the regulations, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

4.Compliance with Regulations

All apparatus and materials supplied and all work carried out shall comply in all respects with such of the requirements of the Regulations and Acts in force in Kenya as are applicable to the Contract Works and with other applicable Regulations to which KETRACO is subject.

5. General Particulars and Guarantees

The Works shall comply with the general particulars and guarantees stated in the Schedules of Technical Information.

All working methods employed, and all plant and apparatus supplied under this Contract shall be to approval.

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees, whether the Project Manager has approved such particulars and guarantees or not.

6. Compliance with Standard Specifications

Except where otherwise specified or implied, the works shall comply with the latest applicable Standards or Recommendations of the International Electrotechnical Commission (IEC), Institute of Electrical and Electronics Engineers (IEEE) or to the standards of the British Standards Institution (the said Specifications being hereinafter referred to as BS).

Standard specifications and codes of the following listed authorities wherever cited herein are referred to by use of the abbreviations shown below.

All materials and workmanship shall comply with the requirements of applicable codes.

Table: Standards

Standard	Description
Substation Design	
IEC 60071-1	Insulation coordination-Part 1: Definitions, principles, and rules
IEC 60071-2	Insulation coordination-Part2: Application guide
IEC61936	Power Installations exceeding 1kV a. c.
ISO 9001	Quality management systems Requirements
IEEE 80/81	IEEE guide for safety in AC substation earthing materials
Standards of particular importance for documentation	
HV Circuit Breakers	
IEC 62271-1	HV Switchgear-Part 1: General Requirements
IEC 62271-100	AC HV Circuit Breakers
IEC 62271-110	Inductive load switching
IEC 62271-310	Electrical endurance testing for HV circuit breakers above $U_r=52\text{kV}$
HV Disconnectors and Earthing Switches	
IEC 62271-1	HV Switchgear Part 1- General requirements
IEC 62271-102	HV Switchgear Part 102-Alternating current disconnectors and earthing switches
HV Instrument Transformers	
IEC 61869-1	Instrument Transformers Part1: General requirements
IEC 61869-2	Instrument Transformers Part2: Additional requirements
IEC 61869-3	Instrument Transformers Part 3: Additional requirements for Inductive Voltage Transformers
IEC 61869-4	Instrument Transformers Part 5: Additional requirements for capacitor Voltage Transformers
HV Surge Arresters	
IEC 60071-1	Insulation coordination-Part 1: Definitions, principles and rules
IEC 60071-2	Insulation coordination-Part2: Application guide

Standard	Description
IEC 60099-5	Surge arresters- Part 5: Selection and application recommendations
IEC 60099-4	Surge arresters-Part 4: Metal oxide arresters without gaps for AC systems
Busbars and Connections	
DIN 43670	Aluminium busbars – design for continuous current
DIN EN 50182-12	Conductors for overhead lines
IEC 60104	Aluminium-magnesium-silicon alloy wire for overhead line conductors
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
String Insulators	
IEC 60383-1,2	Ceramic or glass insulator units for a. c. systems
IEC 60120	Dimensions of ball and socket couplings for string insulator units
IEC 61109	Insulators for overhead lines, composite type
IEC 61466	Composite string insulator units
Post Insulators	
IEC 60273	Characteristics for indoor and outdoor post insulator >1000 Vac
IEC 60168	Tests on indoor and outdoor post insulators of ceramic material
Substation Gantries and Equipment Support Steel Structures	
ISO 10721-1	Steel structures-Part 1: Materials and design
ISO 10721-2	Steel structures-Part 2: Fabrication and erection
Power Transformers	
IEC 60076	Power Transformers Part 1 to Part 7
IEC 60076-10	Power Transformers Part10. Determination of Sound levels
IEC 60214	Tap-changers Part 1 and Part 2
IEC 60247	Insulating liquids

Standard	Description
Shunt Reactors	
IEC 60076	Power Transformer Part 1 to 7 plus part 10
IEC 60214	Tap-changers Part 1 and Part 2
IEC 60247	Insulation liquids
Auxiliary Transformers	
IEC 60076	Power Transformers all applicable parts
IEC 60214	Tap-changers all applicable parts
IEC 60247	Insulating liquids
MV Switchgear	
IEC 62271-1	HV switchgear and control gear Part 1: Common specifications
IEC 62271	HV Switchgear and control gear Part 100,102, 103
IEC 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV
IEC 60529	Degrees of protection provided by enclosures
AC, DC Installations	
IEC 90947	LV switchgear and control gear
IEC 61439	LV switch and control gear assemblies
Earthing and Lightning Protection	
IEC 60364	Low voltage electrical installations
IEC 60479	Effects of current on human beings and livestock
IEC 61936-1	Power installations exceeding 1kV ac- Part 1 Common rules
IEC 62305	Protection against lightning
Substation Control and Monitoring System	
IEC 61850	Communication Networks and Systems in Substations
IEC 60870-5-101	Communication with remote control centers

Standard	Description
IEC 60870-5-104	Communication with remote control centers
DNP3	Communication with remote control centers
DNP3-over-TCP/IP	Communication with remote control centers
IEC 60970-5-103	Communication with third party devices without 61850 Interface
Protection, Control and Metering Panels	
IEC 60255	Electrical relays
IEC 60664	Insulation coordination for equipment within LV systems
IEC 61000	Electromagnetic compatibility (EMC)
IEC 62052-11,21	General requirements, Metering equipment
IEC 62053-22,23,61	Electricity metering equipment
IEC 62056	Electricity Metering
IEC 60529	Degrees of protection provided by enclosures
IEC 61850	international standard defining communication protocols for intelligent electronic devices at electrical substations
Telecommunication System	
EN 55022	Limits and methods of measurement of radio interference characteristics of information technology equipment
IEC60825	Safety of laser products
IEC60834	Tele-protection equipment of power systems
IEC60870	Telecontrol equipment and systems
IEC60874	Connectors for optical fiber and cables
IEC61000	Electromagnetic compatibility
IEC61300	Fiber optic interconnecting devices and passive components
IEC 61850	Communication Networks and systems in Substations
IEC 62351	Power systems management and associated information exchange
IEC 62488-1	Power line communication systems for power utilities

Standard	Description
IEC62367	Safety aspects for xDSL signal on circuits connected to telecommunication networks
International Telecommunications Union – Telecommunication (ITU-T)	
G.652	Characteristics of a single-mode optical fiber cable
G.653	Characteristics of a dispersion-shifted single-mode optical fiber cable
G.655	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
G.661	Definition and test methods for the relevant generic parameters of optical amplifier devices and subsystems
G.662	Generic characteristics of optical amplifier devices and subsystems
G.702	Digital hierarchy bit rates
G.703	Physical/electrical characteristics of hierarchical digital interfaces
G.704	Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kb/s hierarchical levels
G.707	Network node interface for the synchronous digital hierarchy (SDH)
G.708	Sub STM-0 network node interface for the synchronous digital hierarchy (SDH)
G.709	Interfaces for the Optical Transport Network (OTN)
G.711	Pulse code modulation (PCM) of voice frequencies
G.712	Transmission performance characteristics of pulse code modulation
G.732	Characteristics of primary PCM multiplex equipment operating at 2048 kb/s
G.736	Characteristics of a synchronous digital multiplex equipment operating at 2048 kb/s
G.741	General considerations on second order multiplex equipment
G.742	Second order digital multiplex equipment operating at 8448 kb/s and using positive justification
G.744	Second order PCM multiplex equipment operating at 8448 kb/s
G.745	Second order digital multiplex equipment operating at 8448 kb/s and using positive/zero/negative justification
G.772	Protected monitoring points provided on digital transmission systems
G.773	Protocol suites for Q-interfaces for management of transmission systems
G.774	Synchronous digital hierarchy (SDH) - Management information model for the network element view
G.781	Synchronization layer functions

Standard	Description
G.783	Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks
G.784	Synchronous digital hierarchy (SDH) management
G.803	Architecture of transport networks based on the synchronous digital hierarchy (SDH)
G.813	Timing characteristics of SDH equipment slave clocks (SEC)
G.823	The control of jitter and wander within digital networks that are based on the 2048 kb/s hierarchy
G.825	The control of jitter and wander within digital networks that are based on the synchronous digital hierarchy (SDH)
G.826	End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections
G.831	Management capabilities of transport networks based on the synchronous digital hierarchy (SDH)
G.841	Types and characteristics of SDH network protection architectures
G.842	Inter-working of SDH network protection architectures
G.874	Management aspects of the optical transport network element
G.957	Optical interfaces for equipment and systems relating to the synchronous digital hierarchy
G.961	Digital transmission system on metallic local lines for ISDN basic rate access
K.10	Low frequency interference due to unbalance about earth of telecommunication equipment
K.11	Principles of protection against over voltages and over currents
K.13	Induced voltages in cables with plastic-insulated conductors
K.14	Provision of a metallic screen in plastic-sheathed cables
M.2101	Performance limits and objectives for bringing-into-service and maintenance of international SDH paths and multiplex sections
M.2110	Bringing-into-service international multi-operator paths, sections and transmission systems
M.2120	International multi-operator paths, sections and transmission systems fault detection and localization procedures
M.2130	Operational procedures for the maintenance of the transport network

Standard		Description
M.3000		Overview of TMN recommendations
M.3010		Principles for a telecommunications management network
M.3013		Considerations for a telecommunications management network
M.3016		TMN security overview
M.3020		TMN interface specification methodology
M.3100		Generic network information model
M.3120		CORBA generic network and network element level information model
M.3200		TMN management services and telecommunications managed areas: overview
M.3400		TMN management Functions
Q.16		Maximum permissible value for the absolute power level of a signalling pulse
Q.23		Technical features of push-button telephone sets
X.150		Principles of maintenance testing for public data networks using Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) test loops
Table 1: MV and LV Power Cables		
MV and LV Power Cables		
IEC 60502		Power cables with extruded insulation and their accessories
IEC 60287		Calculation of current ratings
IEC 60227		PVC cables up to and incl. 450/750V
Control, Instrumentation and Telecommunication Cables		
IEC 60189		Low-frequency cables and wires with PVC Insulation and PVC sheath
IEC 60227		PVC cables up to and incl. 450/750V
IEC 60794		Fiber optic cables
Fire Detection and Alarm System		
ISO 7240		Fire detection and alarm systems
DIN EN 54-1		Fire detection fire alarm systems

Standard	Description
Fire Fighting System	
IEEE Std 979 TM-2012	Guide for Substation Fire Protection
Closed Circuit Television (CCTV) System	
IEC62676	Video Surveillance Systems
Civil Works	
The civil/architectural and installation service works for buildings and structures shall be designed and constructed to the highest quality codes /standards and good engineering practices.	

Except if otherwise specified, where such standards are mentioned, the latest revision or edition on the Base Date shall apply.

When the Contract Documents contain particular specifications or more restrictive specification than required in Standards and Codes listed above, the Contract Documents will always prevail.

In case of a lack of precise requirements in the Specifications and even if no reference to any standard listed hereof, these standards shall be used as a reference.

Where the use of a standard other than IEC or BS is agreed then this standard shall be used, where applicable, throughout the work. Where other standards are proposed in place of IEC, IEEE or BS standards confirmation shall be provided that the provisions of the standards are equivalent to or exceed those of equivalent IEC, IEEE or BS standards. Copies of any standards proposed in substitution for IEC, IEEE Standards or Recommendations or British Standards must be submitted with the Bid accompanied where necessary by English translations of the appropriate sections.

No departures from the Specification are to be made without the written approval of the Project Manager.

7. Variations from Conditions of Contract

In the event of there being any inconsistency between the provisions of this Technical Specification and the Conditions of Contract, the provisions of the Conditions of Contract shall prevail and shall be considered as incorporated in the Contract.

8.General Coordination

General

The Contractor shall coordinate his works with those of the other contractors at the Site to whatever extent may be necessary to complete the Project in accordance with the Program of Works, the Drawings, and Specifications and as per the Consultant's instructions.

Employer's Use of Contractor's Temporary Works

The Contractor shall during the progress of the Works allow the Employer, the Consultant, and other contractors employed by the Employer in connection with the Works, the use of his roads, scaffolding, constructional plant, other temporary works, or services such as described in the present Specification. The Contractor shall at every place of work provide proper drainage, lighting and ventilation for other contractors' erection work and for the Consultant's inspection of the Works. Except for those items entered in the Bill of Quantities such assistance shall be included in the rates.

Assistance to the Staff of the Employer and Consultant

The Contractor shall provide the assistance and personnel which may be required by the Consultant's Representative in relation to the preparation of works' supervision, such as messengers, guards, and the like, whether required permanently or from time to time.

The Contractor shall provide labour for attendance on the Consultant and the Employer for operations connected with supervision of the Works and, for attendance and assistance, to other contractors during the erection of the Electrical and Mechanical Works.

Such labour for attendance and assistance to Consultant and Employer shall be included in the rates or lump sums.

Disagreement and Dispute Mitigation with Other Contractors

Should a disagreement or dispute arise between the Contractor and any other contractors, the same shall be referred without delay to the Consultant for his decision. Upon such decision and without any prejudice to his rights under the Contract, the Contractor shall proceed with the works in accordance therewith.

9. Subcontracted Plant, Materials and Labour

The Contractor shall also provide the Project Manager with names and details of local subcontractors before such subcontracts are placed. KETRACO reserves the right to withdraw its consent to local subcontract arrangements if such are considered unsuitable, but consent will not be unreasonably withheld.

Subcontractors/manufacturers for major items of supply or services identified in the prequalification document must meet or continue to meet the minimum criteria specified therein for each item.

Sub-contracting is not permitted to exceed 30% of contract price. Bidder shall include with the bid a list of subcontractors (if any) for major items of services, with elements of work/items and the proposed subcontractor(s) clearly identified including their past experience/capacity.

In general, for items of supply, the vendors must have successfully manufactured and supplied in any one year during the last five years, the quantity being proposed for subcontracting, which are in satisfactory operation/use for the past two years as on the date of bid opening.

Failure to comply with this requirement will result in the rejection of the subcontractor.

In the case of a Bidder who offers to supply and install major items of supply under the contract that the Bidder did not manufacture or otherwise produce, the Bidder shall provide the manufacturer's authorization, using the form provided in Section IV, showing that the Bidder has been duly authorized by the manufacturer or producer of the related plant and equipment or component to supply and/or install that item in the Employer's country. The Bidder is responsible for ensuring that the manufacturer or producer complies with the requirements of ITB 4 and 5 and meets the minimum criteria listed above for that item.

10. Access to Manufacturers' Works

Access to the Contractor's and Subcontractors' works shall be granted to the representatives of the Project Manager and of KETRACO for the purpose of inspection, testing and ascertaining progress.

11. Planning, Progress Meetings and Project Reports

The Contractor shall submit for review, within 4 weeks of the Effective Date of the Contract, an outline design, manufacture, delivery and construction and erection chart. Within a further period of 4 weeks the Contractor shall provide a detailed programme in a format to be agreed by the Project Manager; this programme shall also include details of drawing submissions. The detailed programme shall cover all aspects of the Contract: design, procurement, manufacture, testing, shipment and transport, delivery to site, all site operations related to construction, erection and installation, testing at site, commissioning and completion of the works.

The Contractor shall submit to the Project Manager and KETRACO at monthly intervals, not later than the fifth day of the following month, and in such formats as may be required by the Project Manager, detailed progress reports of the status of design, material procurement, manufacture, works tests, site transportation plan, delivery to Site, erection of all plant and materials included in the Contract, testing and commissioning with regard to the agreed contract programme.

Reports shall include a chart detailing plant manufacture, delivery and erection. The chart shall indicate all phases of the work with provision for modification if found necessary during execution of the Works.

The design aspect of the progress report shall include a comprehensive statement on drawings and calculations submitted for review.

The details on material procurement shall give the dates and details of orders placed, indicating delivery dates and expected inspection dates quoted by the manufacturer. If any delivery date has an adverse effect on the contract programme the Contractor shall state, the remedial action taken to ensure that delays do not occur.

The section on manufacture shall indicate dates of arrival of material, the progress of manufacture and testing and shall state the date on which the material will be ready for transport. Any events which may adversely affect completion in the manufacturer's works shall also be reported.

All works tests and the test results shall be listed and a commentary provided. Any test failures shall be explained and the Contractor shall state his proposed actions to prevent delay to the project completion. The shipping or transport of each order shall be monitored in the progress report and shall give the date when equipment is available for transport, the expected time of delivery to site and the dates actually achieved.

The report on the site works shall be subdivided into each of the activities included in the detailed construction programme and each activity shall be monitored giving work achieved, the percentage completion and estimated

completion dates for each activity, in accordance with the contract programme. The number of men working on site, both labour and supervisory staff, shall be reported together with any incidents or events that may affect the progress of site works. The progress reports shall include photographs of work items of interest and any unusual form of construction or foundation work.

A site weekly programme of work shall be provided each week during the previous week.

Any delays which may affect any milestone or completion date shall be detailed by the Contractor who shall state the action taken to effect contract completion in accordance with the contract programme.

The Contractor shall forward two copies of each progress report to the Project Manager. If during the execution of the Contract the Project Manager considers the progress position of any section of the work to be unsatisfactory the Project Manager shall be at liberty to call progress meetings at site or in his office with a responsible representative of the Contractor.

Project progress meetings shall be held at monthly intervals or as mutually agreed between the Contractor, KETRACO and the Project Manager. The venue for each project progress meeting (including necessary refreshments etc.) is to be provided by the Contractor throughout the duration of the contract.

12. Drawings Supplied to the Contractor

Tender Drawings

The Tender Drawings issued with the Tender Documents are of a general nature only but are sufficient for the purpose of tendering. Tender Drawings are not to be used for construction or ordering materials.

The dimensions given are indicative only and are not final. They may be adapted to suit Contractor's methods and designs with the approval of the Consultant.

The Contractor will communicate and coordinate with contractors of other lots/projects, all documents relative to the procurement of these lots.

Schedule for Issuance of Drawings

The Consultant and Contractor shall jointly prepare a schedule for issuance to the Contractor of Drawings Issued for the Construction of the various parts as soon as the draft program of works is submitted for the Consultant's approval.

Checking of Drawings

During the development of the works and the related construction design, the Consultant and/or Employer shall check all Construction Drawings carefully as soon as practicable after receipt thereof and shall promptly advise the Contractor of any errors or omissions discovered.

Diagrammatic Mechanical, Electrical Drawings

Certain mechanical and electrical drawings are diagrammatic and indicate the general arrangement of the works. The Contractor shall refer to the structural and other appropriate detail drawings, for information as the location of all fixtures and equipment. Where additional information is required, the Contractor shall request this information from the Consultant in writing.

Design and Drawings to Be Carried out by the Contractor.

The Contractor shall prepare all necessary documents giving complete information to enable the Employer/Consultant to consider the Work's design properly.

Documents originated by any Subcontractors shall fulfil all specified requirements and standards. Before submitting those documents, the Contractor must verify concerning measurements, size of members, material, and details to make sure that they conform with the requirements and the Contractual and Technical Requirements' intent.

Documents shall be submitted to the Employer/Consultant in such a sequence that the employer/consultant's information for examination purposes corresponds with the design logic and the works' progress.

The Contractor shall provide drawings showing how the Plant is to be assembled with all information relating to the works required for preparing suitable foundations, for providing appropriate access for the Plant and any necessary equipment to the point on-site where the Plant is to be erected and for making all the required connections to the Plant (whether such connections are to be made by the Contractor under the Contract or not).

The Contractor should highlight on each document any deviations from the specification. It is the responsibility of the Contractor to draw attention to all cases where his submissions do not fully comply with the contractual specification and Basic Design Documents

Drawings to be provided by the Subcontractors shall be checked thoroughly by the Contractor, and those found to be inaccurate or otherwise in error shall be returned to the Subcontractor for correction before submitting them to the Engineer. Documents submitted by the Contractor, which are from a subcontractor or sub-supplier, shall be accompanied by a statement from the Contractor that he has thoroughly checked them and found them fully compliant, highlighting the deviations from the specifications.

Any changes in the updated and/or revised documents shall be clearly indicated using clouds, highlighting, or any other practicable way for easy follow-up. Updated or revised docs without showing the requested clear indication will be sent immediately without any approval comment return to the sender.

The Contractor shall bear any expenses resulting from an error or omission or delay in delivering the necessary documents and information.

The following clauses give a tentative and non-exhaustive list of documents to be supplied by the Contractor.

Design Calculations

The design calculations which may be presented under existing computer forms shall include in particular:

Title page:

- Calculation conditions.
 - The values of the maximum stresses under normal and exceptional operating conditions and during handling, transport, and erection.
 - The main dimensional characteristics.
 - The properties of the materials used.
 - Bibliographical references used for the calculations.
- In the text:
- The loads to which the supply is subjected and their origin; o the forces transmitted to supplies and to the foundations.
 - Stresses to which the equipment will be subjected under normal and exceptional operating conditions (including handling, transport, and erection).
 - The permitted safety factors.
 - In general, any indications required for a proper understanding of the design of the supply.

The design calculations shall be sent with the drawings: no equipment drawings shall be approved until the Consultant has the design calculation for that supply. For any item of equipment, partial design calculations may be submitted to the Consultant depending on the various stages of execution of drawings (for example, grouting drawings, built-in parts, structures, operating devices, etc.).

A complete set of design calculations for each item of equipment shall be given to the Consultant on completion of the execution drawings for the item of equipment in question.

The Consultant reserves the right, during the design period, to request the Contractor for any additional design calculations which he considers necessary.

Drawings

Only the most important documents are listed below. These documents shall be submitted sufficiently in advance so that corrections and amendments desired by the Employer as well as resubmission of the documents will not result in any delay with respect to the guaranteed timetable. The Employer reserves the right to request from the Contractor additional drawings, documents, etc. as may be required for proper understanding and definition of the design and engineering of the plant.

As a minimum, the following documents are to be submitted for approval or review:

- i. General
 - current list of drawings
 - progress reports
 - erection and installation progress reports
 - list of subcontractors/manufacturers
 - proposed inspection and testing programs.
 - detailed program for commissioning
 - testing documents/report of results of all tests
 - training program
 - operation and maintenance manual with description of all equipment and facilities
 - detailed operating and maintenance instructions
 - as-built documentation including drawings of all equipment
- ii. Time Scheduling
 - Overall time schedule for design, manufacture, supply, assembly and commissioning, broken down for the principal plant components and all construction works, stating dates for completion of any preparatory work from others which may be necessary
 - detailed erection, installation, and commissioning schedule
 - complete list of documents with proposed submission deadlines
- iii. Mechanical Engineering
 - arrangement drawings of the principal components, arrangement drawings of auxiliary equipment (cubicles, etc.)
 - piping and instrumentation schematics and isometric drawings, including lists of pipelines and valves, stating materials, nominal diameters, nominal pressures, dimensions and insulation thickness of all pipes
 - plans of main pipelines including location of cable routes
 - characteristics of pumps, fans, etc.
 - details of required auxiliary energy sources and consumables (e.g. electricity, instrumentation air, working air) with condition data and consumption values
 - welding procedures
 - sectional and detail drawings of all components

- for all lifting operations (repair, maintenance, etc.) a lifting plan has to be submitted by the Bidder
- iv. Electrical Engineering
 - electrical single-line diagrams
 - list of motors and consumers
 - cable lists
 - standard circuit diagrams for all different kinds of electrical consumers
 - circuit diagrams for all individual electrical equipment
 - lists of equipment and devices
 - earthing plans with calculations
 - lightning protection plans with details of measuring locations and reports of measurements taken following commissioning
 - EMC concept with coordinated overvoltage protection
 - arrangement drawings
 - line plans of fire alarm system, if applicable
 - arrangement drawings showing exact location of fire alarm devices, if applicable
 - power and lighting installation plans
 - general arrangement drawings of the required cable trays, cable laying plans
 - dimensioned drawings and erection drawings switchgear etc., including frontal and plan views
 - dimensioned drawings of switching cubicles,
 - calculation of mechanical stresses of switchgear rooms due to arcing faults
 - short circuit calculation and determination of protection relay settings for protection and auxiliary electrical supplies
 - protection and metering diagram for unit protection
 - generator charts and exciter characteristics
 - line profile drawing for switchyard extension
 - calculation of conductor and earth wire tension and sags
 - static calculations of all gantries and foundations
 - drawings of all foundation gantries for switchyard extension
 - Instrumentation and Control Engineering
 - control system architecture showing all components
 - layout drawings of the central control room showing spatial distribution of desks and panels
 - layout of electronic rooms showing spatial distribution of cubicles and racks
 - detailed dimensions of desks, panels and cubicles
 - layout of modules within cubicles
 - description for all functional group controls
 - CDS/PLC program listings for all application programs
 - DCS/PLC interface documentation
- v. DCS/PLC I/O point assignment
 - engineering drawings of control valves, control dampers together with their actuators, orifices, nozzles, venture nozzles
 - internal connection diagrams, external connection diagrams, terminal connection diagrams, combined schematic and circuit diagrams
 - instrument loop diagrams
 - instrument hook-up drawings
 - list of recorders/selector switches
 - instrument list

- list of annunciations
- cable lists
- cable routing plan
- vi. Civil Engineering
 - survey drawings for the plant installed
 - general site plan of the entire site showing all buildings and installations, traffic routes and land- scaping, etc.
 - architectural arrangement drawings, design layouts and itemized drawings (plans and sections) to scale 1:100 of all buildings and plants
 - views of all sides of all buildings, scale 1:100
 - architectural drawings of each floor (plans, sections), including all necessary detail drawings, scale 1:50
 - arrangement drawings of the external plants of the site as a whole (existing, planned) with all supply and disposal facilities, roads and parking, vehicle access and manoeuvring areas, sewers, channels and culverts, etc.
 - sectional elevations and roof plan
 - raised floors and suspended ceiling systems
 - underground services and ducts with equipment appertaining to the services
 - sewage and storm water systems
 - layouts for external works showing plants and fencing, etc.
 - diagrams for heating, ventilation and air conditioning systems
 - foundations and other underground concrete works for the transmission line
 - civil drawings of roads

Such drawings will be checked again after completion (as-built drawings).

Submission and Approval

The Contractor shall submit to the Consultant and Employer, for review, all designs and drawings which he prepares under this Clause. The Contractor shall submit on the same day the soft copies of each submission to the Consultant and Employer for review using an email with link to access the files from an online (internet-based) document storage and management system (ODMS) such as Google Drive, Microsoft OneDrive, etc.

Submission shall be done according to the following quantities:

- two black and white prints,
- one soft copy on PDF format
- one soft copy on AutoCAD

The Contractor shall share Internet-based multi-user online document storage management system with the Employer and the Consultant for the proper management of the project documents from project kick-off date to up to the end of Defects Liability Period (DLP) and hand it over to the Employer at end of the Project..

The Consultant will review all such designs and drawings, will appraise them as to whether they are reasonable and consistent with the Construction Drawings and comply with the specifications, and will order changes when deemed necessary.

The Contractor shall ensure that all documents for approval are forwarded to the Employer/Consultant in such a way as to allow sufficient time for examination by the Employer/Consultant. The Contractor shall also ensure that documents are submitted early enough to permit amendments to be made and resubmission for approval without delaying the program of deliveries or the Works' guaranteed completion dates.

All documents prepared or furnished by the Contractors shall be marked with the title block and transmitted to the Employer/Consultant. Each transmittal of documents shall be accompanied by a Document Transmittal Sheet (DTS) giving the titles and numbers.

At monthly intervals, or as agreed upon otherwise (and if required with any document and design document sent for approval), the Contractor shall submit copies of his complete document lists, incorporate the updated schedule as mentioned above, and the latest transmittal sheets. Failure to submit the aforementioned documents shall be sufficient ground (basis) enough to withhold processing subsequent interim payment applications for completed Works.

These lists shall indicate the actual status of every document and design document, i.e., for information only, for approval, resubmitted for approval, approved or as built, and shall bear the revision field and revision date. The nature of the modification shall be clearly stated, no matter if it was already approved, approved on the condition, revised, or not supported.

All documents shall bear the approved contract references and title block as agreed with the Employer/Consultant.

All drawings shall show the metric system's scales, and all descriptive wording shall be in the English language.

All drawings and other documents submitted by the Contractor shall be of one of the following sizes that conform to the international standards specifications ISO 5457:

Table 2: Drawings format (ISO 5457)

Format symbol	Size		Number of fields	
	cut	uncut	Short side	Long side
A0	841 x 1189	880 x 1230	16	24
A1	594 x 841	625 x 880	12	16
A2	420 x 594	450 x 625	8	12
A3	297 x 420	330 x 450	6	8
A4	210 x 297	240 x 330	4	6

All the above formats shall be folded to size A4 with a margin for binding.

The following scales shall be used:

For reductions: 1: 2.5; 1: 5; 1: 10; 1: 20; 1: 50; 1: 100;

1: 200; 1: 500; 1: 1000; 1: 2000; 1: 2500

For enlargements: 2: 1; 5: 1; 10: 1

In addition to the sizes mentioned above, horizontally extended sizes are permissible, for example, for circuit diagrams, wiring diagrams, and route plans; these shall have the following dimensions:

Height: 297 mm

Length: a multiple of 210 mm

The quality of original drawings, master prints, blueprints, and all other copies, irrespective of the method by which they have been produced, must be such that no damage whatsoever, such as partial or complete illegibility, can occur because of extreme climatic conditions.

For drawings, a paper grade weighing of 80 g per square meter shall be used throughout.

Logical and graphical symbols and abbreviations used in the drawings shall be identified in a legend. Abbreviations shall be described in their full text.

Documents submitted, other than drawings and Contractor's literature shall be A4 size. All documents shall comprise a title block with the following details:

- the name of the Employer
- the name and reference of the Contract,
- the name of the Consultant,
- the number of the corresponding Section of the Specification
- the name of Contractor and if applicable Subcontractor,
- the date, the title and number of the document and each new issue of the document shall be identified by a revision letter
- the signature of the Contractor's representative
- the status of any document such as: 'Preliminary', 'For Approval', 'Approved by the Consultant on (date)', 'As Manufactured', 'As Built', shall be clearly marked by the Contractor.

The Consultant shall approve the title block and numbering principle.

The reference to Construction Drawings, if any, shall appear in the bottom right-hand corner of the drawing.

Within twenty-one working (21) days after submission of the drawings, the Consultant will advise the Contractor of his conclusions regarding the drawings.

The Consultant's conclusions may be one of the following:

- "APPROVED"
- "APPROVED EXCEPT AS NOTED"
- "NOT APPROVED" (with relevant reasons determining rejection duly indicated).
- "RETURNED" (Not fully reviewed due to missing attachment of supporting documents stated in this Specification and/or required by the Consultant and/or Employer).

Within fifteen working (15) days of the return of designs and drawings marked "APPROVED" or "APPROVED EXCEPT AS NOTED", the Contractor shall present to the Consultant:

- two black and white prints,
- one soft copy on PDF format
- one soft copy on AutoCAD

No drawing shall be considered valid unless approved by the Project Manager (in which case PM is either the Owner's Engineer or UETCL Project Manager).. The approval by the Project Manager of such drawings shall not relieve the Contractor of his obligations and responsibilities under the Contract.

Those marked "NOT APPROVED" shall be redone and submitted anew to the Consultant.

The Contractor shall not be entitled to a time extension based upon the rejection of designs or detail drawings, because such designs or detail drawings fail to conform to sound Project Managing principles, or to the Specifications.

All materials ordered, or works performed, prior to approval of the relevant designs, shall be at the Contractor's risk.

The Contractor shall bring to the attention of the Consultant any variation to the Contract in the document submitted for approval.

The number of documents for approval is limited to 20 documents per week or otherwise agreed by all the Consultant and the Contractor. The Substation Contractor shall within 1 month after Commissioning submit As-Built Drawings / Documentation approved by the Client / Client's representative both in hardcopy (3 printed copies) and soft copy (3 copies) and an email with link to access the files from an online (internet-based) document storage and management system (ODMS).

Table: Drawing Georeferenced

The drawings should be Georeferenced to:

Projected Coordinate System:	Arc_1960_UTM_Zone_36N
Projection:	Transverse Mercator
Geographic Coordinate System:	GCS_Arc_1960
Datum:	D_Arc_1960
Prime Meridian:	Greenwich
Angular Unit:	Degree

Soft copies provided shall be in both PDF format and in fully editable AUTO CAD, which version shall be confirmed at design review stage format on a Flash Drive (3Nos.).

A GIS shape file shall also be submitted by the contractor for Each equipment with Associated details. The GIS Schema will be shared by the Employer at the project's kick-off meeting.

The approved As-Built Drawings and Calculations shall be submitted with Document Master Lists categorized as below for each of the substations.

1. As Built (.....SS Project) Electrical Primary Drawings
2. As Built (.....SS Project) Electrical Secondary Drawings
3. As Built (.....SS Project) Civil Drawings

The Contractor shall submit Document Master Lists (Format & Content) for approval by the Client / Client's representative at the start of Project Implementation.

Note: For layouts and SLDs the contractor should consider the entire substation. Ownership of Drawings and Data

All the drawings, details, bill of materials and any other information or documents prepared and submitted by the Contractor and approved by the Consultant shall become the property of the Employer and shall be non-returnable. The Employer will have the right to use this property.

13. Layout of Work and Surveys

Reference Points, Lines and Levels

For Electrical Equipment

The Contractor shall determine in agreement with the Consultant the center lines and reference levels for the installation of the equipment from the above reference points.

Complementary Setting Out

During the execution of the Works, the Contractor shall complete the general setting out by as many stakes, seats and gauges as may be necessary.

Lines and Levels of Reference for Erection of Equipment by Others

At the beginning of erection of equipment supplied and erected by others, the Contractor shall place complementary reference points. The position of lines and levels shall be defined by mutual agreement of all parties. In case of disagreement, the Contractor shall follow the final decision issued by the Consultant.

The Consultant will draw up a report to confirm completion of these operations in the field.

14. Quality Assurance

To ensure that the supply and services under the Scope of this Contract, whether manufactured or performed within the Contractor's works or at his subcontractors' premises or at Site or at any other place of work are in accordance with the Specification, with the Regulations and with relevant authorized standards, the Contractor shall adopt suitable quality assurance programmes and procedures to ensure that all activities are being controlled as necessary.

The quality assurance arrangements shall conform to the relevant requirements of ISO 9001:2008.

The systems and procedures which the Contractor will use to ensure that the Works comply with the Contract requirements shall be defined in the Contractor's Quality Plan for the Works.

The Contractor shall operate systems that implement the following:

Hold point – “A stage in material procurement or workmanship process beyond which work shall not proceed without the documented agreement of designated individuals or organisations.”

The Project Manager's written agreement is required to authorise work to progress beyond the hold points indicated in reviewed quality plans.

Notification point – “A stage in material procurement or workmanship process for which advance notice of the activity is required to facilitate witness.”

If the Project Manager does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice, then work may proceed.

14.1 Quality Assurance Requirements

The Contractor and subcontractors, shall, for all phases of work to be performed under the Contract, establish and implement quality assurance arrangements which, as a minimum, meet the requirements of ISO 9001:2000, “Quality management systems: Requirements”.

The Contractor shall ensure that all work carried out under the Contract is performed by suitably qualified and skilled personnel and that good quality materials, which meet relevant international standard specifications, where such exist, are used.

14.2 Quality Assurance Arrangements – Quality Plan

The Contractor shall submit a comprehensive contract specific Quality Plan for review and comment, within two weeks of award of Contract.

The quality plan concerns the civil works and the Electrical equipment.

General

- The Quality Plan prepared by the Contractor with reference to his Quality Assurance Manual and as per the ISO Standard shall be submitted to the Consultant.
- This plan will reflect the know-how of the Contractor as well as the requirements of the Contract. The contractor's Quality plan shall include, but not be limited to, detailed procedures, instructions, or statement covering the following.

Organization and Procedures

- The Quality Plan shall describe Contractor's Quality Assurance organization and delineate the responsibility and authority of the various personnel and groups involved. The Quality Assurance Department's relationship with other departments shall be defined and their independence of Consultant, construction, cost, and scheduling shall be stated. An organizational chart shall be included with lines of authority and communication.
- Procedures for communication between the Contractor, the Consultant and the Employer will be established by the Consultant. As a rule, any documents issued by the Contractor including letters, various Reports, Notes, etc. shall be addressed to the Consultant with copies sent simultaneously and directly by the Contractor to the Employer and when applicable to Representatives on site. A particular procedure will be established for communications on site.

Procurement Control

- The Contractor's procurement process shall assure that purchased items, whether purchased directly or through his sub-suppliers, comply with the Specification. This assurance shall be provided by the inclusion of the quality requirements into the Contractor's procurement documents and adequate inspection of the material at its source or upon receipt.
- Prior to procurement, the Contractor shall furnish to the Consultant a list of Sub-Contractors and vendors with whom orders are to be placed for materials and equipment which will be incorporated directly into the Works. The Contractor shall also furnish such pertinent information as to capacities, efficiencies and sizes, and such other information as may be required by the Consultant.
- Copies of the Contractor's orders for materials and equipment and a list of his stock material or equipment shall be provided to the Consultant. All orders and stock lists shall state the standard specification under which the material is to be furnished, pertinent drawing and the required delivery dates. They shall state that the materials and equipment are subject to inspection by the Consultant.

Material Control

The Quality Plan shall provide assurance that procured, and subsequently processed material meets the Specification requirements. Material identification shall be provided and maintained throughout the manufacturing cycle. Controls shall be provided for the documentation and disposition of non- conforming

material, parts or components, and their subsequent rework or repair and re-inspection. The program shall also provide for the prior notification to the Consultant of proposed rework or repair or non-conformance, for this evaluation and approval.

Special Processes

Special Processes such as welding, soldering, brazing, heat treatment, cleaning, non-destructive examination, etc., shall be performed in accordance with documented process procedures and by quality personnel. The procedure shall describe the process sequence and methods, process prerequisites, equipment, qualification of personnel and equipment, and acceptance criteria. The procedures shall also describe the preparation and retention of documents used to record the results of special processes.

Non-Destructive Testing

Non-Destructive Testing (NDT) shall be done according to written procedures. The current edition of ISO 9712 shall be used as a guide for the NDT procedures. In addition, the specific requirements of the applicable Code and Standard shall be satisfied, and the procedures shall be submitted to the Consultant for review and approval prior to the initiation of the test. The items to be non-destructively tested to the extent of testing, and the acceptance Standard shall be clearly defined in the procedures and in accordance with the referencing Code and Standard. NDT personnel shall be qualified and certified in accordance with the current edition of ISO 9712 or equivalent.

Inspection

The Quality Plan shall provide for the in-process and final inspection of material, equipment and activities by the Consultant and/or the Employer to assure compliance with approved documents. Examination or measurements shall be performed at each applicable work operation. Qualified independent individuals shall perform inspection activities.

Calibration

Procedures shall be established to assure that test and measuring devices used to test, inspect, or accept material and components are calibrated at specified intervals to maintain the proper accuracy. Devices used shall be of the proper range, type, and sensitivity to reliably measure the parameters being evaluated. The calibration of such devices shall be documented and shall be performed using certified measurement Standards.

The Quality Plan shall identify as a minimum:

- a. the Contractor's organisation and responsibilities of key management including quality assurance personnel;
- b. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;
- c. the prime project documents, specifications, codes of practice, standards;
- d. the correspondence and reporting interfaces, and liaison between the Project Manager and the Contractor;
- e. the procedures the Contractor intends to use to manage and control the Contract, including:
 - i. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;
 - ii. hold and notification points;
 - iii. submission of engineering documents required by the Specification;
 - iv. the inspection of materials and components on receipt;

- v. reference to the Contractor's work procedures appropriate to each activity;
- vi. inspection during fabrication/construction;
- vii. final inspection and test.

It is recommended that separate Quality Plans be submitted for the design/manufacture and construction/installation phases.

The Contractor shall review, amend and re-submit quality plans as necessary during the Contract.

14.3 Monitoring by the Project Manager

During the course of the Contract the Project Manager reserves the right to monitor the implementation of the Contractor's quality assurance arrangements.

The Contractor's compliance with equipment, documentation, drawing, delivery, construction, installation and commissioning schedules shall be monitored by the Project Manager.

Monitoring may be by means of a programme of formal audits and/or surveillance of activities at the work locations. Where deficiencies requiring corrective actions are identified, the Contractor shall implement an agreed corrective action programme. The Project Manager shall be afforded unrestricted access at all reasonable times to review the implementation of such corrective actions.

For site work the Project Manager may monitor all aspects of the Contractor's daily work including that of subcontractors and assess the achievement of milestones as detailed by schedule deliverables.

The Project Manager reserves the right to monitor the subcontractors and the Contractor shall ensure that all subcontracts include, and subcontractors are aware of, this requirement.

14.4 Contractor Quality Audits

The Contractor shall carry out a formal programme of project quality audits. These shall include audits of the design, manufacture, assembly, erection, installation, test and commissioning functions of the Contractor's organisation and those of its subcontractors and suppliers. The Project Manager reserves the right to accompany the Contractor on such audits.

The Contractor shall formulate a 6-month project specific audit programme, covering 6-month periods, which shall be submitted to the Project Manager for review within 4 weeks of the Effective Date of the Contract and thereafter every 6 months. Any revision to the audit programme shall be forwarded to the Project Manager.

14.5 Control of Subcontractors

The Contractor shall be responsible for specifying the quality assurance requirements applicable to subcontractors and suppliers, for reviewing the implementation of subcontractors' quality assurance arrangements and for ensuring compliance with the requirements.

The Contractor shall ensure that all appropriate technical information is provided to subcontractors and suppliers. The Contractor shall, for the supply of items, plant or equipment (including those subcontracted), arrange for suitable protection for the product at all stages including delivery and installation at the site.

The Contractor shall submit, for information, a detailed programme defining the basis of control to be applied to each subcontract or supply order.

14.6 Inspection and Tests

Inspection and test plans shall be prepared for all major items of equipment/plant, defining the quality control and inspection activities to be performed to ensure that the manufacture and completion of the plant complies with the specified requirements.

Inspection and test plans shall be submitted for review.

The Contractor shall submit for review, within 30 days of the Contract Award, a schedule defining the plant/equipment/systems/services that are to be subcontracted, identifying all items for which inspection and test plans will be submitted.

The Contractor shall review all inspection and test plans and associated control documents, of any subcontractors and suppliers, to ensure their adequacy prior to submission.

The Contractor shall be responsible for identifying and arranging any statutory verification activities in the country of manufacture.

Inspection and test plans may be of any form to suit the Contractor's system, but shall as a minimum:

- a. Indicate each inspection and test point and its relative location in the production cycle including incoming goods, packing and site inspections.
- b. Indicate where subcontract services will be employed (e.g. subcontractor NDT or heat treatment).
- c. Identify the characteristics to be inspected, examined, and tested at each point and specify procedures, acceptance criteria to be used and the applicable verifying document.
- d. Indicate mandatory hold points established by the Project Manager that require verification of selected characteristics of an item of process before this work can proceed.
- e. Define or refer to sampling plans if proposed and where they will be used.
- f. Where applicable, specify where lots or batches will be used.

The Contractor shall include in all orders to subcontractors, a note advising that all materials and equipment may be subject to inspection by the Project Manager as determined by the inspection and test plan. Copies of such purchase orders shall be forwarded to the Project Manager.

In order to verify compliance with engineering, procurement, manufacturing requirements and programmes, the Project Manager shall have access, at all times, to all places where materials or equipment are being prepared or manufactured, including the works of the Contractor's subcontractors or supplies of raw materials.

The Contractor shall advise the Project Manager of the readiness of inspection at least 4 weeks prior to a nominated inspection/surveillance witness or hold point. Work shall not proceed beyond a hold point without the written agreement of the Project Manager or his nominated representative.

Inspection of the plant/equipment may be made by the Project Manager and could include the following activities:

- 1.1. Periodic monitoring to confirm the effectiveness of, and the Contractor's compliance with, the established quality plan, system procedures and inspection and test plan.
- 1.2. Witnessing of inspections and tests and/or verification of inspection records to be carried out at the Project Manager's discretion covering:
 - 1.2.1. compliance of raw material with specified requirements
 - 1.2.2. compliance of manufactured parts, assemblies and final items with specifications, drawings, standards and good engineering practice
 - 1.2.3. witnessing of inspection and tests
 - 1.2.4. packing for shipment including check for completeness, handling requirements, and case markings and identification.

Raw materials, components, shop assemblies, and the installation thereof, shall be subject to inspection and test by the Project Manager as required by the Specification and to the extent practicable at all times and places, during the period of manufacture.

The Contractor shall keep the Project Manager informed in advance of the time of starting and of the progress of the work in its various stages so that arrangements can be made for inspection and for test. The Contractor shall also provide, without additional charge, all reasonable facilities and assistance for the safety and convenience of the Project Manager in the performance of his duties. All of the required tests shall be made at the Contractor's expense, including the cost of all samples used.

The Contractor shall not offer, unless otherwise agreed, any item of equipment or system for inspection to the Project Manager until all planned inspections and tests to date have been completed to the satisfaction of the Contractor.

The Project Manager shall endeavour to schedule the performance of inspection and tests so as to avoid undue risk of delaying the work. In the event of postponement, by the Contractor, of tests previously scheduled, or the necessity to make additional test due to unsatisfactory results of the original tests, or other reasons attributable to the Contractor, the Contractor shall bear all costs for new tests and the costs incurred by the Project Manager or his nominated representative in re-inspecting the non-conforming item or its replacement.

The inspection and tests by the Project Manager of any equipment/component or lots thereof does not relieve the Contractor of any responsibility whatever regarding defects or other failures which may be found before the end of the defect liability period.

The Contractor shall provide a quality release certificate confirming compliance with the Contract requirements and a data book, comprising the inspection, test, qualification and material records required by the pertaining specifications.

No material shall be shipped to the Site or put to work until all tests, analysis and inspections have been made and certified copies of reports of test and analysis or Contractor's certificates have been accepted and released by the Project Manager or by a waiver in writing.

14.7 Construction/Installation Phase

Within 30 days of mobilisation of works, inspection and test plan(s), similar in form and content to that described in the 'Inspection and Tests' part of this specification above, shall be submitted defining relevant inspection and test points for all stages of construction/erection, installation and commissioning. The inspection and test plans shall identify activities for which method statements shall be prepared.

Method statements shall be submitted to the Project Manager for review.

Programmes of site construction works shall be submitted to the Project Manager, giving notification of forthcoming test/inspections on a weekly basis.

14.8 Non-Conformances

During manufacture and site works, after each assessment or measurement of quality, cases of non-conformity, identified either by the Contractor's quality control supervisors or by the personnel in charge of execution or by the Consultant, will be divided into four categories:

NC.1: Minor defects which shall be repaired immediately, then recorded on standard follow-up documents.

NC.2: Defects which can be repaired according to a pre-established procedure. The repairs shall be carried out immediately and recorded on special documents.

NC.3: Defects which cannot be repaired according to a pre-established procedure. The decision to repair, modify or rebuild or remanufacture the item shall be proposed by the Contractor for the Consultant's approval.

NC.4: Main defects on critical items. The Contractor shall propose a solution to the Consultant. Then the Consultant, after due consultation, will notify the Contractor of the final decision

All items or services not in accordance with the Contract technical specification, or deviating from a previously reviewed document, shall be considered non-conforming.

All such items shall be clearly identified and isolated where practical, and reported to the Project Manager via a non-conformance report. Information to be provided with non-conformance notifications shall include:

- a. identification of the item(s);
- b. reference to relevant specification/drawings, including applicable revisions;
- c. reference to the application inspection and test plan stage;
- d. description of the non-conformance, with sketch where appropriate;
- e. method by which the non-conformance was detected;
- f. cause;

- g. proposed corrective action, with technical justification, where necessary;
- h. for significant non-conformances, proposed action to prevent recurrence;
- i. applicable procedures.

The Project Manager shall have complete authority to accept or reject any equipment or part thereof considered not to be in accordance with the specified requirements.

Approval of any concession applications is the prerogative of the Project Manager, and approval of a particular case shall not set a precedent.

Any non-conformances identified by the Project Manager shall be notified by issue of the Project Manager's non-conformance report to the Contractor. Notification of re-inspection shall not be made until the completed non-conformance report, together with any applicable concession applications have been accepted by the Project Manager.

Acceptance or rejection of the equipment and/or components will be made as promptly as practicable following any inspection or test involvement by the Project Manager. However, failure to inspect and accept or reject equipment and/or components shall neither relieve the Contractor from responsibility for such items, which may not be in accordance with the specified requirements, nor impose liability for them on the Project Manager.

14.9 Records

Records packages to be delivered shall be agreed with the Project Manager prior to setting-to-work of each phase, i.e. design, manufacture, construction, installation and commissioning.

The Quality Plan shall include a system to ensure that the documentation necessary to attest the completion of fabrication, erection, and installation, use of correct material; completion of required inspections and tests and acceptability of results are generated, reviewed, maintained and turned over to the Consultant at the required time.

The system shall ensure that such documentation is reviewed by the Contractor for legibility, completeness, validity of data, traceability of document to activity or equipment and acceptability of results.

Documentation to be generated and maintained during manufacturing and site works period as applicable, shall include at least:

- Raw material test report (mechanical, chemical, radioscopic, etc.) as per Standards. In the case of materials for which such practice is usual, the Consultant may accept the Contractor's certified mill and laboratory certificate.
- Weld and weld repair procedure
- Inspection and test procedures
- Inspection and test reports

If a demonstrable satisfactory service record is available for a material, the Consultant may waive certain specified tests.

In the case of Standard labelled stock products which have a record of satisfactory performance in similar works over a period of not less than 2 years, the Consultant may accept a statement from the Contractor attested by a certified laboratory certifying that the product conforms to the applicable specifications.

- Vendor surveillance reports

- Heat treatment records
- Final inspection reports
- Packing and shipping procedure
- Certificates of compliance

14.10 Submittal of Contractor's Documents

The Contractor shall submit to the Consultant the following documents:

- The Contractor's Quality Plan
- The Contractor's Inspection and Test Plan

This Plan, which will be the basis for the selection of shop witness or observation points, shall sequentially list all major material and component processing or assembly operations, and all routine and special inspection and tests. Tests and inspection listed in the Plan shall include reference to the applicable inspection, test or special process. To allow possible inspection of materials and equipment during, or on completion of the preparation or manufacture or assembling or testing, the Contractor shall give the Consultant written notice:

- of the workshops and places where the materials and equipment are manufactured, stored, or tested and advise him of the state of general progress of the works of the program with the dates of the test types I and S
- During any inspection of materials or equipment, the Contractor shall place all quality control documentation, including the previous test reports concerning these materials and equipment, at the Consultant's disposal. The Consultant may also require that this documentation be sent prior to the inspection.
- Drawings, calculation notes and other design documentation as required.
- Test and inspection program and procedures

For each major test, the relevant detailed test program and procedures shall include descriptions of the test methods, applicable Standards, testing equipment and installations and test record sheets with theoretical data and tolerances.

- Tests documents

Within one week after completion of tests and inspection:

- Record Drawings (as manufactured)
- Contractor's Data Report
- Certificate of Compliance
- Certified Material Test Reports
- Heat Treatment Charts
- Non-Destructive-Tests Examination Reports
- Non-conformance Reports
- Performance Test Reports
- Routine and Special Tests
- Final Inspection Report

The "Permission to Deliver" of any item of the Substation shall be issued by the Consultant after the receipt of the test reports and other certificates as detailed above, showing that these items comply with the Contract; then the Contractor will be authorized to proceed with the packaging and shipping.

- Shipping documents

The Contractor shall supply shipping documents (copy of packing lists, bill of lading, and insurance certificate) for each dispatch. Packing lists shall include details of the content of each crate or package dispatched together with the identification numbers of each package, the dimensions net and gross weights and where necessary, any special indications regarding storage and the type of packaging.

- Erection manuals

The Contractor shall supply erection manuals which include appropriate procedures for the installation of the main items of the Substation. These documents shall include all information and sketches necessary for proper erection and disassembly, in particular:

- the use of erection platforms with overall dimensions sketch,
- lifting and handling equipment required,
- detailed operation sequences,
- erection drawings,
- erection clearances and tolerances

14.11 Method Statements

Prior to commencing work, the Contractor shall submit method statements setting out full details of his methods of working. This is a hold point.

15. Design and Standardization

The design shall be according to International Standards, ISO, IEC, EN, BS or equivalent while local material shall conform to KEBS¹, EA, other locally accepted standards. Corresponding parts of all material shall be made to gauge and shall be interchangeable. When required by the Project Manager the Contractor shall demonstrate this quality by actually interchanging parts. As far as possible all insulators, fittings and conductor joints and clamps should be interchangeable with the equivalent items of the existing transmission system, details of which are obtainable from the Project Manager.

The Works shall be designed to facilitate maintenance and simplicity of operation, inspection, cleaning and repairs, and for operation where continuity of supply is the first consideration. All apparatus shall also be designed to ensure satisfactory operation under the atmospheric conditions prevailing at the Site, and under such sudden variations of load and voltage as may be met with under working conditions on the system, including those due to faulty synchronising and short circuit.

The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the Works and of associated works supplied under other contracts.

16. Quality of Design, Materials and Manufacture

All material used under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

¹ Kenya Bureau of Standards

No repair of defective parts including welding, filling and plugging will be permitted without the sanction in writing of the Project Manager.

All items of the Plant shall be designed and manufactured in the soundest manner, using materials most suited to the service and giving due consideration to the most recent technical advances. All materials and components shall be new and unused. The design and materials shall be such as to enhance service life, operational reliability, freedom from wear and tear and ease of maintenance, inspection, and adjustment. Back-up facilities shall be provided to ensure reliable and safe operation in the event of faults.

17. Language, Weights and Measures

The English language shall be used in all written communications between KETRACO, the Project Manager and the Contractor with respect to the services to be rendered and with respect to all documents and drawings procured or prepared by the Contractor pertaining to the work.

Whenever anything is required under the terms of the Contract to be marked, printed or engraved, the English language shall be used except where otherwise provided in the Specification.

The design features of all equipment, all quantities and values which are required to be stated in the Schedules of Technical Information and all dimensions on drawings whether prepared by the Contractor or not shall be stated in the International System of Units (SI).

18. Testing and Inspection

All materials used in the Contract Works shall be made available for inspection and test by the Project Manager during manufacture and it is the Contractor's responsibility to advise KETRACO when equipment and materials are available for inspection.

The Contractor shall carry out the tests stated in the Technical Specifications in accordance with the conditions thereof and the latest applicable Standards or Recommendations and such additional tests as in the opinion of the Project Manager are necessary to determine that the Works comply with the conditions of this Specification either under test conditions (in the Manufacturer's Works, on the Site, or elsewhere), or in ordinary working. Type tests may be omitted at the discretion of the Project Manager if satisfactory evidence is given of such tests already made on identical equipment.

All materials used shall also be subjected to and shall withstand satisfactorily such routine tests as are customary in the manufacture of the types of plant or material included in the Works.

All tests shall be carried out to the satisfaction of the Project Manager and in his presence, at such reasonable times as he may require, unless agreed otherwise.

Not less than 4 weeks' notice of all tests shall be given to the Project Manager in order that he may be represented if he so desires. As many tests as in the opinion of the Project Manager are possible shall be arranged together.

The original and copies of test records whether or not they have been witnessed by the Project Manager shall be supplied to the Project Manager.

Measuring apparatus shall be approved by the Project Manager and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

The Contractor shall be responsible for the proper testing of work completed or plant or materials supplied by a sub-Contractor to the same extent as if the work, plant or materials were completed or supplied by the Contractor himself.

The Contractor shall supply suitable test pieces of all materials as required by the Project Manager. If required by the Project Manager test specimens shall be prepared for check testing and forwarded at the expense of the Contractor to an independent testing authority selected by the Project Manager.

No inspection or passing by the Project Manager of work, plant or materials whether carried out by the Contractor or sub-Contractor, shall relieve the Contractor from his liability to complete the Contract works in accordance with the Contract or exonerate him from any of his guarantees.

18.1 Factory Acceptance Tests

The equipment listed below, shall require factory acceptance tests to be witnessed by two representatives from the Client and one representative from the Consultant as a minimum:

- Main (Auto-)Transformers
- (Earthing and) Auxiliary Transformers
- Instrument Transformers
- Circuit Breakers
- Disconnectors & Earth Switches
- Surge Arrestors
- Protection, Control & Metering Panels
- Substation Automation and Control System
- Telecommunication Equipment
- 110VDC Battery Chargers and UPS
- Gentries, Steel Structures and Accessories
- Post and String Insulators
- Standby Diesel Generators

The costs associated to carrying out the above FATs shall be borne by the Contractor. This shall include but not limited to

- i. Return flight ticket on economy class for employer and consultant.
- ii. Visa application and processing fee and Local transport expense at the manufacture's country.
- iii. Full board accommodation in a minimum 4-star hotel including laundry services, International calls expenses, FAT documentation and daily incidental for each of the Employer's Representatives for the total duration of FAT USD 200 per KETRACO Engineer per day.

The contractor shall issue a 45-day notification prior to commencement of the FAT. All FAT related documentation including Quality control documents, design documents, test record sheets, test procedures shall

be approved before offering equipment for FAT. The duration of each FAT shall be discussed and agreed by KETRACO and the Project Manager. This shall be reasonable enough to allow for conclusive testing of the equipment.

19. Erection, Supervision and Checking of Work on Site

General

The carrying out of all work on the Site included in this Contract shall be supervised throughout by a sufficient number of qualified representatives of the Contractor who have had thorough experience of the erection and commissioning of similar Works.

The Contractor shall ascertain from time to time what portions of the work on the Site the Project Manager desires to check, but such checking shall not relieve the Contractor from the liability to complete the Works in accordance with the Contract or exonerate him from any of his guarantees.

If at any time it appears to the Project Manager that the Contractor will be unable to complete any Section of the Works in the time stipulated, then the Contractor shall, if required by the Project Manager, carry on such work outside normal working hours and shall not make any claims for any extra expense thereby incurred unless, in the opinion of the Project Manager, the delay is due to causes for which the Contractor would be entitled to an extension of time under the Conditions of Contract.

The Contractor shall satisfy himself as to the correctness of all connections made between the apparatus supplied under the Works and apparatus supplied under any other contract before any of the former is put into operation.

If the Project Manager shall certify that defects have shown themselves in the Works, the Contractor shall, for the purpose of the maintenance after the completion of the Works provided for by the Conditions of Contract, keep on Site supervisory staff of such numbers and for such periods as the Project Manager may require.

The Contractor is to keep the site, on which he erects or stores plant, reasonably clean removing all waste material resulting from the Works as it accumulates and as reasonably directed. On completion of the Works the Site is to be left clean and tidy to the satisfaction of the Project Manager. Any damage done to buildings, structures and plant or property belonging to KETRACO is to be made good at the Contractor's expense.

The Contractor's scope of delivery includes all site test and inspection expenses, e.g., all labour, materials, water, electricity, consumables, chemicals, and stores as well as the instruments and apparatus as may be required to perform such tests efficiently. The Contractor is responsible for and shall include in his delivery all safety measures such as barriers, warning signs etc. required for inspection and testing while erection is in progress and all interruption of work in this connection will be at his expense.

All instruments and apparatus used for site inspection and testing shall be calibrated to an agreed standard at a laboratory of international standing to be nominated by the Contractor. The cost of making such calibrations shall be borne by the Contractor in all cases.

During the erection of all mechanical, electrical, control, monitoring and telecommunication equipment the Contractor shall make the plant item available at any reasonable time for inspection by the Employer's Representative and/or by the Employer, should so require.

To assist the Employer and his Representatives in their review of the quality of the work being performed, the Contractor's senior field representative shall provide the Employer's Representative with a schedule of the specific areas and items of work that will be performed during each work week. The list shall be presented to the Employer's Representative prior to the start of work on a day agreed by the Employer's Representative.

All work that is executed prior to such notification shall be done at the Contractor's own risk and may, at the Employer's Representative's request, be subject to removal and replacement by the Contractor at his expense.

In particular, the Contractor has to mark in his implementation schedule all stages of erection or commissioning which are subject to the Employer's Representative's acceptance and has to notify him one week in advance when such acceptance becomes due. The stages subject to acceptance shall include but not be limited to the items indicated in the specification.

Before energizing certain checks need to be carried out. For start-up the Contractor will propose a program to be approved by the Employer's Representative. The program should give a step-by-step guide for the start-up considering, but not limited to, the checking of each disconnect, circuit breaker, circuit identification, current, voltage and power indication, phase rotation and correct phasing (this start-up shall also include all the substation auxiliary supplies and air ventilation).

Prior to placing each unit into commercial operation, commissioning tests shall be performed on the plant. These tests will be coordinated by the Employer, but the Contractor shall assume full responsibility for the testing operation and safety of the plant within his scope of work.

The Contractor shall cooperate with the Employer and with the other Contractors to permit all necessary tests to be performed.

The Contractor shall provide all necessary instruments to perform the tests on the plant within his scope of work. The test instruments shall be new, of a current model and type, and with the precision required to conduct the specified tests. The Contractor shall follow operating procedures agreed by the Employer.

Copies of all log sheets and test readings shall be given to the Employer as the tests proceed.

After the conclusion of the tests, the Contractor shall compile a comprehensive test report to the approval of the Employer. This report shall include copies of all log and calculation sheets and all necessary tables and curves to record the results of the tests.

Substation Material

The Employer's Representatives' written approval of completed work stages shall be obtained before continuing with erection. If it should be necessary to dismantle subsequently erected parts to gain access for inspection on rectification this shall be at the Contractor's expense and no claim by the Contractor for delay shall be considered. A completed and countersigned 'erection check list' is a prerequisite for approval to commence commissioning of an operation assembly.

The following checks and test measurements shall be made during erection unless otherwise specified in the Particular Technical Requirements of this Specification (as appropriate) in accordance with agreed standards:

- checking for complete delivery
- cable route and laying depth inspection.

- special filling resistance tests
- screwed connections for correct assembly.
- terminals and terminal connections for correct assembly
- checking of earthing connections and testing of earthing resistances
- measurement of insulation values
- fire-proof partitioning
- marking, inscription, provision of designation plates
- safety signs and warning signs
- setting indicators
- checks on wiring and cabling for conformity with the constructional circuit-drawings and plans.
- measurement of the resistance of main circuit
- power frequency voltage withstands test.
- All routine tests for the standby Diesel Generator set system including control panel and automatic fuel pumping system.
- All routine tests for the installed 415V AC, 110V DC and 48V DC panel systems.
- All routine and measurement tests for the normal and emergency Lighting systems in Substation buildings and switchyard as per the approved designs.
- All routine tests for the water supply systems including automatic water pump systems as per the approved designs.

The Employer's Representatives written approval of the erection works for an operation assembly with the signature of the certificate of erection works complete, will allow the start of commissioning tests.

Electrical Equipment

The following checks and test measurements shall be made during commissioning unless otherwise specified in this specification (as appropriate) in accordance with agreed standards:

- All routine tests for 220kV, 132kV, 33kV and 415V switchgear and surge arresters
- All routine tests for, 132/33kV power transformers, 33/0.415kV station transformers, 220kV line and bus reactors, neutral earthing/grounding reactors.
- All routine tests for 220kV line traps.
- All routine tests for 220kV, 132kV, 33kV and 415V instrument transformer (CT and CVT) tests
- verification of substation earthing grid resistance, integrity and neutralization conditions (e.g. step or touch voltage) in accordance with VDE 101 / IEEE80
- verification of lightning protection system
- All relevant Protection circuit tests which will be, but not limited to:
 - CT polarity and magnetization curves
 - Insulation resistance tests of relays, wiring and CTs
 - Primary injection tests of all CTs
 - Secondary injection tests.
 - Stability tests and in-zone fault test for differential protection schemes
 - Operation of tripping and control elements at reduced DC voltage (80% of the rated DC voltage)
 - Measurement of the end-to-end tele-protection channel transmission times
 - Combined logic tests of signalling / protection / auto reclosing / schemes under various simulated fault and operating conditions.
 - All relay operations must show the correct operation of the respective circuit breaker.

- Point-to-point verification of control wiring terminations between the terminations in the switchyard and the bay control units.
- fuses, overcurrent trips, short-circuit trips, time settings, relay settings.
- safety signs and warning signs
- setting indicators
- checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- high voltage test on cables and switchgear
- functional test on each equipment

Local and remote-control tests using bay control units and control panel mimic diagram with control selector switches for all switchgear bays. Local and remote control tests using automatic voltage regulation relays and control selector switches for autotransformers, power transformers and shunt reactors. Verification of configuration and integration of alarm and switchgear status indication signalling in the substation control system and SCADA

During the erection period and before the associated plant item is put into operation all local and remote control and monitoring and switchgear interlocking functionality of 400kV, 132kV, 33kV and 415V AC installations using SCADA and the HMI of the substation control system shall be tested.

calibration tests of all analogue measuring loops including all remote indications and recorders and the input signals used for closed loop control.

- wiring test of all control cabling in the switchyard, relay room, control rooms, LVAC power distribution room, DC chargers and power distribution room, diesel generator room and all other rooms with control cables combined with the function tests.
- testing of all control modules in the control room
- functional testing of remote control of drives, circuit breakers, solenoid valves, actuators etc.
- testing of remote and logic control devices especially all sequence logic equipment using simulated inputs
- testing of all interlocks to ensure safe operation.
- testing of the alarm annunciation and event recorder system in connection with all field and control room devices using simulated inputs
- testing of all closed loop controls

The Contractor shall on request submit a comprehensive description of each test. This shall include the type and classification of all test equipment and shall be submitted at least two months before the proposed date on which each test is to be carried out unless otherwise specified.

Certificates shall be issued for each test made. Group certificates are acceptable for the tests of cabling and similar items.

Telecommunication Equipment

- General

Before field testing is started, the Contractor shall verify that all communications equipment has been updated with the latest engineering changes. If any updates have been omitted that are deemed necessary by the Employer's Representative, the Contractor shall immediately make the necessary modifications.

The field tests include fibre reel test, installation tests, communications tests, and integrated telecommunication system tests.

- Fiber-Optic Cable Field Acceptance Test

The Contractor shall perform field acceptance test and document the results of the installed optic fiber cable to verify the optic fibre cable's performance as required by this specification.

The Contractor shall notify the Employer and the Employer's Representative in advance so that the Employer and the Employer's Representative can witness these tests.

If the optic fibre cable from the substation control room building to the OPGW splice box at the gantry or the associated optic fibre splicing does not pass the field acceptance test, the Contractor shall replace the optic fibre cable and/or re-do the splicing at the Contractor's expense in order to meet these specifications. Attenuation per Distance / Uniformity

The Contractor shall measure the attenuation vs. distance and attenuation uniformity of the fibres while the cable is on the reel as well as of the installed cable using an Optical Time Domain Reflectometer (OTDR). Measurements will be made at 1310 nm and 1550 nm. The attenuation of the fibre optic cable shall not exceed the requirements in these specifications.

- **Attenuation with Bending**

The Contractor shall perform attenuation with bending tests using a 260 mm diameter mandrel on the cable and a 75 mm and 25 mm mandrel on selected individual fibres. The attenuation due to bending shall not exceed the requirements in these specifications.

- **Tensile Strength of Cable**

The Contractor shall extract a sample length of cable from each reel and subject it to a pulling tension of 550 kg force and inspect for cable damage due to stress. The Contractor shall measure before, during, and after the test pull. The attenuation increase due to tensile stress shall not exceed the requirements in these specifications.

- **Fiber-Optic Equipment Field Acceptance Test**

Operational tests shall be carried out to demonstrate correct system operation also in conjunction with other parts of the telecommunication system.

The Contractor shall be responsible for the correct test procedures and testing shall be done in the presence of the Employer's Representative. The tests shall include but not be limited to the following:

- check of optical continuity of the transmission path
- measurement of bit error rate
- measurement of jitter performance
- measurement of laser and receiver characteristics
- measurement of transmission times for protection and control signals
- individual checks of each transmitted signal
- check of safety measures (e.g., laser shutdown) and alarm systems
- measurements of optical parameters (attenuation, chromatic dispersion) shall be performed for each fibre on the completely installed sections of the transmission path

The results of these measurements shall be stored in a database for comparing them with subsequent check measurements.

If the result has not been met, the Contractor shall locate and correct all equipment faults, which have caused this shortfall in specified availability.

20. Maintenance

The Contractor shall guarantee the efficient and good working of the equipment supplied under the Contract for a period of 5 years from the date on which the Project Manager takes over the Plant in accordance with the General Conditions of Contract.

20.1 Tools and Appliances for Maintenance

The following tools and appliances shall be supplied under this Contract.

- a) One set of standard tools, spanners, etc., at each Site of appropriate size and type to fit each nut and bolt on the whole of the plant and equipment covered by the Contract at that Site.
- b) One set of any special tools or gauges, at each Site, required for the normal maintenance of the plant and equipment covered by the Contract at that Site.
- c) One set of any special lifting and handling appliances, at each Site required for the normal maintenance of the plant and equipment covered by the Contract at that Site.
- d) One set of any special tools, gauges or other test equipment required for the dismantling, re-assembly, checking or adjustment (but not normal maintenance) of the whole of the plant and equipment covered by the Contract.
- e) One toolbox to include electrical appliances for example multi-meter, electrically insulated star and flat screwdrivers, set of spanners, testing leads, different sizes and types of lugs, crimping tools, wire strippers, pliers, insulating tape.

Each tool or appliance is to be clearly marked with its size and/or purpose and is not to be used for erection purposes.

Each set of tools and appliances under categories (A) and (B) above together with the smaller items under (C) and (D) above are to be suitably arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the layout of the plant and equipment in question. If the weight of any box and its contents is such that it cannot conveniently be carried it is to be supported on steerable rubber wheels.

Each box is to be fitted with a lock and is to be painted black and clearly marked in white letters with the name of the plant or equipment for which the tools and appliances therein are intended.

The tools and appliances with the appropriate boxes are to be handed over to the Employer at Completion of the Facilities.

21. Tools and Equipment for Erection, Installation, Commissioning and Operation

The Contractor shall supply special tools and equipment as recommended by the manufacturer for erection, installation and commissioning purposes as mentioned in the general technical specification (including the following items, but not limited to). Acceptance of any tool/equipment will not take place before the Contractor submit the complete final detailed list of all special tools and equipment.

The finalized special tools and appliances shall be supplied under this Contract for each substation of appropriate size and type. Each tool or appliance is to be clearly marked with its size and/or purpose.

Following special tools and equipment shall be supplied, but not limited to:

- a) Multi-ammeter (clamp type) for each substation
- b) Megger with 1/2/5/10 kV for each substation
- c) Digital ground resistance measuring test set
- d) Test set specially designed for timing of C.B. 's (operating sequence, duty cycle) operating, making, dead time (auto reclosing), reclosing and closing for each bidding package
- e) Test set specially designed for measuring of low resistance path portable type (specially for measuring of resistance between CB's an DS's contacts) for each bidding package
- f) Test plugs of protection system for each substation
- g) Thermometer, density meter, tools for battery filling and fuse puller for each substation
- h) Thermo-vision camera (1 for each substation)
- i) Digital camera (1 for each substation)
- j) Walkie-talkie (2 pairs for each substation)
- k) Gas handling trolley (complete set), 1 set for each substation
- l) Portable Earth Leads for each voltage level at each substation
- m) Forklift, 1 set for each storage warehouse (1no. for Rumuruti substation)
- n) Aluminium ladder, 1 set for each substation

o) Mobile Lifting Crane

It shall be in the scope of the contractor to supply a new crane for lifting substation equipment whose vendor and specifications shall be approved by the Employer/Project Manager.

All the necessary accessories for the proper functioning of the crane shall be under the scope of the contractor. This shall include but not limited to engine oil, diesel fuel (full tank), oil filters, chain slings, lifting slings, shackles, etc.

The Contractor shall also provide the following for use by the Employer's project implementation team and shall be as approved by the Project Manager. These shall remain the property of the Employer.

A. Project Laptops

Four (4) Project Laptops for each of the substations (Total = **8no.**) shall be provided by the Contractor for use by the Employer project implementation team members.

The laptops shall remain property of the employer upon completion of the project. The laptops shall meet the following minimum specifications:

- Windows 11 Pro for Workstations
- Intel Core i7-620 @ 2.67GHz, 1066MHz FSB; 3MB L3 Cache
- 16 GB (2x8 GB) DDR4 3200 SODIMM ECC
- 1 TB PCIe-3x4 2280 NVME Self Encrypted (SED) OPAL2 TLC SSD
- 15.6" diagonal, FHD (1920 x 1080), UWVA IPS, anti-glare, 250 nits, 45% NTSC, for HD Webcam

- NVIDIA® T1200 Graphics (4 GB GDDR6)
- 1TB (7200RPM) Seagate Momentus 7200.4 ST9320423AS
- Intel® AX201 Wi-Fi 6 (2x2) and Bluetooth® 5 Combo, vPro
- DVD R/W dual-layer LightScribe Optical Drive
- 2.0-megapixel webcam
- VGA and Display Port outputs
- USB 3.0 x 4; eSATA x 1
- RJ-45 (Ethernet 10/100/1000)
- SD / MMC / SDHC Multimedia Card Reader
- Removable 55WHr 6-Cell or 9-cell 100WHr Li-ion Battery
- 13.21" x 9.30" x 1.23" (Dimensions)
- Genuine leather Laptop carry bag.
- Key Board-Full size, Dual Point Backlit spill-resistant keyboard with drains
- Audio by Bang & Olufsen, dual stereo speakers, dual array digital microphones, functions keys for volume up and down, combo microphone/headphone jack, HD audio
- 150 Watt Smart PFC Slim AC Adapter
- C13 1.0m Premium Power Cord
- 8 Cell 94 WHr Long Life Battery
- Three-year warranty
- External I/O Ports:
Left side:1 RJ-45; 1 headphone/microphone combo; 1 SuperSpeed USB Type-A 5Gbps signaling rate (charging); 1 SuperSpeed USB Type-A 5Gbps signaling rate; 1 nano security lock slot
Right side:1 power connector; 1 Mini DisplayPort™ 1.4; 1 HDMI 2.0b; 2 Thunderbolt™ 4 with USB4™ Type-C® 40Gbps signaling rate (USB Power Delivery, DisplayPort™ 1.4, Sleep and Charge)
- Expansion slots 1 smart card reader; 1 SD 7.0 media card reader
- Security management
Absolute persistence module; Device Access Manager; Power On Authentication; Integrated smart card reader; Master Boot Record security; Pre-boot authentication; Windows Defender; Secure Erase; Manageability Integration Kit; Sure Sense & Click; Secure Platform; Sure Recover; BIOSphere; Sure Start; Sure Run; Tamper Lock; Nano Security Lock Slot; Client Security Suite; Trusted Platform Module TPM 2.0; Windows Secured Core
- Integrated Security- Security Lock Slot plus steel cable (5.5mm thick) with a combination lock
- Applicable software (MS Office, PDF, AutoCAD, Relays software)

Four (4) laptop tablets to be provided by the Contractor for use by the project management team. The devices shall meet the following minimum requirements:

- Chip: Apple M2 chip, 8-core CPU with 4 performance cores and 4 efficiency cores, 10-core GPU, 16-core Neural Engine, 100GB/s memory bandwidth, 16GB RAM with 2TB storage;
- Model: iPad Pro
- Display: Liquid Retina display, 11-inch (diagonal) LED backlit Multi-Touch display with IPS technology, 2388-by-1668-pixel resolution at 264 pixels per inch (ppi), ProMotion technology, Wide color display (P3), True Tone display, Fingerprint-resistant oleophobic coating, Fully laminated display, Antireflective coating, 1.8% reflectivity, SDR brightness: 600 nits max, Supports Apple Pencil (2nd generation), Supports Apple Pencil (USB-C), Apple Pencil hover
- Media engine: Hardware-accelerated H.264, HEVC, ProRes, and ProRes RAW, Video decode engine, Video encode engine, ProRes encode and decode engine
- Video Recording: 4K video recording at 24 fps, 25 fps, 30 fps, or 60 fps (Wide), 1080p HD video recording at 25 fps, 30 fps, or 60 fps, 720p HD video recording at 30 fps, ProRes video recording up to 4K at 30 fps (1080p at 30 fps for 128GB storage), 2x optical zoom out, Audio zoom, Brighter True Tone

- flash, Slo-mo video support for 1080p at 120 fps or 240 fps, Time-lapse video with stabilization, Extended dynamic range for video up to 30 fps, Cinematic video stabilization (4K, 1080p, and 720p), Continuous autofocus video, Playback zoom, Video formats recorded: HEVC and H.264, Stereo recording
- Cellular and wireless: Wi-Fi 6E (802.11ax) with 2x2 MIMO; speeds up to 2.4 Gbps⁴, Simultaneous dual band, Bluetooth 5.3
- Wi-Fi + Cellular model: 5G (sub-6 GHz and mmWave) with 4x4 MIMO, Gigabit LTE with 4x4 MIMO and LAA
- SIM Card: Nano-SIM, eSIM
- Power and Battery: Built-in 28.65-watt-hour rechargeable lithium-polymer battery
- Size and weight: 1.04 pounds (470 grams)

One (1) Rugged Laptop per substation (Total = 2) to be provided by the Contractor used for the substation control and protection systems (CRP/SAS) configuration and setting which shall have the appropriate software and licenses installed to facilitate the communication and interfacing with the IEDs, Ethernet switches as well as relevant substation automation systems equipment. The Contractor shall provide communication/interface cable for all types of relays/IEDs installed in the substation.

The Rugged Laptop specifications:

- Display 14.0" FHD (1920 x 1080), 1000 nits DynaVue® sunlight readable display with capacitive multi-touch screen, User selectable touch mode for Finger/Water, Glove, or Stylus programmable function
- Operating System Windows® 10 Pro 64-bit
- Processors Intel® Core™ i7-1185G7 vPro™ (11th Gen) 3.0GHz processor with Turbo Boost Technology up to 4.8GHz, 12MB cache
- Memory 2 slots 8GB up to 64GB (3200MHz DDR4)
- Storage Main: 256GB/512GB/1TB NVME PCIE SSD, Optional 256GB/512GB/1TB SATA SSD
- Graphics Intel® Iris® Xe Graphics, Optional NVIDIA® GEFORCE GTX 10501
- Camera Integrated 2.0 MP web-cam with shutter design, Optional IR camera for Windows Hello1
- Audio Integrated microphone, Intel® High Definition Audio Compliant, Integrated speaker x 2, Keyboard volume and mute controls
- Media Bay (One Option Only) Optional DVD super Multi, Optional 2nd battery, Optional SATA SSD
- Expansion Box Optional PCI-Express 3.0 (2 slots)1,6, Optional discrete VGA1,6, Optional storage extension with RAID 0/1/5/101,6, Optional military-grade connectors1
- I/O Ports: Thunderbolt 4 (type C) x 1; USB 3.2 Gen2 (type C) x 1 (support DP)
- USB 3.2 Gen2 (type A) x 1
- USB 3.2 Gen1 (type A) x 1
- USB 2.0 (type A) x 1
- Audio in/out (combo jack) x 1
- microSD card (microSDXC) x 1
- 10/100/1000 Ethernet (RJ45) x 2
- VGA port (D-sub,15-pin) x 1
- HDMI port (type A) x 1
- Serial port (RS232 : D-sub,9-pin) x 25
- Docking connector (41-pin Pogo) x 1
- SIM card x 1
- Smart card reader x 1
- DC-In jack x 1
- ExpressCard 54 x 1 (default) or PCMCIA Type II x 1
- Optional RF antenna pass-through for GPS, WWAN, and WLAN

- Keyboard & Pointing Device, 2 user-definable keys (P1/P2), RF signal slide-switch, Standard membrane keyboard with LED backlight
- Communications Integrated 10/100/1000 Ethernet, Intel® Wi-Fi 6 AX201 (802.11 ax), Bluetooth® V5.2 ,Optional dedicated GPS module (UBLOX-NEO-M8N), Optional 4G LTE multi-carrier mobile broadband, Optional RF antenna pass-through for GPS, WWAN, and WLAN
- Security
 - Intel® vPro™ Technology (per CPU options), TPM 2.0
 - NIST BIOS compliant
 - Easy removable SSD
 - Smart card reader
 - Stealth mode
 - Night vision mode
 - Kensington lock
 - Optional Windows Hello1
 - Optional fingerprint scanner
 - Optional HF/LF RFID reader1
- Power
 - AC adapter : 100-240V, 50Hz-60Hz, 90W
 - Optional AC adapter (100-240V, 50Hz-60Hz, 120W), with NVIDIA® VGA
 - Main battery Li-Ion, 10.8V, 7800mAh, 16 hours2
 - Optional 2nd battery Li-Ion 10.8V, 4700mAh, 9 hours2
 - Optional bridge battery : 5 minutes swap time3
- Warranty
 - 3-year warranty standard

B. Control System Printers

One (1) SOE Printer, One (1) Station Log Printer and One (1) General Purpose Printer for each substation shall be provided by the Contractor for use by the Employer.

C. Software

The contractor shall provide software, server based licenses (where applicable) and subscriptions for the Client. The contractor shall provide six user licenses for a period of six years. This software shall be as indicated in the Scope of supply document. The following, in addition to other software used by the contractor in the project design, shall be provided in the latest version:

- Anti-Virus Software
- Microsoft Office Latest
- BCU Interface and Configuration Software
- HMI Server/Client and Configuration Software License

22. Drawings, Models and Samples

A list of the drawings attached to bid documents is given in the Part 2-D.

A list of the drawings that are to be submitted by the contractor with his Bid and a list of drawings to be submitted after the Effective Date are given in the relevant Technical Specification. The Contractor shall provide free of charge any additional drawings and/or copies of any reviewed drawings required by the Project Manager.

The Contractor shall submit samples of materials as required from time to time by the Project Manager or Project Engineer.

The Contractor shall submit all drawings or samples of materials for review in sufficient time to permit modifications to be made and the drawings or samples resubmitted without delaying the initial deliveries or the completion of the Contract Works.

If the Contractor shall require review of any drawing within 4 weeks of its submission in order to avoid delay in the completion of the Contract Works, he shall advise the Project Manager to such effect when submitting the drawing.

The number of copies of each drawing or of any subsequent revision to be submitted to the Project Manager is given elsewhere in the Tender Documents. Following review, further copies of the reviewed drawing shall be supplied to the Project Manager for distribution to KETRACO and to Site.

Drawings for review shall be submitted electronically in a commonly used format and as paper prints and shall bear the authorised Contract reference.

All drawings shall be drawn to one of the preferred scales quoted in Section 7 of BS Publication PD6031 or available on a standard ruler and on paper of the appropriate size from the International Series of A sizes.

All detail drawings submitted for review shall be to scale and of a size not less than 1/25 full size. All-important dimensions shall be given and the material of which each part is to be constructed shall be indicated.

Except as otherwise specifically approved, all drawings shall be of size not be greater than A0 (normally 841 mm x 1189 mm) or smaller than A4 (normally 210 mm x 297 mm).

All dimensions marked on the drawings shall be considered correct although measurement by scale may differ there from. Detailed drawings shall be acted on where they differ from general arrangement drawings.

The Project Manager reserves the right to request any further additional information that may be considered necessary in order fully to review the Contractor's drawings.

Any drawing modified from a previously submitted drawing shall bear a new version number. Revised drawings reissued for review shall have at least one copy clearly marked indicating the amendments to the drawing. Revision boxes must be provided giving the date, revision letter and brief description of each drawing.

Any drawing or document submitted for information only shall be indicated as such by the Contractor. Drawings submitted for information only will not be returned to the Contractor unless the Project Manager considers that such drawings do need to be reviewed, in which case they will be returned suitably stamped with comments.

All drawings submitted by the Contractor shall include the following particulars in the lower right hand corner: Contractor's name, date, scale, number and title of the drawing, contract number, substation title and equipment description.

The Contractor when submitting drawings, shall provide an indexing system for all the drawings categorized for each type of equipment.

The drawing format and the indexing system will be agreed at the first Contract meeting between the Contractor and the Project Manager.

All prints shall be folded to A4 size and the title, drawing number and revision suffix shall remain visible.

Drawings, samples and models already submitted by the Contractor and reviewed by the Project Manager (and such drawings, samples and models as shall be thereafter submitted by the Contractor and reviewed by the Project Manager) shall not be departed from without the instruction in writing of the Project Manager.

All drawings, samples and models shall be submitted in accordance with the provisions in the Schedules and shall become the property of KETRACO.

23. Labels and Colours for Equipment & Substation Building

Warning Notices

The Contractor shall provide sufficient warning notices and signs for the Works of a form and wording acceptable to the Employer.

Nameplates

Each major and auxiliary items of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and address of the Contractor, rating data, electrical and mechanical characteristics, and other significant information, as applicable. Nameplate of distributing agents only will not be acceptable.

Nameplates shall also be provided where required for panel-mounted devices. Dials, gauges, and nameplates shall be marked with the nomenclature and units of measure in the metric system, and a schedule of such makings shall be submitted for review and approval by the Consultant.

For equipment with nameplate not visible from ground level, a copy of the manufacturer's nameplate shall be fixed on the equipment support structure in location easily readable at ground level.

All nameplates shall be in the English language.

Colours

The colours proposed shall be submitted to the Consultant for approval.

For guidance purposes, the Contractor could make the choices indicated hereafter:

- Aluminium: for equipment exposed to sunlight, the thermal effects of which could be detrimental to protection performance.

- Equipment moving around the personnel's access areas shall comprise black stripes 6 cm wide and inclined at 30° to the vertical.

Identification of services: all pipes, ducts and other services shall be colour coded in accordance with BS 1710.

Other colours shall be to approval.

Switchgear and Panel labels

All switchgear operating mechanisms shall have permanent labels on the front door indicating the bay name, voltage, bay number, switchgear code and three-digit asset number unique throughout the substation.

All 132kV and 33kV gantry structures for incoming and outgoing transmission lines, distributions feeder, shunt reactors and primary and secondary sides of power transformers, autotransformers and station auxiliary transformers shall have permanent labels indicating the bay name, voltage, bay number and three-digit asset number unique throughout the substation. 33kV switchgear shall have permanent labels indicating the bay name, voltage, bay number, switchgear code and three-digit asset number unique throughout the substation.

All other indoor and outdoor panels, cabinets, switchboard, and kiosks shall have permanent panel labels on the front and back doors indicating the bay name, voltage, bay number, function of panel, three-digit asset number unique throughout the substation.

Coloured phase indicator labels

Permanent coloured phase indicator with text labels shall be provided on the steel support structure of the switchgear or surge arrestor connected to the busbar and horizontal beam of the gantry of the transmission line respectively of the same bay.

All 132kV and 33kV gantry structures for incoming and outgoing transmission lines, distributions feeder, shunt reactors and primary and secondary sides of power transformers, autotransformers and station auxiliary transformers shall have permanent colored phase indicator with text labels.

Also, permanent coloured phase indicator with text labels shall be provided on each pole switchgear and instrument transformers.

labelling of cables in panels

All control cables as well as LV DC and AC auxiliary supply cables in both indoor and outdoor panels, cabinets, switchboard, and kiosks shall have labels at each termination point. The entire length of each terminal block shall be shrouded by non-screw plastic cover to prevent accidental touch.,

Both sides of each terminal block in both indoor and outdoor panels, cabinets, switchboard, and kiosks shall have labels at each termination point.

The phase colour coordination of LVAC cables shall be red, yellow, blue for the phases, black for the Neutral and green with yellow strips for the earthing. All Protection devices and relays, control devices, MCBs, voltage supervision relays, contactors, control buttons and selector switches, heaters, panel lighting, sockets, etc. shall be labelled with permanent labels for easy troubleshooting.

The phase colour coordination of DC cables shall be white and brown for the positive and negative polarity respectively.

Labelling for substation building and gates

All substation buildings shall have permanent labels indicating the name of the building installed above or on each entrance/exit door. Each room in all substation buildings shall have permanent label indicating the name of the room installed above or on each of its entrance/exit door. Each main entrance gate and internal gate shall have adequate number of appropriate warning, safety and information signs and a permanent label indicating the name of the substation. Adequate number of indoor and outdoor warning, safety and information signs shall be installed in appropriate and clearly visible locations the substation buildings and switchyard.

24. Maintenance Equipment and Spare Parts

The Contractor shall provide maintenance equipment for the proper maintenance of all equipment in the substations. The maintenance equipment shall be sufficient to enable dismantling and reassembly, testing for wear or deterioration of all wearing parts, and replacement of all spare parts ordered.

The Contractor shall provide a complete and updated list of special tools and spare parts to be delivered to the Employer at the time of receipt.

The delivery to the Employer of the test equipment, special tools and spare parts in accordance with the list will be a condition of the issuance of the Certificate of Receipt, and the labelling and storage of these items on shelves and provide to be installed by the manufacturer.

The Contractor shall supply spare parts and consumable parts for the substations. Spare parts and consumable shall be provided sufficiently to enable routine maintenance and normal operation of the equipment for 5 years. The spare parts shall be provided as replacement parts for all equipment subject to normal wear and tear. The Contractor is expected to be able to provide major items of spares when contacted throughout the period of operation of up to a minimum of 15 years.

All test equipment, special tools, and spare parts either specified or recommended by the Contractor shall be clearly listed and priced independently in the Bid Offer. The Contractor shall supply the specified and recommended spare parts at the individual prices stated in the Schedule. The Employer shall reserve the right to order all or any of the spare parts at their discretion.

All spare parts ordered shall be interchangeable and suitable for use in place of corresponding parts supplied with the plant. They shall comply with the Contract and shall be suitably marked and numbered for identification and prepared for permanent storage in a manner to prevent deterioration.

Refer Bill of Quantity for complete scope of Mandatory and Recommended spares.

The Contractor shall deliver installation and operation manuals for all spare parts delivered including Suppliers' contact information and part ordering details.

The Contractor shall not only depend on use of the spare parts ordered by the Employer under the Contract, for carrying out the Contractor's obligations. All spare parts accepted by the Employer in the Bid Price of the Best Evaluated Bidder shall be supplied by the Contractor.

25. Submittals during contract period

Program of submittals

The contractor will be required to submit and use the document management system that will be provided to them in order to manage all submissions for the project.

All submissions shall be provided in both un-editable and editable versions (e.g. pdf and Word, Autocad, Excel, etc.). Drawings provided for brownfield sites must also show the existing/old infrastructure in addition to the new.

The Contractor shall arrange his design and drawing programme so that the works can be properly co-ordinated by the Project Manager. He shall provide the documentation as specified below within 4 weeks of the award of Contract, together with any drawings and information considered necessary by the Contractor or Project Manager.

A detailed schedule of all plant to be supplied under the Contract. This schedule shall have space for the following information as a minimum requirement in respect of each item:

- a. Manufacturer
- b. Country of origin
- c. Planned CIP delivery date
- d. Planned date of arrival on site
- e. Sub-order number (as applicable)
- f. Allocated drawing numbers

A preliminary schedule of drawings to be submitted to the Engineer for approval in respect of all items of equipment to be supplied under the Contract. The schedule shall include a programme for submittal of all drawings required by the Specification. The schedule shall have space for at least the following information to be added at a later date:

- a. Drawing number
- b. Drawing title
- c. Proposed date of submission
- d. Actual date of submission
- e. Resubmissions
- f. Revision numbers

- g. Date of approval
- h. Release as a working drawing
- i. Date to site
- j. Date to Engineer
- k. Date of as-built drawing

Drawing numbers

The Contractor will apply drawing numbers to all drawings, including those from sub-contractors and those issued for information before they are submitted to the Project Manager. The Contractor's drawing office will be expected to issue the numbers in batches that will cover broad subject areas. The Contractor shall submit to the Project Manager for approval the subject areas he proposes to use prior to the issue of any drawing. The Contractor shall each month issue an up-to-date drawing list to the Project Manager.

25.1 Final Records

After completion of work on Site all Contract drawings shall be revised where necessary to show the equipment as installed and the number of copies of revised drawings as specified in Volume 2 shall be submitted for review. A complete set of reviewed records shall be provided comprising, one full size reproducible copy and one full size print. Record drawings shall be endorsed "As-Built" and shall be correctly titled and carry the Engineer's review number, Contractor's drawing number and where appropriate KETRACO's number allocated to the item. As-Built documents include approved documents of all equipment, material, design drawings, modification and calculations.

After final review of the "As-Built" record drawings, the Contractor shall submit complete sets of records on 3 hard copies, 3 soft copies on 3 discs and 3 flash drives, one of which is for KETRACO as detailed in Volume 2. Electronic copies of the drawings shall be in electronic format suitable for reproduction on paper using KETRACO's preferred software packages. Each disc shall provide a comprehensive drawing list containing the drawing number, sheet, revision and title of every drawing. The raw files for all drawings shall be provided. Each single file drawing record shall be self-supporting without referencing other files. Non-standard items such as fonts, line types, etc. should not be used. If compression techniques are applied to files then any software necessary to decompress the files shall be included on the discs. The Contractor shall ensure that all information contained on the discs has been checked for virus contamination. Each compact disc shall be supplied suitably encased and accompanied with printed documentation describing the contents of the compact discs, the formats and software used to compile the discs and the print hardware required to reproduce the record drawings.

Final record copies shall be handed over before the issue of the Operational Acceptance Certificate.

25.2 Installation and Maintenance Instructions

The Contract Price shall be deemed to include illustrated installation and maintenance instructions written in English. The Installation and Maintenance Instructions shall be sufficiently detailed to enable a skilled maintenance person to undertake the maintenance, fault finding, repair or replacement activities that may become necessary during the life of the equipment.

The instructions are to be as simple and clear as possible, fully illustrated with drawings and diagrams as necessary and detailed with part numbers for ordering of replacements.

As stated in Volume 2 further copies are to be reproduced as a book or books of approximately A4 size and bound into strong black durable imitation leather covers inscribed upon the front generally in the form of the title page to this document except that the references to Specification, Conditions of Contract, drawings, etc., will be replaced by "Installation and Maintenance Instructions".

The name of the main Contractor, but not that of any subcontractor, may also be inscribed upon the cover after the description of the plant. The name of KETRACO shall be inscribed upon the spine.

The finished books are to be handed to the KETRACO not later than 1 month before the Taking-Over Certificate is issued.

26. Responsibility of Contractor

Until each Section of the Works has been taken over or deemed to have been taken over under the Conditions of Contract, the Contractor shall be entirely responsible (save as is provided in the Conditions of Contract) for such section of the Works, whether under construction, during tests or in use for KETRACO's service.

During the period of maintenance, the Contractor shall make such arrangements as to ensure the attendance on the Site, within a reasonable time of his being called upon to do so, of a competent representative for the purpose of carrying out any work of maintenance for which the Contractor shall be liable and during such part or parts of the said period as the Project Manager shall deem it necessary, the said representative shall be continuously available on the Site.

Any work that may be necessary for the Contractor to carry out in pursuance of his obligations under the Conditions of Contract shall be carried out so as to interfere as little as practicable with the normal operation of the substations. Work on the Site shall be carried out at such time and during such hours as the Project Manager may require.

The Contract is to include the whole of the Works that are described in or implied in the Contract Document. All matters omitted from the Specification which may be inferred to be obviously necessary for the efficiency, stability and completion of the Works, shall be deemed to be included in the Contract Price.

Works shown upon the drawings, and not mentioned or described in the Technical Specification and Works described in the Technical Specification and not shown on the drawings will nevertheless be held to be included in the Contract and their execution is to be covered by Contract Price in the same manner as if they had been expressly shown upon the drawings or described in the Technical Specification.

26.1 Additional Services of Contractor's Staff

If the Project Manager shall so require, the Contractor shall provide the services of skilled workmen for the repair of any defect with the Works or for any adjustments necessary which may occur in the period between KETRACO commencing to use any Section of the Works (whether taken over or not) and the expiry of the period of maintenance.

26.2 Contractor's Employees

The Contractor shall fulfil all his obligations in respect of accommodation, feeding and medical facilities for all personnel in his employment, in accordance with the responsibilities imposed on him by the Specification or as necessary to ensure satisfactory execution of the Contract. He is also to comply with the requirements of all local Statutory Employment Regulations.

The Contractor shall be responsible for the behaviour on site of all personnel employed by him. Staff working under the contractor, or their subcontractor will need to submit a certificate of good conduct to their HR departments.

26.3 Alcoholic Liquor or Drugs

The Contractor shall not, otherwise than in accordance with the Laws of the Country, import, sell, give, barter or otherwise dispose of any alcoholic liquor or drugs, or permit or allow importation, sale, gift, barter or disposal by the Contractor's Personnel.

26.4 Packing and Shipment

All materials shall be carefully packed for transport by sea (with seaworthy packing), rail and road and in such a manner that the packing provides adequate protection against all climatic conditions experienced in transit and storage on site during the construction period.

The whole of the materials shall be packed where necessary in non-returnable cases or on non-returnable steel-framed structure (steel cable drums) drums or otherwise prepared for overseas shipment in a manner suitable to withstand rough handling without sustaining damage.

Bundles of steel angle sections shall be properly tied together by an approved method and care taken to ensure that they are robust and not of excessive length for handling during shipment.

The Contractor's attention is drawn to the provision of the Specification wherein the Contractor is required to suitably protect all steelwork before shipment to prevent damage to galvanized surfaces by white rust.

Bolts and nuts shall be crated for shipment.

Crating together of components of dissimilar metals is not acceptable.

Particular attention shall be given to strutting before packing cases are fastened down. Cases shall be upended after packing to prove that there is no movement of the contents.

Timber wedges or chocks shall be firmly fastened in place to prevent their displacement when the timber shrinks.

Where bolts are used, large washers shall be fitted under the head and nut to distribute the pressure and the timber shall be strengthened by means of a pad.

All stencil marks on the outside of the casings shall be either of a waterproof material or protected by shellac or varnish to prevent obliteration in transit.

Wood wool shall be avoided as far as possible.

Waterproof paper and felt linings are to overlap at seams by at least 12 mm and seams shall be secured together in an approved manner but the enclosure is to be provided with screened openings to provide ventilation.

Each crate or package shall contain a packing list in a waterproof envelope. All cases, packages, etc should be clearly marked on the outside to indicate the total weight, show where the weight is bearing, the correct position of the slings and to bear an identification mark relating to the appropriate shipping documents.

The Project Manager may require to inspect and review the packing before items are despatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not exonerate the Contractor from any loss or damage due to faulty packing.

Equipment shall be moved or handled in its crating or protective covering until it is ready for mounting in its permanent location. During unpacking and installation, unnecessary impact to the equipment shall be avoided.

27. Accommodation and Site Storage, Design Meeting, Students' Internship and Graduates' Employment (at each substation)

27.1 Site Office and Living Accommodation

Living accommodation: The Contractor shall make his own arrangements with regard to accommodation for his expatriate and locally recruited staff during the construction period. All dwellings and buildings existing or erected for the purpose by the Contractors shall comply with local regulations with regard to licensing/permits, construction, water supply, sanitation and other requirements. Temporary construction camps shall be provided with proper sanitation and other necessary facilities. All accommodation shall serve as permanent residences and form future communities, if such use can be foreseen or be removed by the Contractor when no longer required and before the granting of the final certificate. After the removal of accommodation, the ground shall be left in a clean and tidy condition.

Medical facilities: These will not be provided by KETRACO and the Contractor shall be required to make his own arrangements where these services may be required for his expatriate or locally engaged staff.

Staff transport: The Contractor shall provide, at his own expense all necessary transport for his own men and materials.

General: Without prejudice to the generality of the several clauses of the Contract and except for the facilities referred to in this Clause, particular attention is drawn to the obligation of the Contractor to make his own arrangements at his own expense for supply and furnishing of offices, workshops, stores and store compounds and the watching and guarding of such.

Office accommodation: The Contractor shall provide office accommodation which can be used by KETRACO during project construction phase.

The Contractor shall also provide at his own cost, two furnished rooms in his site offices to accommodate 8 representatives of the Engineer and KETRACO. The site office shall be kept clean and habitable at all times. The Contractor shall be responsible for timely payment of any monthly utility bills and expenditure for the site office that may occur for the entire project duration.

Each site office provided by the Contractor shall be fully furnished using a good standard of office furniture to be approved by the Employer/Engineer (Project Manager) and fully equipped with:

- Four desks and chairs
- Four filing cabinets
- Four desktop computers (equipped with latest microsoft office and antivirus and adobe reader)
- Two common photocopiers (A3 and A4, specifications as below table)
- Two common printer, scanner and fax machines (A3 and A4, specifications as below table)

The desktop computers shall meet the following minimum specifications:

- Intel Core i7-620 @ 2.67GHz, 1066MHz FSB; 3MB L3 Cache
- 8GB of DDR3 RAM (1333MHz; 2x4GB)
- 23" LED Monitor
- NVIDIA Quadro FX 380M (512MB) graphics
- 1TB (7200RPM) HDD
- 802.11a/b/g/n Wi-Fi
- DVD R/W dual-layer LightScribe Optical Drive
- VGA and Display Port outputs
- USB 3.0 x 4; eSATA x 1
- RJ-45 (Ethernet 10/100/1000)
- Windows 10 Professional (64-bit)
- Key Board-Full size
- Mouse
- Speaker
- Warranty-1year
- Applicable software (MS Office, PDF, AutoCAD, SCADA/DCS software)

Table: Printer, Scanner and Copier Minimum Specifications:

S no.	Parameter	Specifications
1.	General Type	Colour multifunctional for A3 and A4 format
2.	Technology	Laser Colour, HyPAS Solutions platform
3.	Engine speed	Up to 30/15 pages A4/A3 in colour and black/white.
4.	Resolution	600×600 dpi; Multi-bit technology for print quality of 9,600 dpi equivalent ×600dpi.
5.	Warm up time	Approximately 25sec or less.

6.	Time to first copy	Approx. 5.5 sec or less in black/white, approx. 7.3 sec or less in colour
7.	Power Supply	AC 220-240vac, 50Hz
8.	General Memory	3.5GB RAM +160GB HDD
9.	Duplex unit	Yes.
10.	Max output capacity	250 sheet face down, max output capacity 4.300 sheets.
11.	Processor	Dual core 800MHz
12.	Applicable OS	All current windows operating systems, Mac OS X version 10.4 or higher, UNIX, LINUS etc.
13.	Max original size for copy	A3
14.	Continuous copy	1-999
15.	Digital copy feature	Scan once copy many, electronic sort, 2in 1 and 4in 1 function, Image repeat copy, page numbering, cover mode, booklet copy, interrupt copy, form overlay, stamp function etc.
16.	SCAN file type	PDF (High Compressive, encrypted, PDF/A), JPEF, TIFF, XPS
17.	Max scan size	A3
18.	Scan functionalities	Scan to email, scan to FTP, Network-TWAIN, Scan to SMB, scan to Box, scan to USB host, WSD scan.
19.	Scan resolution,	600dpi, 400dpi, 300dpi, 200×100dpi, 200×400dpi (256 greyscales)
20.	Scan Speed	Colour:100 images/minute, black/white:100 images/minute (A4, 300dpi with DP772)
21.	Scanner Type	Flatbed/Sheetfed
22.	Zoom Range	25-400 %

- The printer, photocopier and scanner shall remain the property of KETRACO upon completion of the project.
- Shelving units
- Toilet and sanitary facilities
- Air conditioning
- Lighting
- Sufficient number of fire extinguishers of suitable size and type
- Clean and safe drinking water.
- High Speed Wi-Fi (Minimum 15mbps dedicated) for internet access.
- Tea/coffee/beverages and refreshments

The contractor shall maintain the printers/scanner/photocopier in good working condition including the supply of printer tonners, Cartridges and 10 cartons of A4 size printing papers as well as five (5) rims of A3 papers per month for entire project duration. The printing/photocopying papers shall be handed over to KETRACO project team on a monthly basis.

The desktop computers are to be provided with internet connection with service provided throughout the duration of the contract by a secure broadband internet service provider, for which the Contractor shall be responsible for

all associated charges and costs. An UPS system shall be provided to support the computer system for a minimum of 30 minutes in the event of a power failure. The computers and printer shall be networked on a LAN with facilities to access the Internet (broadband) on a continuous basis. The Contractor shall be responsible for all associated charges and costs.

The Desktop computer / Work station operating system shall be latest version of MS Windows. It should be suitable for continuous process application and should have been tested for the same. The hardware configuration should be of the latest available in the market, industrial type, and subject to approval of KETRACO. Monitoring and control system shall have an option for printing all trend plots, reports, displays etc. A color printer shall be provided in the substation. For storing historical database, sufficient storage facility shall be provided. The complete software package on CDs / DVDs shall be supplied as a backup. Windows operating system with licenses, Monitoring software, drivers for modems and printers and software for remote access shall be included. It should be possible to upgrade / update the system software throughout the lifetime of the system with ongoing development in the technology.

The Contractor shall provide safe bottled drinking water for the duration of the Contract.

Adjacent to the Engineer's offices, the Contractor shall supply graded parking areas including open sided sun shaded parking places adequate for ten (10) vehicles. Each parking bay shall be 3m x 6m and surfaced either by concrete or asphalt. Adequate lighting must also be provided in the parking bays.

The office accommodation is to be provided with an electricity supply, water supply and phone line. All phone rental and usage charges relevant to the transmission project shall be paid for by the Contractor.

Fully Furnished Kitchenettes: The Contractor shall provide a fully furnished Kitchenette with Electric cooker with three rings and oven, one two-burner LP gas cooker with cylinder and valves, deep freeze and refrigerator of minimum size 200 litres and 350 litres respectively, kitchen sink unit with storage work top units and water filter and an adequate number of kitchen utensils.

Storage facilities: The Contractor shall make his own arrangements for storage areas and campsites. The Contractor shall in all cases obtain the approval of the Project Manager for the places along the route of the lines where he intends to store materials. In no case will this be outside the authorised area unless special arrangements are made with the Clients of adjacent property, at the Contractor's own expense. The Contractor is to provide any necessary protection and watchmen to safeguard materials in the areas allocated to him. The handling and storage of any equipment at the site is to be at the risk of the Contractor and without responsibility to KETRACO. The Contractor is to arrange for the protection to the satisfaction of the Project Manager, of these materials against vermin attack, corrosion and mechanical damage during storage and erection at site.

The site storage areas shall be prepared with adequate hard-standing for the orderly storage of equipment, conductor/cable drums, steel, aluminium conductor, insulators, earthing and fittings so that the material will not be damaged by the effects of adverse weather during storage, appropriate housing to be foreseen. Items packed in flammable crates or drums shall be stored in such a manner as to limit the extent of any damage arising from fire.

Compressed air: The Contractor is to make his own arrangements for a supply of compressed air if required for the execution of the contract work.

Lifting facilities: The Contractor is to make his own arrangements with regard to lifting facilities required for transport or on site.

The land on which accommodation and office facilities are to be located shall be supplied/leased by the Contractor as part of the facilities.

Supply of Foodstuffs: The Contractor shall arrange for the provision of a sufficient supply of suitable food as may be stated in the Specification at reasonable prices for the KETRACO's Personnel for the purposes of or in connection with the Contract.

27.2 Living Accommodation for use by KETRACO during Operation at Rumuruti Substation

The Contractor shall provide and erect for KETRACO staff, permanent housings (required units mentioned in clause 1 of this document and as per bid drawings in Part 2-D) at Rumuruti Substation, inside the Substations' land, including roads, fencing, water supply system and sewage system, electrical services, lighting, HVAC, etc. The accommodation shall be available as soon as possible after putting the Substation into service.

The types of accommodation shall be as follows, but alternatives to similar specifications will be considered (subject to compliance with Kenya buildings Code and KEBS regulations and Client/Consultant's approval).

a) Technical Staff Housing

A semi-detached housing containing living room with a dining area, bedrooms, bathroom with shower and bath, toilet, kitchen, storage accommodation, veranda and car port as per bid drawing.

b) Security Staff Housing

A semi-detached housing containing living room with a dining area, three bedrooms, bathroom(s) with shower and bath, toilet, kitchen, storage accommodation, veranda and car port as per bid drawing. Also armory to store the gun to be provided.

The accommodation shall be designed so as to be easily transportable to facilitate early erection and the possibility of changing locations (at rates to be agreed), and designed for easy installation without any special equipment. The accommodation shall also be designed to conform to all relevant specifications, laws and regulations in force in at the time of construction.

The roof shall be designed to limit the effects of the sun including provision of generous eaves. All materials shall be of a good durable standard, and all wood shall be preserved by an approved method against fungal and termite attack. The accommodation shall be provided with all necessary plumbing and sewage disposal to approved standards. Reticulation to the elevated water tank to be carried out. The Staff Housing shall be provided with complete electrical services and if a mains supply is not available, the provision of a generator (and fuel for the duration of the Contract) suitable for the maximum installed electrical load of the premises. Where the electricity needs are dependent on a mains supply a standby generator is to be provided of capacity capable of operating a refrigerator, freezer, a fan and all lighting as provided in the Staff Housing. The standby generator shall be available for immediate connection at all times. Air conditioners shall be provided for each bedroom and living room. Ceiling fans or table fans shall be provided for the living rooms and kitchen. Security lights shall

be provided on each outer wall of the Staff Housing. All windows and outside doors shall be provided with mosquito screens and burglar bars shall be fitted to all windows. A suitable perimeter fence shall be provided.

Adjacent accommodation shall be provided for the use of a steward and family. This shall be of simple construction comprising two living rooms, kitchen and toilet/washroom.

The staff housing area shall be surrounded by a suitable fencing/boundary wall.

All rooms shall be decorated and equipped with hard and soft furnishings including the following minimum provisions.

- **Living/dining room**

Dining room with complete split unit, table and six chairs, sideboard with storage facilities, cutlery, china, book-case, coffee table, four side tables, four easy chairs, desk and general floor covering.

- **Bedrooms**

Two full size single beds with complete split unit, mattresses, pillows, dressing table, wardrobe, chest of drawers, bedside table, easy chair and stool.

- **Kitchen**

Electric cooker with three rings and oven, one two-burner LP gas cooker with cylinder and valves, deep freeze and refrigerator of minimum size 200 litres and 350 litres respectively, kitchen sink unit with storage work top units and water filter and an adequate number of kitchen utensils.

- **Bathroom**

Shower including hot and cold mixer unit, bath, toilet, hand basin and solar water heater with backup electric heating element (which could also supply the kitchen).

- **Intercom between Guard House and Individual Staff Housings**

A private EPABX system for communication between guard house to individual Staff Housings and amongst all Staff Housings shall be provided. The system shall be complete with necessary exchange, telephone equipment, junction boxes, cabling, power supply with battery back-up, etc. and its installation and commissioning. The exchange with power supply shall be installed in a safe and secure place and necessary cabling up to the individual consumer shall be done in a manner subject to approval of the Employer. The type of cables used shall be such that any faults/damages due to movement of vehicles, landscaping and its upkeep, etc. are avoided. Cable route markers to be installed. Manholes shall be provided at suitable locations in case cables are laid in conduits to facilitate cable pulling and maintenance. The make of the EPABX system shall be a reputed one with adequate installed base and is subject to approval by the Employer. In addition, an established aftersales service network is another main requirement. Any statutory approvals necessary for installation and operation of such a system shall be obtained by the contractor.

- **TV and Cable TV network**

Provision for supply and installation of a 42 inch full HD TV and Dish Antenna for TV shall be provided for each Technical Staff Housing. Necessary cabling inside the Staff Housing from the proposed location of Dish Antenna shall be done. The cable shall be suitable for TV signals and Data Network as well. Junction Boxes, Pull Boxes,

Splitter Boxes for TV and Data, TV Adopter, etc. shall be installed to make the network suitable for TV and Data connection. The network shall be available in living room, study room and bedrooms.

- High Speed Wi-Fi (Minimum 15mbps dedicated) for internet access in the Technical Staff housings.
- Sufficient number of fire extinguishers of suitable size and type

27.3 Design Review Meeting (for both substations)

The contractor shall arrange for a design review meeting at the contractor's home country's design office to be attended by a minimum of six (6) KETRACO design Engineers and two (2) Employer's representatives (at least 14 days).

The substation design review shall be done at an early stage of the project to facilitate the understanding and Employer's requirements of the substation designs before any designs are submitted by the contractor for approval.

The detailed agenda items for the design review meeting shall be discussed and finalized at Contract negotiation and kick off meeting.

The Contractor shall provide for each KETRACO staff the following:

- One economy class return air ticket
- Visa expenses, airport taxes and other incidental travel expenses as required.
- Full board 4-star hotel accommodation including laundry services and with international phone dial capability.
- Local transportation to the contractor's home office.
- Daily stipend allowance of US\$ 200 per day to cater for incidental expenses for the entire duration of the design review period.

The Contractor shall provide for each Employers representative staff the following:

- One economy class return air ticket
- Visa expenses, airport taxes and other incidental travel expenses as required.
- Full board 4-star hotel accommodation including laundry services and with international phone dial capability.
- Local transportation to the contractor's home office.

27.4 Internship and Graduates' Employment at each substation

The Contractor shall accommodate two (2) graduates on internship per substation (total=4) for the entire duration of the Contract. The internship shall be for degree level of education and shall cover students in the following disciplines.

- Electrical engineering
- Civil and Structural engineering
- Telecommunication engineering

A minimum monthly stipend allowance of Ksh 25,000 shall be provided to each intern. While undergoing internship, the contractor should ensure the interns obtain maximum practical training on the various fields within the scope of works.

The contractor shall also employ at least one graduate electrical and one graduate civil engineer per substation (Total = 4). The staff shall be maintained for the entire duration of the project. The graduate shall have had no more than 2 years' work experience. The minimum monthly remuneration for each graduate engineer shall be Kshs 100,000. The graduate engineer shall be supervised by a registered professional engineer. A training and experience report must be provided signed by the supervising engineer at the end of the project.

The details of the interns/graduates will be provided by KETRACO.

28. Employer's Representative's Transport and Communications Equipment

28.1 Transport

The Contractor shall provide transport services, for the use of the Employer and Employer's representative, on a 24-hour basis, as detailed further hereon. The number of vehicles to provide the transport services shall be as specified in the Price Schedules. For Type 1 Vehicles, the Contractor shall provide the services of one (1) driver mechanic per vehicle whose remuneration shall be not less than KES. 45,000.00 (net amount after statutory deductions) per month per driver for the entire Contract duration and not less than KES. 6,000.00 per night for travels outside Nairobi/permanent workstation as approved by Employer. The Contractor shall maintain each vehicle in efficient working condition, service it regularly as per the manufacturer's specification, repair, replace defective parts and tyres and provide fuel and oil and other consumables. The Contractor shall provide all documentation in accordance with Kenya Law, always including full comprehensive insurance cover for all vehicles and all drivers for unlimited Third-Party claims, at the rates stated in contract forms.

A fuel card from a reputable oil company shall be provided for each of Type 1 vehicles loaded with a minimum of KES. 100,000 .00 per month.

The vehicles Type 1 provided under the contract for use by the Employer/ Employer's representative are to be available for use by the Employer/ Employer's representative site supervisors (including reasonable personal use) within the general area of the entire project and Nairobi. The vehicles shall be available for their use 24 hours a day, seven days a week and shall be provided within two (2) months of Contract Effectiveness for both Type 1, 2 and 3. Although the maintenance, condition and roadworthiness of the vehicles are the responsibility of the Contractor, the movements of the vehicles shall be entirely under the control of the Employer/Employer's representative site supervisors.

Type 2 vehicles shall be handed over to KETRACO for Operations and Maintenance, while Type 3 will be handed over the KETRACO's Transmission System Planning Department.

The vehicles shall be new (commonly referred to as zero mileage – with less than 100 km reading on the odometer), purchased locally (with a further requirement that pickup vehicles be a model assembled in Kenya commonly referred to as local assembly) and shall be approved by the Employer and Employer's representative before purchase. Each vehicle shall comply with all relevant road traffic laws and be right hand drive. The Contractor shall be required to always make the vehicles available during the Contract Period and until completion of the specified maintenance period and to provide replacement vehicles when the servicing or repair time (including accidents) exceeds a period of 24 hours. The provision of such replacement vehicles shall not be

subject to additional payment. When a vehicle is out of action for any cause, the Contractor shall make a similar vehicle available for the Employer's representative use at the Contractor's expense.

Each vehicle shall be fitted with the following standard equipment: alternator, ammeter, oil pressure gauge, water/coolant temperature gauge, speedometer (km/h) with trip, ash tray, fire extinguisher (including fixing bracket and screws), exterior sun visors, external wing-mirrors, windscreen wiper unit, privacy glass or equivalent, rubber pads for clutch and brake pedals, spare wheel carrier with provision for lock, lockable fuel filler cap or compartment, locking doors and windows, towing pintle, steering damper, radiator chaff guard and all-terrain tyres.

Each vehicle shall be supplied with the basic maintenance tools together with spare belts (fan, cam serpentine and power steering), top and bottom radiator hoses, 6 fuses, a high lift jack, felling axe, cutlass, trenching tool, 15 m of 0.75 tonne fibre rope, inspection lamp and 5m of two core cable.

The Contractor will ensure that one spare tyre is available for each vehicle throughout the duration of the contract. All tyres will be of a roadworthy condition and fully comply with Kenyan Law. Each vehicle will be fitted with driver airbags and passenger airbags. All passenger vehicles shall be equipped with a hydraulic winch.

The vehicles shall be 4 wheel drive with additional low ratio gears for cross-country work and each vehicle shall be fitted with the following standard equipment: alternator, ammeter, oil pressure gauge, water temperature gauge, speedometer (km/h) with trip, ash tray, fire extinguisher (including fixing bracket and screws), exterior sun visors, external wing-mirrors, windscreen wiper unit (passenger side), rubber pads for clutch and brake pedals, spare wheel carrier on dished deluxe bonnet with provision for lock, bonnet lock, lock for spare wheel on bonnet, lock for fuel filler, locking doors and windows, radio interference suppressors, towing pintle, steering damper, front axle with reinforced casing, radiator chaff guard and cross-country tyres.

Each vehicle shall be supplied with the basic maintenance tools together with spare belts (fan, cam serpentine and power steering), top and bottom radiator hoses, 6 fuses, a high lift jack, felling axe, cutlass, trenching tool, 15 m of 0.75 tonne fibre rope, inspection lamp and 5 m of 2 core cable.

The Contractor will ensure that one spare tyre is available for each vehicle throughout the duration of the contract. All tyres will be of a roadworthy condition and comply fully with Kenyan Law. Each vehicle shall be fitted with driver and passenger airbags. All Vehicles shall be equipped with a hydraulic winch. All vehicles shall be provided within two months of Contract Effectiveness.

On completion of the Contract, the vehicles and all equipment shall remain the property of the Employer and the contractor shall transfer the ownership to the Employer.

Vehicle Type 1:

Description : Medium SUV 3.0L Executive 6-AT 4x4 or Equivalent ; Engine :- Displacement - minimum 2800 cc ; Engine Type - Cylinder in line ; Fuel System -Direct injection ; Fuel type -Diesel ; Max power HP/rpm - 204/3000-3400; Max torque Nm - 500/1600 to2800; Number of cylinders - 4 ; Valves/cylinder - 4 Body :- Body style - SUV; Number of doors- 5 doors Dimensions: Minimum Dimensions (L x W x H) in mm: 4795 x 1855 x 1835 ; Ground clearance (mm) 279; Wheelbase (mm) 2745 Transmission :- Gearbox - Automatic ; Transmission: Part time manual 4x4 Weight/capacities :- Additional fuel tank capacity (L); Curb weight (kg): 2190; Fuel tank capacity (L): 80 ; Minimum Gross vehicle weight (kg): 2735; Number of seats: 7; Brakes:- Front brake: Ventilated discs ; Parking brake: Manual ; Rear brake: Ventilated discs Suspensions :- Front suspension: Coil type ; Kinetic Dynamic Suspension System (E-KDSS) ; Rear suspension: Multi-link; Tyres :- Tyre dimension: 265/60 R18 Performance:- Acceleration (sec) : 0 to 100km/h ; Max speed (km/h): 180-240 Fuel consumption :- Consumption mixed cycle (l/100km):7,9 ; Interior & comfort: - 2nd row seats: Folding 40/60 ; 3rd row seats:

Folding ; Adjustable steering wheel: Height and reach adjustable ; Air conditioning: Automatic; Car mat: Yes ; Central armrest: Front, Rear ; Central door locking: Yes ; Central door locking while driving: Yes ; Connections: Bluetooth, USB, Apple CarPlay, Android Auto; Cool box: Yes ; Cup holder(s): Rear, Front ; Driver seat: Height and reach adjustable ; Front seats: 2 ; Gearshift & Brake lever: Leather ; Locking glove box: Yes ; Loud speakers: 6 ; Plug 12V: 3 ; Power seats: Driver & Passenger ; Power Steering: Yes ; Power windows : Front, Rear ; Push & start system: Yes / alternative ; Radio: Radio MP3 ; Room lamps: Yes ; Sequential electric windows: Front / Rear ; Smart keys: Yes ; Sport seats: Yes ; Steering wheel: Leather ; Steering wheel audio control: Yes ; Sun visor: Yes ; Sunvisor with mirror: Driver & Passenger ; Touchscreen: 8" and more ; Upholstery: Leather ; User guide: English ; Video Camera: Rear Active safety:- ABS: Yes ; Brake assist: Yes ; Cruise control: Yes ; Daytime running lights: LED ; Demister: Rear windows ; Door unlock alert: Yes ; Downhill assist control: Yes ; Electronic stability control: VSC ; Eletronic Brakeforce distribution (EBD): Yes ; Fog lamps: Front ; Headlamps: LED ; High position brake lamp: Yes ; Hill-start assist control: Yes ; Immobilizer: Yes ; Seatbelt warning: Yes ; Side turn lamp: Yes ; Trailer Sway Control (TSC): Yes Exterior:- Adjustable side mirrors: Electric ; Bumper – Front & Rear: Body colour ; Door handles: Chrome ; Door mirrors: Body colour ; Folding side mirrors: Electric ; Footboard:- Side step ; Front bumpers:- Body colour ; Front grill: Black ; Mudguards: Rear, Front ; Rear bumpers: Body colour ; Roof rail: Yes ; Spoiler: Front and Rear ; Wheels : Alloy ; Windscreen: Laminated Passive safety: - Airbags:-Knees (driver), Side & Curtains, Passenger, Driver, Curtains ; Anti-theft alarm:- Yes ; Headrests:- 3rd row, 2nd row, Front ; Height adjustable lights:- Automatic ; ISOFIX fixings:- Rear ; Seatbelt pretensioner:- Front ; Seatbelts - 2nd row:- 3 x 3 points ; Seatbelts - 3rd row:- 2 x 3 points ; Seatbelts – Front:- 2 x 3 points ; Spare wheel:- Alloy

Vehicle Type 2:

- **Purpose:** Double cabins are versatile vehicles for transporting personnel and small equipment to project sites and substations.
- **Specifications:**
- **General:** Robust construction with 2400-3000cc, 4x4, diesel utility vehicle, suitable for both on and off-road conditions, capable of operating in tropical conditions, suitable for personnel and cargo transportation.
- **Dimensions:** Overall length, min. 5,000 mm; Overall width, min. 1,750 mm; Overall height, approx. 1,780 mm; Wheelbase, min. 3000 mm; Ground Clearance, min.230 mm; Max. G.V.W. approx. 2,740 Kg; Kerb weight approx. 1,800 Kg; Turning radius, approx. 6,500 mm.
- **Engine:** Engine performance curves supplied; Engine type, diesel, 4 stroke, water cooled; Piston displacement, within range. 2,4003,000cc.; Engine aspiration turbocharged; Number of cylinders min.4; Maximum power output/rpm, min.60 kw/4000rpm; Maximum torque developed/rpm, min180Nm/2400rpm; Engine aspiration, turbocharged; Fuel system, Direct Injection; Air filter, disposable/oil bath Specify; Oil and fuel filter type Disposable; Average fuel consumption (on full load) Specify Kms/lit; Fuel tank capacity, min. 70 Litres
- **Clutch and Transmission:** Manual, Clutch, dry single plate, diaphragm type; Hydraulic, clutch actuation; Manual synchromesh gearbox; Total Speeds, min. 5F/1R.

- **Brakes and Tyres:** Hydraulic dual brake system; Mechanical parking brake, to act on transmission or rear wheel; Locally manufactured dual-purpose tyres; Optimum tyre size-Tubeless.
- **Suspension and Steering:** Front and rear suspension, independent Specify Front with telescopic dampers Rear; Power assisted steering; Right hand drive steering.
- **Pick-Up Body:** Roomy cab to seat 5 adults comfortably including driver, driver's seat adjustable.; Front row adjustable seats for two with safety (seat) belts provided; Second row to seat 3 adults comfortably c/w seat belts; Tools Cabin steel body. Suitable size toolbox to be fitted in the rear cabin; Suitably, fixed ladder carrier on top rear cabin. Firmly fitted side and rear step bars and roof rails.
- **Body and Finish:** All exterior body panels made non-corrosive and external steel fitting to be galvanized or painted. Anti-rust compound applied to under body for operation. All body steelwork to be thoroughly cleaned before painting. Both internal and exterior finish to be proceeded by one coat (ketraco-grey) and undercoat. Truck to be branded in KETRACO Corporate colors as per the provided color codes and instructions by the user; Body construction and all fitments to conform Cap 403 Kenya Traffic Act; Properly safeguard and expose number plate.
- **Electrical System and Instruments:** 12V electrical system, battery capacity, full lighting, standard instruments, gauges, or warning lights.
- **Equipment:** Sun visors, rearview mirrors, radio/CD player, airbags, air conditioner, spare wheel, tools, high-raised jack, windbreakers.
- **Warranty:** Minimum 100,000 km or 12 months, whichever occurs first.
- **Manuals:** Repair manual, parts catalogue, driver's handbook, service schedule.
- **Other Requirements:** Vehicle registration, inspection by Chief Mechanical and Transport Engineer, franchise holder or agent/dealer information, spare parts availability, dealer/agent addresses.
- **GOK Inspection:** The Motor vehicle must conform to 403 Kenya Traffic Act. Vehicle to be registered with the Registrar of Motor under the Employer. Vehicle to be inspected by the Chief Mechanical and Transport Engineer for compliance with the specification prior to delivery to the KETRACO.

Vehicle Type 3:

Description : Medium SUV 3.0L Executive 6-AT 4x4 or Equivalent ; Engine :- Displacement - minimum 2800 cc ; Engine Type - Cylinder in line ; Fuel System -Direct injection ; Fuel type -Diesel ; Max power HP/rpm - 204/3000-3400; Max torque Nm - 500/1600 to2800; Number of cylinders - 4 ; Valves/cylinder - 4 Body :- Body style - SUV; Number of doors- 5 doors Dimensions: Minimum Dimensions (L x W x H) in mm: 4795 x 1855 x 1835 ; Ground clearance (mm) 279; Wheelbase (mm) 2745 Transmission :- Gearbox - Automatic ; Transmission: Part time manual 4x4 Weight/capacities :- Additional fuel tank capacity (L); Curb weight (kg): 2190; Fuel tank

capacity (L): 80 ; Minimum Gross vehicle weight (kg): 2735; Number of seats: 7; Brakes:- Front brake: Ventilated discs ; Parking brake: Manual ; Rear brake: Ventilated discs Suspensions :- Front suspension: Coil type ; Kinetic Dynamic Suspension System (E-KDSS) ; Rear suspension: Multi-link; Tyres :- Tyre dimension: 265/60 R18 Performance:- Acceleration (sec) : 0 to 100km/h ; Max speed (km/h): 180-240 Fuel consumption :- Consumption mixed cycle (l/100km):7,9 ; Interior & comfort: - 2nd row seats: Folding 40/60 ; 3rd row seats: Folding ; Adjustable steering wheel: Height and reach adjustable ; Air conditioning: Automatic; Car mat: Yes ; Central armrest: Front, Rear ; Central door locking: Yes ; Central door locking while driving: Yes ; Connections: Bluetooth, USB, Apple CarPlay, Android Auto; Cool box: Yes ; Cup holder(s): Rear, Front ; Driver seat: Height and reach adjustable ; Front seats: 2 ; Gearshift & Brake lever: Leather ; Locking glove box: Yes ; Loud speakers: 6 ; Plug 12V: 3 ; Power seats: Driver & Passenger ; Power Steering: Yes ; Power windows : Front, Rear ; Push & start system: Yes / alternative ; Radio: Radio MP3 ; Room lamps: Yes ; Sequential electric windows: Front / Rear ; Smart keys: Yes ; Sport seats: Yes ; Steering wheel: Leather ; Steering wheel audio control: Yes ; Sun visor: Yes ; Sunvisor with mirror: Driver & Passenger ; Touchscreen: 8" and more ; Upholstery: Leather ; User guide: English ; Video Camera: Rear Active safety:- ABS: Yes ; Brake assist: Yes ; Cruise control: Yes ; Daytime running lights: LED ; Demister: Rear windows ; Door unlock alert: Yes ; Downhill assist control: Yes ; Electronic stability control: VSC ; Eletronic Brakeforce distribution (EBD): Yes ; Fog lamps: Front ; Headlamps: LED ; High position brake lamp: Yes ; Hill-start assist control: Yes ; Immobilizer: Yes ; Seatbelt warning: Yes ; Side turn lamp: Yes ; Trailer Sway Control (TSC): Yes Exterior:- Adjustable side mirrors: Electric ; Bumper – Front & Rear: Body colour ; Door handles: Chrome ; Door mirrors: Body colour ; Folding side mirrors: Electric ; Footboard:- Side step ; Front bumpers:- Body colour ; Front grill: Black ; Mudguards: Rear, Front ; Rear bumpers: Body colour ; Roof rail: Yes ; Spoiler: Front and Rear ; Wheels : Alloy ; Windscreen: Laminated Passive safety: - Airbags:-Knees (driver), Side & Curtains, Passenger, Driver, Curtains ; Anti-theft alarm:- Yes ; Headrests:- 3rd row, 2nd row, Front ; Height adjustable lights:- Automatic ; ISOFIX fixings:- Rear ; Seatbelt pretensioner:- Front ; Seatbelts - 2nd row:- 3 x 3 points ; Seatbelts - 3rd row:- 2 x 3 points ; Seatbelts – Front:- 2 x 3 points ; Spare wheel:- Alloy

Table 2: Vehicle Description and total quantities for both substations

Item	Description	Quantity
1	Type 1: Medium SUV type, 3.0L engine, Executive 6-AT 4x4 or equivalent with air conditioning, full service and maintenance	8
2	Type 2: Double Cab Pick-Up, Vehicle, 4x4, LWB :	4
3	Type 3: Medium SUV type, 3.0L engine, Executive 6-AT 4x4 or equivalent with air conditioning, full service and maintenance	1

28.2 Project Communication Devices

Project Communication Devices

The Contractor shall also provide at least Ten (10) mobile phone sets (smart phone, approved by the Employer) for each substation for use in Project oversight by the Employer's Project Implementation Team with all usage charges relevant to the transmission project paid for by the Contractor. Mobile telephone coverage is to be provided for the length of the line by a major Kenyan mobile telephone service provider which provides coverage across the country. In addition, the contractor shall provide five (5) satellite phones in this Lot for use by the Employer's Operation and Maintenance team.

The costs of providing mobile telephones (approved by the Employer) and a reasonable monthly airtime allowance (Kshs 5,000 per phone per month) is deemed incorporated into the project price. The specifications for the communication devices shall be submitted for approval by the Employer's representative. The project communication devices shall remain property of the employer upon completion of the project. The devices shall meet the following minimum requirements:-

Network Technology: GSM / CDMA / HSPA / EVDO / LTE / 5G or latest; **Body Dimensions:** 163

x 77.6 x 8.3 mm (6.42 x 3.06 x 0.33 in); Weight: 227 g (8.01 oz); Build: Glass front, glass back,

titanium frame (grade 5); SIM: Nano-SIM + eSIM + eSIM (max 2 at a time; International); IP68

dust tight and water resistant (immersible up to 6m for 30 min); Apple Pay (Visa, MasterCard,

AMEX certified); Display Type: LTPO Super Retina XDR OLED, 120Hz, HDR10, Dolby Vision,

1000 nits (typ), 2000 nits (HBM); Size: 6.9 inches, 115.6 cm² (~91.4% screen-to-body ratio);

Resolution: 1320 x 2868 pixels, 19.5:9 ratio (~460 ppi density); Protection: Ceramic Shield

glass (2024 gen); Always-On display; Platform: OS iOS 18, upgradable to iOS 18.4 or latest;

Chipset: Apple A18 Pro (3 nm) or latest; CPU: Hexa-core (2x4.05 GHz + 4x2.42 GHz); GPU:

Apple GPU (6-core graphics) or latest; Memory Card slot: No; Internal storage: 512GB 8GB

RAM NVMe; Main Camera: Triple 48 MP, f/1.8, 24mm (wide), 1/1.28", 1.22µm, dual pixel PDAF,

sensor-shift OIS; 12 MP, f/2.8, 120mm (periscope telephoto), 1/3.06", 1.12µm, dual pixel PDAF,

3D sensor-shift OIS, 5x optical zoom; 48 MP, f/2.2, 13mm (ultrawide), 1/2.55", 0.7µm, PDAF;

TOF 3D LiDAR scanner (depth); Features: Dual-LED dual-tone flash, HDR (photo/panorama);

Video: 4K@24/25/30/60/100/120fps, 1080p@25/30/60/120/240fps, 10-bit HDR, Dolby

Vision HDR (up to 60fps), ProRes, 3D (spatial) video/audio, stereo sound rec. ; Selfie camera:

Single 12 MP, f/1.9, 23mm (wide), 1/3.6", 1.0µm, PDAF, OIS SL 3D, (depth/biometrics sensor);

Features: HDR, Dolby Vision HDR, 3D (spatial) audio, stereo sound rec; Video:

4K@24/25/30/60fps, 1080p@25/30/60/120fps, gyro-EIS; Sound: Loudspeaker - Yes, with

stereo speakers 3.5mm jack -No; Communication: WLAN, Wi-Fi 802.11 a/b/g/n/ac/6e/7, triband, hotspot; Bluetooth 5.3, A2DP, LE; Positioning: GPS (L1+L5), GLONASS, GALILEO, BDS,

QZSS, NavIC; NFC – Yes; Radio -No; USB - USB Type-C 3.2 Gen 2, DisplayPort; Features:

Sensors; Face ID, accelerometer, gyro, proximity, compass, barometer; Ultra Wideband (UWB)

support (gen2 chip); Emergency SOS, Messages and Find My via satellite Battery Type: Li-Ion

4685 mAh; Charging Wired, PD2.0, 50% in 30 min; 25W wireless (MagSafe), 15W wireless

(Qi2); 4.5W reverse wired Miscellaneous: Colors - Black Titanium/ White Titanium/ Natural

Titanium/ Desert Titanium; Models: iPhone17,2 or latest , A1392 ; SAR 1.01 W/kg (head) 1.15

W/kg (body); SAR EU 1.22 W/kg (head)- 1.45 W/kg (body) 3DMark: 4731 (Wild Life Extreme);

Display: 1796 nits max brightness (measured); Loudspeaker : -24.4 LUFS (Very good) Battery

(new); Active use score 17:18h

The contractor shall provide five (5) satellite phones with the following features:

System/Frequencies		4G: B1, B3, B7, B8, B20, B28A 3G: B1, B3, B8 2G: B3, B8
SIM cards	Satellite 1 SAT SIM slot (Mini-SIM)	Cellular 1 SIM slot (Micro-SIM)
Data services	Satellite GmPRS up to 60/15 Kbps (down/up)	LTE/4G/5G up to 30 Mbps down up tp 9 Mbps up

Size (phone body)	Max: 140x60x30mm
Weight	Max 250 g
Satellite services	Calls, SMS, SMS to email
Battery	3400 mAh battery: - up to 11 hours talk time, - up to 100 hours standby time
Global Navigation, Satellite System (GNSS)	GPS, BeiDou, Glonass, Galileo
Display	2.4" toughened Gorilla® glass outdoor display
Ingress protection	Water resistant, dust resistant, shock proof (IP65/IK05)
External interfaces	USB-C connector, Earphone connector, (3.5mm), Antenna connector for docking units
PC compatibility	Win 11/10
Environmental specifications	Operating temperature: - 10° C to + 55° C

28.3 Trainings

The Contractor shall provide on-site practical training to KETRACO staff during all stages of the installation works and testing and commissioning stages.

There shall be no limitation on the number of KETRACO staff to be trained at site during the entire project duration and shall be covering theoretical and practical aspects of systems and equipment. training manuals, in hard and electronic copy, shall be provided for all participants. These manuals and provided training in practice shall include equipment installation, testing, commissioning, calibration, routine operation and maintenance requirements and also spare parts replacement procedure, principle and philosophy of systems and equipment, the method of detection, troubleshooting and analysis of defects. The training program and schedule at three stages of installation, testing and commissioning and operation & maintenance for equipment and systems shall be subject to approval of KETRACO/Client. The language of the training shall be as specified in the 'Special conditions of the Contract'.

The employer's personnel will be present during the installation and testing and commissioning stages of the project and will be fully involved in the activities.

The Contractor shall also provide specific training for KETRACO's personnel. The training shall take place during the design stage at the design Contractor's home Country or a reputable training centre preferably run by manufacturer or power transmission electricity utility.

The specific training for the project shall include but not limited to the following:

I) Substation Equipment Design Training (4 Design Engineers and 2 TSP Engineers for 3 weeks):

- I.1. Earthing System Design and Calculations by CYMGrd/CDEGS Software
- I.2. Procedure and main criteria for designing of layout drawings in HV substations
- I.3. Minimizing the dimension of high voltage AIS substations by hybrid/compact equipment
- I.4. 3D Modelling in high voltage substations by AutoCAD, 3D-Max and PDMS software, Substation Design Suite™ Physical for AutoCAD by SBS, Substation Design Suite™ Protection and Control by SBS
- I.5. Electrical/mechanical buswork calculation of Stranded and Rigid conductors
- I.6. CT and CVT sizing calculations
- I.7. Cable sizing by ETAP software
- I.8. Surge arrester and lightning protection system calculations
- I.9. AC/DC load evaluation, battery and battery charger calculation and design of AC/DC systems
- I.10. Indoor/outdoor Lighting calculation by DIALux and related requirements
- I.11. Online monitoring of transformer and its bushings
- I.12. Power transformer technical specifications and
- I.13. Auxiliary and earthing transformers technical specification
- I.14. Heat, ventilation and Air-Conditioning system calculations (HVAC)
- I.15. Equipment lifetime analysis
- I.16. Risk assessment /management in substations
- I.17. Preventive maintenance of high voltage equipment

II) Protection and Control for Electrical Power Systems (4 Engineers for 3 weeks)

- II.1. Introduction to a large electrical power system and overview on the general requirements and objectives of transmission line protection
- II.2. Overview of the power system structure and behaviour
- II.3. Different configurations of substations and their components and typical substation automation system structures
- II.4. Interfacing the primary system (switchgear) with the substation automation system
- II.5. Understanding the most common protection schemes and basic requirements for protection systems and the role of protection and station automation in power systems
- II.6. Protection philosophies, principles, typical application arrangements and tripping methodologies for different power devices. Study protection principles and evaluate the appropriate protection concepts
- II.7. Principles and calculation rules for instrument transformers and describe the influence of CT saturation.
- II.8. Design protection schemes for transmission lines and select important protection functions
- II.9. Coordinate different protection and establish selective and graded schemes
- II.10. Calculate the settings of several protection functions
- II.11. Specify and verify instrument transformers for use with line protection
- II.12. Design protection schemes for busbars, circuit breakers and transformers and select important protection functions
- II.13. Prepare a protection coordination study Work intensively with advanced protective relay applications. The goal is to familiarize technical personnel with the area of numerical protection devices.
- II.14. Role of substation automation in the power system management

- II.15. Finalise with the Design of the protection system for the substation under Construction by the Contractor.

III) Power System Analysis (4 TSP Engineers for 2 weeks)

- III.1. Overview of the properties of transmission, distribution and industrial power systems
- III.2. Explain the power system dynamic and stable behaviour including the transitions between the different power system states
- III.3. Components and general behaviour of the power system from generation over transmission and distribution to consumption
- III.4. Basic power flow concepts and system analysis based on some system examples
- III.5. Power system modelling and analysis the
- III.6. Learn computation techniques for fault calculations
- III.7. Power system modelling simulation and analysis (load flow, contingency, switching, shortcircuit, protection, etc as necessary for power line planning, design and operation) using DlgSILENT software
- III.8. Power system planning and studies (load flow, contingency, switching, shortcircuit, protection, etc as necessary for power line planning, design and operation) by PSS/E software

IV) Communication & Substation Control System– Application & Design (4 Engineers for 2 weeks)

- IV.1. Introduction in IEC61850 standard structure - used protocol elements.
- IV.2. Need for a communication standard for substation automation and an overview of the communication in power systems and basics of communication and of functions in substation automation systems including protection and the approach of IEC 61850
- IV.3. Summarize the concepts of data communication, protocols and standards
- IV.4. Requirements of the signal data flow for utilities and the properties of the signal data flow in a substation from the power process level (switchyard) through the bay and station level up to the network level
- IV.5. Features of the most common standardized protocol used in communication systems of power utilities and especially in substations
- IV.6. List and compare the essential features of all these protocols and explain the use of all these protocols
- IV.7. System Architecture Design for Substation Automation with IEC61850 – Application & System Design
- IV.8. Principles for SCS and changing parameters such as database objects, signal texts, measurement scaling and others
- IV.9. Create graphic displays in SCS e.g. single line diagrams, overview pictures, system overview picture
- IV.10. Configure NCC communication protocols IEC 60870-5-101,104 and configuration of device hardware CPU and interfaces (Ethernet, GPS ...).
- IV.11. Configuration and interrogation of the energy meters, energy meter software interaction.

V) Civil/ Structural Design Training (for 3 weeks for 4 Design Engineers and 2 TSP Engineers)

- V.1. Substation civil and structural works design
- V.2. Steel structure design and detailing using Staad Pro or other structural design software
- V.3. 3D modelling in high voltage substations in Substation Design SuiteTM Physical for AutoCAD by SBS
- V.4. Structure foundation design
- V.5. Substation drainage design

VI) Site Operation and Maintenance Training

The training will be tailored for substation operators and maintenance engineers (at least 10 persons) with a task of equipping the staff with operation principles as well as capacity for trouble shooting and repairs of key substation equipment. This shall be well structured to last for two (2) weeks at site.

The substation operators and maintenance engineers will be trained on the hands-on operation of the Substation Control systems as well as operation of all key substation equipment including but not limited to battery chargers, UPS systems, battery banks, AC DC panel (auxiliary services panels) operations, Diesel generator operations.

The Contractor shall submit a detailed site training proposal for review/approval by Employer/Project Manager.

For each of the training above that is not held within the Client's country, the Contractor shall provide for each KETRACO staff the following:

- One economy class return air ticket
- Visa expenses, airport taxes and other incidental travel expenses as required.
- Full board accommodation in a minimum 4-star hotel including laundry services and with international phone dialling capability for the entire training duration and Local transportation.
- Daily allowance of US\$ 200/day for food and incidental expenses for the duration of the training

29. Temporary Works

Temporary works (including provision of safety facilities for the Contractor's and the Client's staff/representatives) are identified as follows but not necessarily limited to:

- i. Establishing site office
- ii. Required machineries, tools and instruments
- iii. Site power and water supply
- iv. Site temporary fencing
- v. Project sign boards
- vi. Site internet connection
- vii. Storage facilities
- viii. First aid facilities
- ix. Working clothes, safety shoes and safety helmet, safety harness, safety glasses, safety gloves, insulating gloves, safety rope, welding mask
- x. Firefighting extinguishers (CO2, Dry powder, foam)
- xi. Ambulance facilities
- xii. Site Toilets
- xiii. Drinking water for workers
- xiv. Watch and ward and access control to site during construction

30. Climate Change Impact Mitigation

The contractor shall undertake a tree planting exercise at location(s) to be identified in consultation with KETRACO, the community and relevant authorities. The contractor shall plant trees worth KES 5,000,000 or at least 30,000 trees whichever is higher. The tree planting exercises commence immediately after contract effectiveness. The cost shall be deemed to cover the entire exercise which shall involve the following:

1. Selection of trees species with the highest survival rate and can grow with baseline environmental conditions at the selected planting locations.
2. Transportation of the seedlings to the selected planting locations.

3. Preparation of the land including but not limited to clearing the site of invasive species and preparing the hole.
4. Planting the seedlings at the onset of long rains
5. Protection and care of the planted tree for a period of 12 months.

31. Corporate Social Responsibility

The Contractor shall implement CSR projects for the community. The total cost of the CSR projects to be implemented shall be at least KES 10,000,000. The projects to be implemented shall be determined in consultation with KETRACO and the local communities. The contractor shall design and implement the CSR projects selected.

B. Specifications

TABLE OF CONETENTS

PART 2 – EMPLOYER’S REQUIREMENTS.....1

1. General Technical Requirements

The Equipment Technical Specifications take precedence over any clauses contained in the following General Technical Requirements.

1.1 General

In complying with the requirements of the Specification, design shall conform to the best current engineering practice. Each component part of the Plant shall be to the maker's standard design provided that this design is in general accordance with the Specification.

The essence of design shall provide simplicity and reliability in order to give long continuous service with high economy and low maintenance costs. Particular attention shall be paid to internal and external access in order to facilitate inspection, cleaning and maintenance.

Type test certificates of all major equipment and major material shall be submitted together with the Tender Documents as stated in the relevant specifications. If necessary, type test certificates shall be translated in all aspects to the English language by the issuing test institute. Type test certificates shall be properly issued to the manufacturer and to the manufacturer's factory location.

Type test certificates/ type test reports are subject to the approval of Employer/ Engineer. Type-test certificates/ type test reports shall not be older than five (5) years at the time of their submittal. Compilation of type test certificates/ type test reports shall be covered by a table of contents, clearly structured by equipment designation, the relevant standards, their sub clauses and designation of the relevant test.

Type tests shall have been performed by an internationally accredited independent testing laboratory not associated with the manufacturers. Also type tests performed at manufacturer's laboratory and witnessed by accordingly accredited independent third party are acceptable. Accreditation to the testing laboratory/ third party shall be given by an according signatory member of International Laboratory Accreditation Cooperation (ILAC).

Upon submission of relevant type test certificates and proof that the equipment and material to be tested is identical to that covered by the test certificates, the Employer/ Engineer may waive the requirements for corresponding type tests called for in this Specification and/ or specified in the Standards.

On request of Employer/ Engineer full type test report/ protocol shall be provided.

The design dimensions and materials of all parts shall be such that they will not suffer damage as a result of stresses under the most severe service conditions.

Fully detailed specifications of the component parts of the Plant shall be submitted describing particularly the materials to be used.

The materials used in the construction of the Plant shall be of the highest quality and selected particularly to meet the duties required of them. Mechanisms shall be constructed to avoid sticking due to rust or corrosion.

Workmanship and general finish shall be of the highest quality throughout.

All similar parts of the Plant shall be interchangeable.

All apparatus shall operate without undue vibration and with the least practicable amount of noise.

All equipment shall be designed to minimise the risk of fire and any damage which may be caused in the event of fire.

All apparatus shall be designed to obviate the risk of accidental short, malfunction or damage due to vermin. The use of materials which may be liable to attack by termites or other insects is to be avoided.

All items of equipment which may have to be lifted for erection or maintenance shall be provided with lifting eyes, jacking pads or alternative handling facilities.

The equipment is to be designed to prevent accidental contact with live parts.

Fixed installed maintenance platforms, where the height of the switchyard equipment necessitates them to perform operation and maintenance, shall be included in the delivery.

1.2 Units of Measurement

In all correspondence, technical schedules and drawings S.I. units (System International Unites) shall be used. On drawings where Imperial or other units have been used the equivalent SI units shall also be shown.

1.3 Erection Marks

All members, comprising multipart assemblies, e.g., steel frameworks, piping installations, etc., shall be marked with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks, if impressed before painting or galvanising, shall be clearly readable afterwards.

Colour banding to an approved code shall be employed to identify members of similar shape or type but of differing strengths or grades.

1.4 Anticorrosion Protection, Cleaning and Painting (Other than Civil Works)

1.4.1 General

The equipment shall be treated and protected to withstand at least five years of operation under the environmental conditions prevailing at site without sustained corrosion or attacks from fungus or rodents, provided the surfaces remain mechanically undamaged.

Type of Paint and Painting Procedure

The paint shall be polyurethane type with two components of the product group "Aliphatic isocyanate" or an equivalent approved by the Employer. The characteristics of this paint must prevent yellowing and rotting. The procedure comprises a first coating of "polyamide epoxy" with a finishing coating of polyurethane. Besides, a coating of wash primer must be included in the aluminium painting procedure.

Cleaning and Surface Preparation

The surfaces to be painted must be cleaned before any application of paint or surface treatment.

Any oil, grease, dirt, rust, loose crusts, welding stains, clinker build-up, paint damaged by ambient exposure and other noxious substances must be removed as specified hereafter.

In general, all the oil and grease must be removed before starting the mechanical cleaning or chemical treatment.

Chemical treatment is always required. However, at the Contractor's request, the Employer could accept jet cleaning (sand, steel pellets, etc.) as an alternative.

The chemical treatment consists, mainly, in the immersion of steel in zinc or iron phosphate and aluminium in chromium phosphate. The procedure for the treatment must be accepted by the Employer.

When jet cleaning is performed, clean tissue and fluids shall be used to prevent that a residual greasy film from remaining on the cleaned surfaces. The cleaning and painting must be scheduled adequately so that dirt or cleaning stains do not fall on wet surfaces or fresh paint.

The brass, stainless steel and galvanized pieces do not require any paint.

Paint Application

All the work shall be performed with care, so that the finished surfaces are free from squirts, drops, ribs, waves, laps or unnecessary brush traces. All the coatings must be applied carefully to obtain a uniform layer and an even surface completely covering all corners and splits.

Characteristics, Mixing and Dilution of Paint

The paint applied shall give a well finished and smooth surface. During application, paints must be mixed thoroughly, applied, and kept with a uniform consistency. The paints can be diluted in accordance with volumes 1 and 2 of SSPC (Steel Structures Painting Council USA).

Atmospheric Conditions

The paint shall only be applied on perfectly dry surfaces and in such atmospheric conditions that the degree of humidity and temperature allows evaporation instead of condensation. The test to measure the degree of evaporation consists in wiping the surface to be painted with a damp cloth, if after a few minutes the humidity goes away leaving stripes; this means that conditions allow evaporation.

The paint shall be mixed and shaken thoroughly at the moment of application. The basic coating and the paint must not be applied at temperatures below 10 °C.

Tests

At the request of the Employer, the Contractor shall perform checks using samples such as: checks on the sandblasting cleaning or chemical treatment, measurement of thickness on coatings of paint applied and complete reticulation (with solvent acetone methyl ethylene) and a control of the materials used for the paints.

Furthermore, at the request of the Employer, the Contractor shall submit for review his schedule of the following tests: shine, hardness, flexibility, humidity, shock resistance, adherence, scratch resistance, exposure to weather elements and saline fog. Tests shall be performed in accordance with applicable ASTM standards.

Method to Apply the Paint

The coatings of paint in the plant shall be applied with an air or airless spray gun. The primer coating must have a minimum thickness of 50 micrometres and the finish coating 50 micrometres.

Manufactured Parts

Bronze, brass, finished surfaces, surfaces with rolling contacts and hoisting cables must not be painted.

Touch-ups

A sufficient amount of every base and finishing paint used shall be supplied for touch ups at the sites. It must be contained in perfectly sealed containers identified with the name, the formula, the number of inspections, the colour, the special instructions, the Manufacturer's name and manufacturing dates.

The Contractor shall provide an amount equivalent to 10% of the volume of each type of paint used for the equipment, but not less than a Liter.

The Contractor shall pack them separately and clearly identify these supplies.

Warranty

All the paints, protections, etc. shall be guaranteed by the Contractor for an additional 12 working months with respect to the equipment specified warranty period.

All bright metal parts shall be covered before shipment with an approved protective compound and protected adequately during shipment to Site. After erection these parts shall be cleaned with a correct solvent and polished bright where required.

Before testing, all steel pipes shall be thoroughly cleaned by an approved process. Any protective coatings shall be applied after tests have been carried out.

Pipes, valves and other similar parts of the Plant which are subject to hydraulic test and are not readily accessible for drying out are on completion of tests at the manufacturers' works to be drained out by washing with an approved de-watering oil prior to protection for shipment.

All surfaces shall be prepared before coating in accordance with BS 2569.

All iron and steel surfaces shall be protected against corrosion and painted in accordance with BS EN ISO 12944 and shall withstand the site environment for at least 10 years without need for maintenance.

Where painting is carried out at the manufacturers' works and where erection at Site is the responsibility of the Contractor, any damage during delivery or erection at Site shall be made good to the requirements of the Project Manager including, where deemed necessary, application of a complete finishing coat of an approved colour and quality paint.

Where painting is carried out entirely at Site after erection, the whole of the Plant, including bare pipe surfaces and hand railing, shall be well wire brushed down and cleaned after which all parts shall be given one coat of primer, one undercoat and at least two finishing coat of an approved colour and quality paint.

All paint shall have appropriate standard finish, requiring at least two finishing coats on prepared surfaces properly filled in to provide a smooth finish. The insides of outdoor control cubicles, cabinets, etc., where condensation is liable to occur, shall receive the same number of coats.

Tanks and Accessories

Interiors of oil tanks shall be thoroughly cleaned by shot blasting or other approved methods and, where exposed to corrosion before use, shall be coated with an approved corrosion preventing compound. The internal surfaces of oil tanks that will be exposed to atmosphere in service shall be painted with an epoxy or other approved oil resisting compound.

The exterior shall be thoroughly cleaned by shot blasting or other approved methods and given one coat of primer, two coats of contrasting colour of durable oil and weather resisting paint and a final coat of gloss paint.

Radiators

Radiators shall be thoroughly cleaned and treated externally by phosphating or other approved rust inhibiting process and given, preferably by flood painting. Radiators which are hot dip galvanised to BS EN ISO 1461:2009, shall be given one coat of etch primer followed by one coat of zinc chromate primer followed by the same number and type of paint coatings specified previously.

1.5 Rating Plates, Nameplates and Labels

1.5.1 General

The equipment shall be fitted with nameplates and indication plates, which must be manufactured of stainless steel or aluminium, with a minimum thickness of 1 mm engraved in black letters on a light background.

All items of plant shall be provided with nameplates or labels designating the service of the particular equipment. Such nameplates or labels shall be of corrosion resistant material with permanent lettering of a contrasting colour or, alternatively, in the case of indoor equipment, of transparent plastic material with suitable lettering engraved on the back.

Items of Plant, such as valves, which are subject to handling, shall be provided with nameplates with permanent inscriptions thereon, specifying also their normal position and use of other positions.

1.5.2 Rating Plate

Each main and auxiliary item of Plant shall have attached to it in a conspicuous position, a rating plate upon which shall be engraved any identifying name, type or serial number, together with details of the loading conditions under which the item of Plant in question has been designed to operate, and such diagram plates as may be required by the Project Manager, including the short-time rating of switchgear.

1.5.3 Labels

Each item of Plant shall be provided with number plates bearing the equipment number allocated by the Project Manager according to his standard operational numbering scheme, details of which will be advised during the Contract stage.

The device number shall be displayed in text height 30mm on all operating mechanisms and 60mm or larger in height on principal items of Plant. The same device number shall be displayed on control cubicles in text height 10mm or larger as may be required by the Project Manager.

The label for the feeder designation shall be provided on middle phase surge arrestor structure. The text height shall be 60mm or larger. Phase identifications with respective color disks shall be provided for the main bus bar as well as incoming line. The material to be used for engraving the labels shall be approved by the project manager. The labels shall be of black color with white writing.

1.6 Color of Equipment and Wiring

The colours must be in accordance with the following table:

Table : Colour (RAL) for Equipment

EQUIPMENT	COLOR (RAL designation)
Outdoor	
Outside surfaces of Equipment	Grey RAL 7038
Inside surfaces of reservoirs	White RAL 9003
Inside surfaces of cabinets, panels, and junction boxes, etc.	White RAL 9003
Ends of bushings (Live end)	Red RAL 3020
Porcelain	Brown
Indoor (buildings)	
Outside surfaces of cells, panels, cabinets, and junction boxes	Grey RAL 7038

EQUIPMENT	COLOR (RAL designation)
Inside surfaces of cells, panels, cabinets and junction boxes	White RAL 9003

Table : Colour (RAL) for Wiring

— D.C. circuits:	— positive-White, Negative-Brown
— CT circuits:	— Phases:Red,Yellow,Blue,Neutral-Black
— PT circuits:	— Phases:Red,Yellow,Blue,Neutral-Black
— Alarms circuits:	— Grey
— Grounding:	— green or green with yellow stripes
— 3-phase, 4W power circuits:	— red, yellow, blue, black (neutral)
— 1-phase, 2W A.C power circuits:	— red, black (neutral)

1.7 Nuts, Bolts, Studs and Washers

Nuts and bolts for incorporation in the plant are preferably to conform to ISO metric coarse to BS 3643, BS 3692 and BS 4190. Other sizes or threads are permitted for threaded parts not to be disturbed in normal use or maintenance. Where the Contract includes nuts and bolts of different standards, then the tools to be provided in accordance with this Specification shall include spanners, taps, and dies for these nuts and bolts.

Fitted bolts shall be a driving fit in the reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

On outdoor equipment all bolts, nuts and washers shall be of non-rusting material where they are in contact with non-ferrous parts in conductor clamps and fittings and elsewhere where specifically required by the Project Manager.

All washers shall be included under this Contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the Project Manager. Taper washers shall be fitted where necessary.

Where there is risk of corrosion, bolts and studs shall be finished flush with the surface of the nuts.

1.8 Rivets

Rivets shall conform to the appropriate British Standard and for general use pan heads are preferred. Rivets on bearing surfaces shall be flat counter-sunk, driven flush. Whenever practicable, riveting shall be done by hydraulic tools and the rivets must completely fill the holes when closed. If loose, or if the heads are badly formed, cracked or eccentric to the shank or do not bear truly on the plate or bar, such rivets shall be cut out and replaced. All surfaces to be riveted must be in close contact throughout.

1.9 Forgings

All-important forgings shall be jointly examined at the maker's works by the Project Manager and by a representative of the Contractor during forging and heat treatment and shall be examined by the latest methods for the detection of defects.

1.10 Castings

All castings shall be as free from blowholes, flaws and cracks as is practicable. No welding, filling or plugging of defective parts shall be done without the sanction of the Project Manager and then only with his approval in writing.

All cast-iron shall be of close-grained quality and shall be corrosion- resistant for those parts in contact with seawater. Cast-iron is not to be used for any part of the equipment which is in tension or which is subject to impact stresses. This clause is not intended to prohibit the use of suitable grades of cast-iron for parts where service experience has shown it to be satisfactory.

1.11 Welding

Where fabrication welds are liable to be highly stressed, the Contractor shall satisfy the Project Manager before such welding commences, that the welders or welding operators are qualified in accordance with the requirements of the appropriate section of BS 4872 Part 1 or other relevant British Standard Specification.

The Project Manager will inform the Contractor of the stages at which inspection will be required. It will be the Contractor's responsibility to notify the Project Manager when one or more of the inspection stages will be reached and no further work shall be carried out until the specified stage has passed the Project Manager's inspection.

In addition to the above, the Project Manager reserves the right to visit the Contractor's Works at any reasonable time during fabrication of the items of Plant and to familiarise himself with the progress made and the quality of the work to date.

All tests shall be carried out in accordance with the relevant British or other approved Standards. Where required by the Project Manager, non- destructive examination of the finished weld shall be made. If the examinations be by radiograph means, then the recommendations of BS EN 1435 where applicable shall be followed and the resulting negatives shall be made available to the Project Manager.

For the steel structures, the welding must be performed in compliance with the last edition of AWS D1.1.

All manual welding must be carried out using the protected metal arc welding procedure and automatic welding using the submerged or protected metal arc welding procedure.

All-important welding that, according to the Employer, may be subject to excessive efforts or do not seem to comply with the standards, may be X-rayed at his request.

1.12 Galvanized Work

All iron and steel structures and components intended for use outdoors shall be galvanised.

All materials to be galvanised shall be of the full dimensions shown or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process commences.

All galvanising shall be done by the hot dip process with spelter, not less than 98% of which must be pure zinc and in accordance with BS EN ISO 1461:2009 or BS EN 10244-2:2009 as applicable. No alternative process shall be used without the approval of the Project Manager. Bolts shall be completely galvanised including the threads, but the threads shall be left un-coated in the case of nuts.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

Galvanised wire shall comply with the requirements of BS 182, and the thickness of the coating and testing thereof shall comply with BS EN 10244-2:2009. Nuts and bolts and small components shall be tested in accordance with BS EN ISO 1461:2009. The Project Manager may select for test as many components to be weighed after pickling and before and after galvanising as he may think fit.

Galvanised steel structures shall be treated after galvanising with Sodium dichromate or other approved solution.

All galvanised parts shall be protected from injury to the zinc coating due to abrasion during periods of transit, storage and erection. If, in the opinion of the Project Manager, the extent of the damage found on Site to a galvanised part appears to be capable of repair the Contractor may, after receiving such agreement, attempt to affect a repair by approved methods. The agreement to attempt the repair shall not bind the Project Manager to accept the repaired part when this is re-offered for inspection.

Should any emergency arise on Site necessitating drilling, cutting or any other process likely to damage the protective zinc surface, this will be permitted only in extreme circumstances and with the Project Manager's express authority. In such a case, the bared metal will be coated with an approved zinc dust paint or other approved flake metallic compound.

Defects and Major Damage

These defects include non-adherence of zinc on the steel, galvanization excessive thickness variations, thick zinc deposits, excessive roughness or any other defect showing that the galvanizing was not applied according to applicable standard. Such defects, caused by defective application of acid dip, presence of grease, lamination, inadequate draining and handling of the vertically immersed steel or any other factors that result in a defective galvanization, shall constitute cause for rejection.

Also, the thinning of the zinc coating to the extent of exposing the bare metal shall be considered a major defect. Consequent damage caused by abrasion during shop handling when loading and unloading will be cause for rejection.

1.13 Chromium Plating

The chromium plating of those components of the Plant where specified and where offered by the Contractor shall comply with the requirements of BS EN 12540.

1.14 Lubrication

The Contract is to include for the supply of flushing oil for each lubrication system when the item of plant is ready for preliminary tests and the first filling of approved lubricants for the commercial operation of the plant.

A schedule of the oils and other lubricants recommended for all components of the Contract Works is to be submitted to the Project Manager for approval. The number of different types of lubricants is to be kept to a minimum. Copies of this schedule shall be included in both the draft and final copies of the operating and maintenance instructions. In the case of grease lubricated roller type bearings for electric motors a lithium-based grease is preferred.

Where lubrication is affected by means of grease, preference will be given to a pressure-gun system with a separate nipple to each point. Where necessary to accessibility, the nipple is to be placed at the end of extension piping, and, when a number of such points can be grouped conveniently, the nipples are to be brought to a battery plate mounted in a convenient position. Nipples shall be of the hexagon headed type complying with BS 1486 Part 1 table 1 type 11B. Where special greases are to be used and where high temperatures are encountered, then 'button' nipples in accordance with BS 1486 are preferably to be used.

The Contractor is to supply at least one set of grease gun equipment for each type of nipple provided. Where more than one type of special grease is required, a grease gun for each special type is to be supplied and permanently labelled.

1.15 Oil Level Indicators

Oil level indicators of approved magnetic type design are to be fitted to all oil containers such as transformer conservators etc.

The indicators are to have a scale of 150mm diameter (minimum) to show the level at all temperatures likely to be experienced in service, are to be marked with the normal level at 25°C clearly visible from normal access levels and are to be easily dismantled for cleaning. In addition, the normal filling level of all removable containers is to be marked on the inside.

1.16 Cubicles

1.16.1 Basic Design and Construction of Cubicles

All cubicles shall be industrially produced, made by reputable manufacturer and internationally approved by independent test laboratories.

The cubicles shall be fully assembled, wired and tested.

Standard designs and models from the Bidder's/ Contractor's manufacturing program are preferred; provided they meet the requirements of this Specification and serve the intended purpose.

Cubicles shall be either of the free and self-standing, floor mounted type or wall mounting type. Transportation shall usually be in vertical position. In some cases, transportation in horizontal position might also be required. All cubicles provided within the same room shall be coordinated particularly with regard to size, doors, plinths, arrangements of plates, lamps and labels, colour, etc. in order to achieve a uniform front design.

Each cubicle shall have a designation label at the top. On the left upper corner there shall be space for manufacturer's logo if applicable. The cubicle naming shall be in the middle and on the right upper corner shall be placed the designation in accordance with DIN 40719 Part 2. The letter height shall be minimum 20 mm. The fixing of the label shall be by screws. The designation label is part of the approval by the Employer/ Engineer.

Generally, all cubicles shall be designed such as to facilitate extension at both side ends.

For wall mounted or structure mounted cubicles and boxes the size shall be selected based on the required number of terminal blocks/ terminals or relays and other protection elements. However, the design of these cubicles shall be basically in conformity with that of the floor mounting cubicles except for the size.

The numbers and size of cubicles shall be selected such as to consider the requirements of maximum allowable heat dissipation by all equipment installed in the cubicle, so as to ensure satisfactory and reliable performance under the specified environmental condition. A written confirmation of cubicle's manufacturer on the same is mandatory.

The cubicles shall be vermin proof and protected against dust and water by protection class IP51 for indoor and IP55 for outdoor, and against external mechanical impacts according to protection code IK06.

Cubicles shall be designed for bottom entry of all cable types and/ or conduit wiring via vermin proof removable gland plates of galvanised sheet steel with at least 3 mm thickness and fire-resistant bushings (if any). The gland plates shall be equipped with suitable cable glands, made of non-corrosive material (e.g. nickel-plated brass or stainless steel) and shall be of metric size. They shall provide protection class of at least IP 67 at 5 bar. They shall be sealed or plugged during transport. Cable screens and armours shall be contacted in a circumferential manner for earthing purpose. Gasket material shall not be exposed to sunlight radiation. If due to any comprehensible reason cubicles may need cable entry from top, this shall be decided together with the Employer/ Engineer. The cubicles shall allow sufficient room for incoming/ outgoing cable cores to be neatly and conveniently channelled to their respective terminals.

The bottom plate shall be suitable to wear a weight of 150 kg without lasting deformation.

The free and self-standing cubicles shall be mounted on base frames. In case of raised floors these frames form part of the raised floor. The base frames need to be designed for the load of the fully assembled cubicles. In case of not floor mounted cubicles (e.g. operating mechanisms) the cubicles shall be properly fixed on steel supporting frames. All cubicles shall be well coordinated in respect to the height of the enclosures plinth and of the base frame.

A tinned copper rope or copper bar shall run along the full length of the cubicle row, connected every five meters to the substation earthing mesh. Each cubicle shall be earthed through two tinned copper earth cables to this

copper rope. The dimensioning shall be appropriate to meet the requirements of operational and protective earth, most notably regarding maximum rated short-circuit currents and electromagnetic interference. Outdoor cubicles and stand-alone cubicles shall be directly connected by tinned copper earth cables to the earthing mesh.

The cubicles shall be built-up of high stability profiles with rounded edges. They shall have a format system frame with the required punching in all three planes in accordance with IEC 60917 to allow standardization of cubicle components and system accessories (mounting rails, swing frames, lighting, etc.). Three-dimensional corner pieces shall be preferably welded to each section to guarantee optimum stability.

Side panels shall fit with the design of front doors and back panels. With field-by-field assembly in-stead of two back-to-back side panels between cubicles a partition plate may be used.

The cubicles shall be completely corrosion protected. The outside surfaces shall be preferably electrophoretic dip coat-primed and powder-coated. The inside surfaces shall be varnished as well or sendzimir galvanised, whereas cold galvanisation is restricted to treating of edges and refinishing treatment. The thickness of the dry film shall be at least 80 µm; the adhesive strength shall be GT1 or better according to the standard ISO 2409.

The Employer/ Engineer reserves the right to determine the thickness of coating by making appropriate tests. For such tests, the Contractor shall make available the apparatus to be used.

The paint film, under visual examination, must in any case present the appearance of an accurate application and be free of lesions, porosity, cracks or bubbles.

Where sharp edges cannot be avoided by constructional means edge protections shall be applied.

All metallic parts of the cubicles shall be connected with each other in a conductive manner. Varnished parts shall be earthed twice at least on diametrically opposed points.

All built-in equipment in the cubicles shall be fully accessible from the front.

All the material, wires, cables and cable-ducts in the cubicle shall be halogen free and flame retardant.

The text on labels for push buttons, selector switches, indicating lamps and other installed equipment shall have a minimum letter height of 5 mm.

The cubicles shall have a seismic withstand capability according to IEC 60068-3-3 of class AG5 with 5 m/s², respectively of the application class III with 15 m/s² for the acceleration of decks.

For seismic withstand capability the complete cubicle shall be qualified according to the requirements of IEEE 693-2005 and shall meet the requirements of the high qualification level. The test report shall be submitted together with the bidding documents.

1.16.2 Doors

The door shall be of 2 mm sheet steel with removable tubular door stiffener frame with holes on a 25 mm DIN pitch pattern, padlocking facilities integrated in door handle and a door opening angle of 170°. Swing-frames or

inner panels or doors if applicable shall have an opening angle of at least 150°. They shall be equipped with a door stay hinge.

Doors are to be arranged so that every individual door or frame can be opened without moving doors of adjacent cubicles. Doors shall be equipped with hinges and suitable sealing to satisfy the required protection class. The front door or alternatively one side panel shall be equipped with a rigid and securely fixed steel pocket sufficient to store the concerned circuit diagrams and site commissioning/ test reports.

Separate latch (es) shall be provided within the door, being made of anti-rust material. The latch shall require minimum maintenance and oiling for indefinite period. Doors shall be handled by smooth action locking bars with rollers and security lock system, prepared for insert lengths of 40 or 50 mm. Closing of doors shall be possible with one hand action only.

Glazed front doors shall have tempered security glass with a minimum thickness of 3 mm. Fixture of the glass shall be continuously along the edges by profiles or non-aging, UV-resistant glue. The glass fitting shall be of a width as to allow the electronic equipment to be seen behind. The vertical centre-line of the window cut-out shall be congruent with the one of the 19" rack.

Sufficient space, not less than 1.0 m, to other equipment or switchgear shall be kept free after opening the cubicles door at 90 degrees on the front plane.

Cubicle wiring and wiring on the frames shall be protected against mechanical damage when work is carried out inside the cubicles by facilities allowing easy removal and reinstatement. Each door shall be fitted with two flexible tinned copper strips on top and bottom with a minimum cross-section of 10 sqmm. With covers of boxes flexible earthing conductors having a minimum cross section of 6 sqmm shall be used for connecting any cover to a housing.

1.16.3 Swing frame

All cubicles for bay control units and substation monitoring and control system, protection relays and metering equipment shall be provided with swing frames and a glazed front door.

The swing frames shall be constructed of a rigid steel box section frame and at least triple folded mounting section. It shall be made of galvanised sheet steel and shall be equipped with a swing frame stay hinge. Free access of at least 50 cm width to the terminal blocks at the back of all installed equipment shall be achieved by using hinges of a sturdy design.

The installation kit shall allow an adjustment of the swing frame at any time in order to have it always plumb. Even with a heavy components load, swivelling shall be possible easily with the provision of chassis guides. Closing of swing frames shall be possible with one hand action only.

Swing frames shall have a punching according to IEC 60297 (19" series).

Each swing frame shall be fitted with two flexible tinned copper strips on top and bottom with a minimum cross-section of 10 sqmm.

The 19" racks and accessories, such as sub-racks shall be shock and vibration tested according to IEC 60068.

1.16.4 Mechanical Equipment

The cubicles shall be supplied completely with all locks, cable end boxes, floor fixing kits and anchoring devices, gland plates, bus-bars, internal wiring, terminal boards and accessories, such as wall brackets and angles as well as eye bolts, complete with reinforcement plates and the like. In the case of wall mounting cubicles all fixing accessories shall be provided.

Mounting plates inside the cubicles shall consist of rigid galvanised sheet steel with the edges folded backwards and the assembly systems used shall be of standard design and construction. Rails, brackets etc. shall fit to the pitch system of the basic support frame.

For incoming cables the cubicles shall have cable clamp rails equipped with sufficient cable clamps. Above that, suitable and well accessible earthing bars shall be mounted each providing two 13 mm-holes for the main earth connection to the earthing mesh of the substation. The earthing bars shall be equipped with sufficient number of earthing terminals. The earthing bars shall be mounted on isolators.

1.16.5 Keys and Key Box

Key locked switches as far as applicable shall be provided with an approved lock for locking in the neutral position. A similar lock shall be provided for each selector switch for locking the switch in any of its positions.

Approved means shall be provided for locking the cubicle doors, live terminal shutters, etc.

In general, each lock or padlock used shall be different from the others and shall be supplied with three keys. All keys shall fit to a master key system and six keys to open any lock or padlock shall be supplied.

Each key shall have one identification label attached to it and an identical label shall be fixed above the key hanging hook inside the key box.

The Bidder/ Contractor shall submit for approval a key list and plan/ schedule for the intended system to be provided for securing the electrical operations and interlocking by keys.

A key box shall be provided at the substation control room for storing the keys.

1.16.6 Packing and Marking

General

The purpose of the following general standards is to ensure that the Contractors pack and mark the materials according to acceptable standards and that the appropriate packing material is used. The Contractor is solely responsible for the quality of the packing material.

The Employer may, at any time, reject any packing or marking if it is deemed to be non-conforming to the standards specified in this contract.

If the packing is rejected, the Employer is entitled to have it redone, at the expense of the Contractor, and the latter will not have the right to claim the incurred expenses.

This specification is non-limiting.

The packing must resist all the risks associated with extensive handling by:

- Forklift
- Cranes (slings)

The packing must facilitate all types of handling.

The packing must be suitable to resist long periods of storage (that could extend to several months) under variable weather conditions, to consider deterioration factors typical to this kind of project, such as:

- Cold
- Damp heat
- Abundant rain
- Temperature fluctuations
- Saline air
- Vibrations
- Parasites
- Insects
- Etc.

The technical specifications, dimensions, material, and equipment weight are the other criteria to consider when designing and performing the packing.

Interior Packing

The packing shall be adequate and sufficient to avoid any damage to the contents during the handling or difficult transport conditions. In all cases, the items shall be arranged or wrapped in such a manner to minimize the volume.

The Contractor must wedge, shore or screw, as needed, or use any other available method to prevent the rupture of partitions, the free movement of pieces within the rigid container and prevent any damage resulting from shock or vibrations.

Fragile pieces unable to endure handling and difficult transportation conditions and those that cannot be disassembled shall be properly supported before the wrapping is done. All pieces that are rotating, sliding, and free moving or mounted on springs and whose movement is not blocked by a safety device shall be wedged and bound securely.

Exterior Packing

The following paragraphs describe the minimum requirements for packing. The material not specified in the following paragraphs must be packed according to specifications for equivalent material. The Manufacturer can refer to the basic guidelines of packing in ANSI/NAS and ISO Standards.

The packing shall be performed in conformance with the accepted standards for marine, railway or overland shipping. The materials shall be solidly packed to withstand the different means of transportation and on any kind of difficult roads.

All the equipment must be packed to be protected against any possible damaging effect caused by salt water (maritime packaging).

Packing of Electrical Equipment

It is the Contractor's responsibility to ensure that packing is adequate for transportation to site to guarantee integrity of equipment.

Any material liable to deterioration or corrosion must be packed in tightly closed crates.

Whenever fittings or accessories are removed from an apparatus for easier transportation, the openings left must be properly covered.

Cables or plug wires coming out of the apparatus must be wrapped with insulation tape and covered with a polyethylene film of at least 0.12 mm thick, to protect them from outdoor conditions. They must also be firmly fastened to the equipment to avoid deterioration while handling.

The equipment and/or the materials must be fastened to a structural wooden base built with wooden beams of 100 mm minimum thickness. The equipment must be handled with cranes using slings.

The packing of equipment to be transported by air must be made using plastic containers and materials as light as possible without compromising efficient protection against the risks associated with air transportation.

The items that can be gathered in bundles shall be sorted out according to length and size and the bundle shall be bound with steel strapping and shall not exceed 100 kg each.

The equipment and all the accessories shall be packed in closed crates, designed to resist the effects of negligent handling during overland and maritime transportation while loading and unloading and to prevent losses or theft. Besides, the packing shall be adequate to resist long periods of storage and outside exposure to all kinds of weather in harbour yards or any other places.

The crates containing the electrical equipment or fragile pieces must have an adequate mechanical reinforcement to ensure their stability. Open crates shall not be accepted.

All heavy crates or large crates must be clearly marked for handling while unloading and during overland transportation.

In particular, the marking must show how and where to install the slings and hooks for hoisting, pulling, and transporting the crate.

All the crates must have identification marks, as indicated in the marking chapter. When a shipment contains several packages, the latter must be identified in relation to the main equipment. If exists ferrous pieces assembled with the non-ferrous pieces, the former must be well protected.

The pieces liable to be affected by water condensation or humidity absorption while loading and during transportation must be packed with waterproof materials. All filling material must be of non- hygroscopic type.

In order to absorb the humidity, drying products must be placed in every crate.

The spare parts with precise machined surfaces or materials, with ferrous parts, must be specially treated and packed for perfect conservation for many years and under normal storing conditions.

The packaging may be subject to the acceptance of the inspector appointed by the Employer. The Contractor must submit the packing drawings for acceptance by the Employer.

Packing of Power Transformers and Shunt Reactors

If the power transformers and the shunt reactors are not fitted with skids or lifting eyelets they must be fastened to a base for shipping and handling. In all cases, the apparatus must be able to be loaded and unloaded and installed by means of a gate hoist, jacks and crane.

The disassembled radiators must be shipped tied to a solid wooden base. The radiators must not be in contact with each other to avoid damaging the paint.

The fan motors must be covered with a waterproof film kept in place with strapping (nylon strapping is not acceptable).

The porcelain bushings (HV and LV) must be shipped in crates to prevent them from breaking. The bushings can be packed in a slanted position on their own support so that the bushing insulation is always covered with oil. Each bushing must be lying on a solid base and protected by adequate filling material to avoid free movement during transportation. If the manufacturer deems it necessary, the bushings can be strapped with nylon belts to block them in place.

The control cabinet shall be shipped in a closed crate and must contain a silica gel bag to absorb humidity.

The accessories, piping, bolts, and materials other than those mentioned above, will be shipped in closed crates.

Packing of Structural Steel

Packing methods and the packing lists are the responsibility of the Contractor, and they shall be submitted for acceptance to the Employer who reserves the right to inspect the supplies and their packing before shipment.

The metal pieces are not to be stacked or packed before the chromate treatment is completely dry. The galvanized metal pieces stored outside must be on an incline position to permit the runoff of water.

All the galvanized materials shall be protected against the risk of corrosion such as "white rust" which might be caused by water, saline air, or prolonged humidity.

The bundles of angles are to be sufficiently attached and of sufficient size as to give them the resistance required for shipping. Each bundle is to contain the members of the same structure. The maximum weight of each bundle should be approximately three (3) metric tons.

Care must be taken during handling and shipping to avoid damage to the galvanization and/or to the chromate treatment.

The packing may be prepared once the manufacturing is finished. The pieces shall be assembled in tightly attached bundles, using packaging materials that will not oxidize easily so as not to damage the galvanization and/or chromate treatment.

The bolts, nuts and washers are to be packed by type and size in airtight new 2 ½ gallon drums (11 Liters).

The maximum weight of the 2 1/2-gallon drum is to be around 35 kg. The diameter, length, class and quantity along with the packing number and total weight of the drum is to be painted black on the side and top of the drum. The maximum weight of a pallet is limited to 3000 kg.

Protection against Humidity

- Waterproofing

Since the packing must be waterproof, it is important to avoid water condensation which promotes metal corrosion. Therefore, a waterproof film such as polyethylene or tarpaper must cover the equipment in such a manner as to allow sufficient ventilation for water evaporation.

- Dehydrating Agents

All goods sensitive to humidity and to contamination must be wrapped with plastic film or waterproof paper thoroughly sealed using a waterproofing method.

The Contractor shall generally use polyethylene; however, aluminium compound sheets are required for all electric and electronic equipment sensitive to humidity and contamination.

Silica gel, in bags of standard dimensions, must be placed in the most appropriate places inside the package to expose all the hollow spaces of the equipment to the dehydrating action of the silicate.

The quantity of silica gel bags for every package must be sufficient to maintain the humidity rate at 40 % for a minimum period of six (6) months.

This method, based on water absorption, can be used for any type of material.

Closed Crates

The Contractor shall limit the weight of crates to 3 metric tons.

The bottom of each crate must be reinforced so as to withstand the weight of the packed equipment and to resist vertical shocks.

The pieces of compact equipment must be solidly bound to the crate. All lifting points must be identified.

All crates must be mounted on skids.

The structural wooden members as well as the ones intended for forklifting must be placed on the points of high load concentration. They must be sufficiently thick (2.5 cm) to withstand the weight. The structural members must have a width of at least 10 cm and be screwed to the skids with bolts. There must be a spacing of at least 2.5 cm between the structural wooden members and the item, on the side and on the top. Fragile items must be protected by allowing a space between them ranging from 2.5 to 10 cm. This free space must be increased for items requiring no impact mounting.

The filling material that will fill the empty spaces inside the crates shall be synthetic. Wood shaving and shredded paper shall not be acceptable. The design of the crates must be in accordance with the weight of the material to be packed:

Less than 250 kg

The crates containing less than 250 kg shall be built with cleats of no less than 2.5 cm and the wood or plywood to be used shall be 1.9 cm thick.

The strapping must be steel belts 19 mm wide crimped with steel fasteners.

From 250 kg to 500 kg

The crates must be made with wood 1.9 cm thick. The bottom of the crate must be 2.5 cm thick, and the uprights must be made with 5 x 10 cm boards. The strapping must be steel belts 32 mm wide crimped with steel fasteners.

From 500 to 3000 kg

The crates to contain more than 500 kg must be mounted on a base with supports of at least 10 x 10 cm. The support shall be bolted to the base with bolts of 1.25 cm diameter, minimum. The wood thickness of the base must be more than 2.5 cm. The uprights must be 5 x 7.5 cm or more.

The walls must be made of wood or plywood, 2.5 cm thick.

The top must be made of wood, 2.5 cm thick with waterproof paper in between the two layers of the double top.

The corners can be reinforced with steel belts 3.2 cm wide. The crates will be strapped with steel belts 51 mm wide installed vertically and horizontally and in sufficient quantity proportionally to the dimensions of the crate.

Openwork Crates

Open work crates are used to ship material non-sensitive to outdoor conditions.

Materials to Be Transported on Pallets

To make material and certain containers handling easier (drums, crates) the usage of wooden pallets is required.

These pallets shall be solid, sturdy, and new.

The strapping must be carefully done and in sufficient quantity to prevent the packages from slipping.

Materials to Be Transported in Metallic Drums

New 2 1/2-gallon drums (11 Liters) shall be used mainly to transport bolts. Any other material to be transported this way shall be subject to acceptance by Employer. These drums shall be airtight to prevent water from entering during transport and storage. The bolts or any other materials shall be regrouped by size and diameter and properly identified.

The drums must be set on pallets to facilitate handling. They must be placed in a maximum of two rows. One wooden pallet must be placed on top of the drums to increase stability and compactness when stowing.

The weight of each pallet shall not exceed 3 metric tons.

New 45-gallon drums (204.5 Liters) can be used for small pieces such: gussets, splices. The weight of each drum must not exceed 200 kg. The drums must be set on pallets and be fitted with a lifting device (crossbars or lifting eyelets). The drums must have three holes (approximately 1 cm diameter) at the bottom to allow drainage of any water that might enter the drum.

The pieces transported shall not be in direct contact with the bottom of the drum, therefore wedges must be used. The pieces must not move inside the drum, so efficient blockage is necessary. A metallic lid must snugly cover the top to avoid water, mainly rain, from entering the drum.

Reels for Conductors and Cables

All cables shall be packed on wooden reels which dimensions shall be as a function of the length and size of the cables.

Packing Materials

The material specification described in this paragraph applies to all packing methods calling for this type of material.

Solid Wood

The solid wood to be used for packing must be new, solid and well dried. It must be free from rot, wear, clinker, holes, loosen knots and excessive deformations. The humidity degree must be between 10 and 20 %. The knots must be healthy-looking and not bigger than 1/3 of the width of the board.

Plywood

The plywood must be new, good quality and well dried. Three-layer plywood must be used for the crates with cleats and five-layer plywood for nailed crates.

Nails

The nails must be circular and preferably covered with a coating of cement or chemical glue. Other types of nails that may be used are with helical or ring-shaped shafts.

Strapping

The metallic strapping shall be made of non-annealed steel installed with a binding device and tied with steel fasteners. The steel must be protected against corrosion. Where the metallic belts touch the finished surfaces there must be protective pads at these points to avoid abrasion.

The dimensions of steel belts will be in accordance with the manufacturer's specifications and in relation to the weight of the bundle to strap.

Marking

The marking must be in English and must also be as big as the available space on the crates allows without exceeding 100 mm. A packing list, written in English, shall go along with each shipment and be attached to each crate. The packing list shall be in a closed envelope, covered with plastic.

All the crates must be marked on opposite sides.

The Contractor must, according to the destination site, identify the packages by writing the appropriate code that has been allocated to each site of final destination.

If tags are to be used, they shall be printed or typed with permanent ink and shall be solidly secured to the wooden surface by means of staples, nails, or tacks; if this is possible, they must be fastened with metallic wire or a very solid rope (the tags shall be waterproof).

Warning signs such as: FRAGILE, KEEP DRY, POISON, etc. shall be clearly indicated if the nature of the merchandise calls for it.

1.16.7 Electrical Equipment

1.16.7.1 General Requirements

All electrical devices and material shall be installed safe from finger-touch (finger safe) according to IEC 61032, if such is not given by the devices or material itself covers must be installed.

The electrical equipment shall be arranged so as to afford as may be necessary:

- Sufficient space for the initial installation and later replacement of individual items of electrical equipment
- Accessibility for operation, inspection and fault detection, testing, maintenance and repair

Care must be taken that all cubicle metering indicators, recorders, lamps, displays and other indicators and control switches are mounted at levels not less than 1.6 meters of the final ground floor level (cable plinth, if any, of enclosures shall be considered).

Operating devices not being installed at the front shall be mounted on the back of the cubicle clearly visible in an easily accessible position at a convenient height from the floor.

Indicating instruments shall be included for the functions listed. Measuring instruments shall be flush-mounted, quadratic switchboard types with 96 mm width and an accuracy class of 1.5 % or better, and with 90° or 270° scales. They shall be installed at approximately eye-height for easy reading by the operators, having anti-glare glasses.

Contacts of switches shall be of the self-cleaning type, mercury contacts are not acceptable.

All supervision circuits shall be in fail safe mode, fail of supply voltage shall result in a faulty status of any supervision.

The labelling of the individual devices shall be clearly visible and readable. Labels of synthetic or of aluminium foil with black letters on clear background shall be provided for all instruments, relays, control switches, push-buttons, lamps, breakers etc. Sticker paper labels are not acceptable.

All equipment is to be connected to the earth bus with individual wires. No looping of earth wires is allowed.

1.16.7.2 Reduction of Electro-Magnetic Interferences

In the secondary circuits the following are the minimum measures to be adopted to reduce EMI:

- Separation of the various circuits connected with devices having different degrees of interference level (power supplies, input and output network circuits, earth connections).
- Galvanic separation of the I/O signal circuits and of the auxiliary supply circuit lines with isolating relays, opto-diodes, transformers, coupling capacitors.
- Screens of cables shall be earthed.
- Screens of cables from the switch bay shall not be laid in the cubicle adjacent to unshielded circuits.
- Coils of relays shall have a protective circuit to limit the voltages, induced on the coil on circuit interruption, to a value that does not pose a danger to any connected electronic devices. The type of protective circuit (e.g. diode) shall be selected according to the intended function, under consideration of the prolongation of the contact switching time due to the protective circuit.
- Switching of loads with inductive component like contactors, solenoid valves, motors, etc.: A protective circuit shall be used to suppress the formation of an arc; the protective circuit shall be implemented directly at the load e.g. at the coil of the contactor; depending on the application the protective circuit shall be a diode, a series connection of diode and zener-diode, a suppressor diode, a varistor or a R/C combination.
- Separation (spacing out or different routes) as far as possible of power circuits from control cables.
- Separate cabling of the low frequency and high frequency circuits
- Twisted pairs or quadruple cables shall be adopted where necessary (i.e. low current circuits and data lines).
- Screen of low resistance, protected of the external high frequency electric and magnetic field from the cables shall be provided.
- Earthing of the screen shall have very low impedance with adequate section minimum length and optimum contact arrangements.

1.16.7.3Power supply

Generally, signalling and trip circuits, shall be fed by DC. For the particular electrical equipment to be installed reference is made to subsequent articles with special requirements and/or separate part of this specification.

The circuits shall be protected by adequate miniature circuit breakers with alarm contacts suitably wired and integrated in the overall alarm system of the substation. Particular attention shall be given to the selectivity of all MCB's. Fuses will not be accepted.

Completely separate and isolated circuits shall be used for Switchgear control, individual protection relays, redundant tripping, CB-motor, disconnector motors, alarms, interlocking circuit and further individual auxiliary devices.

1.16.7.4Heating and lighting

Each cubicle shall be illuminated by fluorescent light. The lighting shall be controlled by the cubicle door or by the swing frame through a switch.

Unless otherwise stipulated one 240 V AC socket outlet according to local standard for maintenance purposes shall also be provided inside the cubicle. The outlet shall be protected by RCD (residual current device).

Each cubicle shall be equipped with heater. The heater shall be controlled by humidity and by temperature.

The heater shall be located at a suitable position and its capability shall be as required to maintain the difference in temperature of 5 K above the dew point taking into consideration the specified environmental conditions.

Heating elements shall not be mounted onto the front door; they shall be installed vertically, with minimum all around clearances of 50 mm.

Heating and lighting circuits shall be protected by miniature circuit breakers with the necessary amount of auxiliary contacts for local and remote signalling.

Suitable temperature control to improve the internal convection of the cubicles temperature by a provision of forced air circulation, using internal fans, may be proposed. These fans (if any) shall be fed by the corresponding DC supply used in that particular cubicle.

1.16.8 Wiring

In selecting cable and wire sizes, due regard shall be paid to the appropriate derating factors in relation to the climatic conditions at site. All cables and wires shall continuously carry their rated currents under the worst temperature prevailing conditions, and shall also withstand maximum fault currents without damage or deterioration.

All secondary copper wiring within cubicles shall be in accordance with the relevant IEC standards, and shall also be selected to handle the rated nominal and test voltages. Test voltages are 3 kV AC/ 1 min. for current transformer (CT) and voltage transformer (VT) secondary's and 2 kV AC/ 1 min for others.

The colour coding of the wires shall be as per KETRACO standard.

Control wiring shall be of highly flexible stranded copper and must have a cross-sectional area not less than 1.5 sqmm. VT secondary's shall be wired with a cross-sectional area not less than 2.5 sqmm, CT secondary's not less than 4 sqmm.

Each end of each control wire and cable core shall be terminated with an insulated crimp-type connector sleeve or plug termination of industrial quality, preferably tinned brass shall be used and tinned phosphorous bronze for Faston-connectors. Correct size crimps and crimping tool shall be used throughout. Any bending of wire lugs by movements of the connected wire shall be avoided.

Each end of each wire and cable core shall be permanently marked with a securely fitted, non-combustible, thread-on type marking tag or sleeve. Alternatively imprinted or etched into the conductor insulation in more than one position is also acceptable. The tag/ sleeve/ imprint/ etch must be marked with a non-removable identifying code according to (withdrawn) IEC 391 Figure 11b, dependent local end marking.

The tag/ sleeve/ imprint/ etch must be clearly visible and readable, wiring on more than one level as e.g. with contactors or double layer terminals shall be spaced accordingly.

Conductors shall be laid in halogen free plastic ducts, as far as possible all circuits shall run along the shortest path to their addresses but only in horizontal and vertical planes. Diagonal runs are not acceptable. However, the wire runs shall not block access for testing or removal of any device when needed without disturbing other devices.

Wiring between enclosure and/ or mounting plate to swing frames and doors shall be performed as bundles in flexible cable conduits along with suitable conduit clips, providing conduit fixing, strain relief and cable tie eyelets. Movements of the door/ swing frame shall twist the wiring, a bending or folding of them is not acceptable. Each bundle shall be anchored such that the moving bundle length is the maximum available without loops.

All wires shall be led to terminal blocks for connection according to a connection diagram. Excessive looping between devices in the same cubicle shall be avoided as far as practicable. Direct looping of wires between devices in different cubicles, even if adjacent, will not be permitted.

All power circuits, control and protection wiring and low-level signal wiring shall be physically separated. Separate laying-way shall be provided for power cables, and the working voltage of each power circuit shall be marked on the associated terminals.

The filling degree of the cable ducts of the ready installed cubicle shall be not more than 75 %. This has to be regarded and checked already in the design phase of the project.

All wiring shall be installed such that the likelihood of damage during normal operation, maintenance and fault conditions is minimized. The practice of doubling back wires on themselves to absorb slack is not acceptable.

Separate screened multi-core cables of highly flexible stranded copper wires shall be applied for CT and VT connections. VT secondary circuits shall be equipped with dedicated MCBs in VT junction boxes and also in each cubicle with voltage measuring circuit connection.

Signals with a voltage beneath DC 60 V shall not run outside of a cubicle, and screened cables shall be used inside cubicles, where normal battery voltage used for motors and contactors is prevailing. Connections for indicating instruments and for the telecommunication circuits from transducers, or modem outputs, shall use individually shielded wire pairs together with a separate outer shield, earthed on both ends of the cable.

Soldered or wire strapped connections shall only be inside electronic systems. Any wire wrapping shall be in accordance with IEC 60352.

Fibre optic cables shall have a dedicated rigid mechanical protection cover.

1.16.9 Terminals

1.16.9.1 Terminal Arrangement

Terminal rows of the line-up and expandable type are preferred for all control wiring requiring external connections. They shall be segregated each by function and cabling destination with those going to a common destination allocated to adjacent terminal blocks. Segregation and fixing shall be performed by suitable end brackets.

Rows of terminals shall be spaced not less than 100 mm apart. Where plastic channels are used a minimum space of 50 mm shall be left between terminal boards and channel. Terminal boards shall be mounted vertically on TH 35 rails according to IEC 60715 at the sides of the cubicles. Terminal blocks in the rear shall be angled towards the front. The lowermost terminals shall have a minimum clearance of 200 mm to the incoming cable gland plate.

The arrangements shall be in such a way that it is possible to safely connect or disconnect terminals on live circuits when the cubicle is live. All terminal blocks shall be arranged straight in the cubicles, a sloped arrangement of terminals is not acceptable.

The connecting terminals shall be provided in such a number that all auxiliary cables running from other sections of the substation can be connected. Minimum ten percent spare terminals, but not less than four spare terminals of each type shall be provided on each terminal block in general.

The terminal block wiring shall be done in such a way that one side of the terminal blocks is kept free for outgoing cable connections. The termination of two conductors at one terminal is not acceptable, suitable bridges and links shall be used.

1.16.9.2 Terminal Marking

The terminal and terminal row designation shall correspond to the wiring diagrams. Terminals shall be provided with marking tags for wiring identification on both sides. One side of the terminals, facing towards the door or upwards, shall be marked with a consecutive numbering, preferably beginning with "1", from left to right or top to bottom. The other side of the terminals shall be marked with potential designations of power supply potentials, CT- and VT-terminals with the signalling designation.

Terminal strips for different voltage levels must be physically separated from each other and suitably identified, different potentials shall be at least segregated by additional insulation barriers. Terminals carrying dangerous voltages even when the main circuit-breakers are off must be marked with a particular colour and carry suitable warning labels.

1.16.9.3 Terminal Design and Material

Terminals for incoming power supply cables shall be suitable for connection of solid conductors with cross-sections from 2.5 mm² up to 35 mm², and they shall either be connected directly in series with standard terminals or shall have a sliding link to allow disconnecting and testing of the incoming supply circuit.

Terminals for control, trip and signalling circuits shall have isolation and test facilities, i.e. they shall be of type knife disconnect terminal with test socket for insertion of test plugs.

The CT terminal blocks shall have shorting, isolation and coloured insulated injection test facilities whereas VT terminals shall have isolation and coloured insulated injection test facilities. The switching status shall be clearly visible.

- Shorting shall be possible between adjacent terminals by a shorting bridge, being not removable without tool
- Isolation shall be possible by means of links, which can be securely fixed in the open and the closed position

- For injection test two integrated coloured terminal test sockets per terminal shall be available.

Performing of star point shall be realized with fixed bridges and earthing of secondary CT and VT circuits shall be in direction of the CT/ VT.

Connections to the CT circuits second to the star point shall have shorting facility in a phase-wise disconnecting and bypass function.

Terminals for metering purpose shall be covered and lead-sealed.

CT- and VT-terminal design is subject to a separate approval of the Employer/ Engineer.

Terminal blocks shall be conforming to IEC 60947-7-1 considering switchgear-specific items of IEC 62271-1 and IEC 61869. The value of the rated insulation voltage shall be at least 800 V, the individual rating and size shall be suitable to their application. They shall be designed to pollution severity degree 3 and material group III.

Terminals must be completely of non-corrosive material like copper alloy, corrosion protection is not applicable.

The insulating material of the terminals shall be of moulded, toxic free, non-hygroscopic polyamide (PA), inflammability class V0 acc. to UL 94 respectively IEC 60695-11-10 (-20).

Each individual block design shall have a foot design that ensures a secure fit on the rail and allows removal of individual terminals from the centre of an assembly.

Terminals shall be safe from finger-touch (finger safe) according to IEC 61032. If such is not given by the terminal itself (i.e. only back-of-hand-proof), transparent plastic covers must be installed. It shall be noted that such arrangement will only be allowed in exceptional cases and must be approved by Employer/ Engineer.

1.16.10 Relays

Auxiliary and interposing relays shall have adequate thermal capacity for continuous operation in circuits in which they are used. DC relays shall work with the substations DC voltage considering a voltage range between 80 % and 110 % of the rated voltage. The relays shall be designed for a duty ratio of 100 %. The electrical life time shall be more than 100'000 cycles (full loaded contact operation). The contact material shall be suitable for the intended application (e.g. low voltages and low currents).

1.16.11 Indicating Lamps

Indicating lamps shall be of the panel mounting filament type and low watt consumption. Lamps shall be provided with series resistors, preferably built-in the lamps assembly. The lamps shall have escutcheon plates marked with its function, wherever necessary.

Colour Coding shall follow IEC 60073.

When associated with push buttons, status indication lamps (e.g. OPEN/ CLOSED) shall be directly above the push button.

Lamps shall have translucent lamp-covers.

1.16.12 Control and Selector Switches

1.16.12.1 General

All control and selector switches shall be of the rotary control board type with operating knobs on the front and the operating contact mechanisms on rear. Each switch shall be provided with ample contact stages and suitable arrangement, to perform the function. Contacts of all control and selector switches shall be self-aligning and shall operate with a wiping action. A positive means of maintaining high pressure on closed contacts shall be provided. The covers or plates on the switches shall be readily removable for inspection of the contacts. All control and selector switches shall be designed for an insulation level suitable for the voltage of the circuit to be operated. All such switches shall be capable of satisfactorily withstanding a life test of at least 10'000 operations with rated current flowing in the switch contacts. All switches shall be capable of continuously carrying 20 A without exceeding a temperature rise of 30 °C and shall be capable of interrupting inductive loads of not less than 4 A for 220 V DC or AC.

1.16.12.2 Escutcheons and Name Plates

Each control and selector switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identifications shall be engraved on the escutcheons or on separate nameplates.

1.16.13 Push Buttons

Push buttons shall comply to IEC 60947. The protection degree according to IEC 60529 shall be IP67. The mechanical life time is required as minimum 5'000'000 switching operations. The necessary operating force shall be less than 5 N. The push buttons are to be provided with escutcheons and name-plates adequately describing their function. Where decided during design stage, protective covers are to be installed to prevent inadvertent pressing of the button. The buttons shall be coloured as given by the international standards, e.g. in case of open and close, as per the Employers standard or as decided during the design stage.

1.17 Padlocks and Key Cabinet

Non-ferrous padlocks with stainless steel shanks with different key changes and two keys for each lock and bay-wise submaster as per standard practices of KETRACO shall be provided.

Wall mounted lockable cabinets for the accommodation of padlocks and keys, whilst not in use, shall be provided and labelled in an approved manner so that keys can be easily identified. Duplicate keys shall be mounted in a separate cabinet.

For extensions/modifications to existing substations, the prevailing "master/submaster" system shall be matched. Control room doors and gates of the new substations shall be fitted with locks to suit the master series of existing substations. New substations shall be provided with key changes to suit the submaster series bay-wise. No grandmaster for each substation is required. Submaster series keys shall be locked off in a separate cabinet. All padlocks and keys shall be engraved with proper identification numbers e.g., circuit number, equipment number, etc. as per KETRACO standard numbering scheme. Locking facilities shall be such that it will accept sizes of padlocks & keys large enough to permit identification numbers, etc. to be embossed on them. Equipment shall be such that it can accept interlocks/scheme identical to that in existing substations.

1.18 Detailed Design and Engineering

The Contractor shall provide an identification system for the detailed design drawings, to facilitate reading and consultation.

The arrangement of equipment will be based on the following criteria:

- Electrical clearances: the distance between the parts under voltage and grounded structure will be based on the assigned level of insulation, the configuration of the earthing electrodes, and environmental conditions. The distance to the ground will be sufficient to ensure the safety of personnel or vehicles traveling in the substation. It will be calculated as the sum of the height of objects plus the clearance established previously (see IEC 60071 and documents of CIGRE Committee 23).
- Circulation inside the substation: the arrangement will allow access to all equipment with a vehicle equipped with the necessary facilities (crane) to ensure easy maintenance or recuperation.
- Expansion: the design shall provide for future expansion of feeder and transformer bays, as shown on the reference drawings.
- Access of personnel to live parts: when personnel can access energized equipment, structure or pad shall be provided to maintain a distance (according to electrical clearances) between the person and the live parts equal to the length of a fully extended arm in all directions. For reference purposes, the height of a person with a fully extended arm is at least 2.5 meters.
- Short-circuit withstand capability: equipment and busbars shall withstand dynamic and thermal stresses of short-circuit currents specified.
- Busbars: The Contractor shall include all materials to complete the busbar arrangement. In addition to its ability to withstand nominal and short-circuit currents, busbars shall be designed to account for mechanical stresses such as wind loads reactions to an earthquake, vertical deflections, and thermal expansion (see IEEE 605). The connections will be made using connectors or flexible stranded type conductors with associated accessories. It is not allowed to make rigid connections to main equipment. Measures should be taken to prevent the corona using the right accessories, joints, and shields for connections.
- All connections shall be mechanical; welding on site is prohibited.
- Structural loading tree: a drawing with an isometric representation of substation structures that shows the forces of the busbars, incoming lines, short-circuits, equipment weight, rigid busbars, seismic loads, etc. This information shall be provided to the manufacturer who is responsible for the detailed design of the station structures.
- Clearances for work safety: equipment shall be accessible to ensure safe maintenance. In principle, the maintenance area around high-voltage equipment (HV) is set to 5.84 m vertically and 6.8 m horizontally.

The Contractor will be responsible for the detailed design and take all necessary measures on site for the construction of electromechanical works including, but not limited to:

- Measuring soil resistivity (with the Wenner method), as defined in the IEEE 81 standard.
- The design and the calculation of buried ground grids, according to latest edition of the IEEE 80 standard.
- The detailed single line diagram, arrangement plan and elevation views and installation of equipment with their connection.
- Design calculations, details, assembly drawings for each type of structure and steel support as well as the general arrangement drawing of structures and supports.
- Calculation for the selection of conductors and bus bars of the substation.
- The design and the calculation of sags and tensions of tensioned cables (or strained busbars).
- Design and calculation (loading tree) of substation gantries and equipment bases.
- The design and calculation of busbars.
- The design and the calculation of both internal and external substation lighting

- The list of quantities for equipment and various materials.
- Batteries and battery chargers sizing.
- The load calculation for substation auxiliary services, including loads required for protection, control, SAS, and telecommunication equipment.
- The wiring diagram of equipment, with voltage drop calculations in the AC power cables and DC power of switching equipment.
- The design and the calculation for indoor and outdoor Fire Detection and Suppression Systems.
- Design and calculation for installation of both MV power cables, and LV signalling Cables
- Power and control cable schedules, as well as cables for SCADA system.
- Programming, configuration and adjustment of all software controlled digital devices.

The design of the electrical distribution system will be based on the following requirements, but not limited to:

- Redundancy: The supply of redundant equipment will be divided to ensure their availability. This redundant equipment includes auxiliary service transformers and wiring to the transfer panel, emergency diesel generator and its separate control power supply, battery chargers and their individual AC input from the switchboard and DC feeders to switchboard with moulded case circuit breakers, a separate DC power supply from primary and secondary distribution boards, etc.
- Service continuity: the loads are assigned to distribution circuits such that in case of failure of a circuit, the service will not be completely interrupted in a sector of the substation or control building. Adjacent outlets or lights and the mechanisms of high voltage disconnecting switches shall be supplied by different circuits.
- Voltage regulation: circuits shall be designed for a voltage regulation of the equipment supplied of $\pm 5\%$ to the terminals in AC and a maximum / minimum operating voltage in DC.
- Voltage drop: Size the cables shall be selected in such a manner that limits the voltage drops to the following values in normal operation:

Supply circuit	2.5%
Measuring and control circuit	2%

- Short-circuit interrupting capacity: the interrupting capacity of the protection devices shall be calculated and validated by the Contactor based on system impedances. The circuit elements connected shall withstand the short-circuit current for the time of the fault.

The wiring design will be based on, but not limited to, the following criteria:

- Separation / isolation of cable circuits: one cable should not transmit at the same time the redundant AC and DC circuits signals from various AC or DC power equipment, such as metering transformer current or voltage.
- Spare wires: Contractor shall provide spare wires in sufficient quantity such that at least 10% spare wires are available in the cable connecting two devices or two junction boxes.
- The cables will be laid separately according to their voltage level. AC power cables are preferably placed in cable trench bottom and DC cables on top.
- Power cables shall adequately be separated from AC/DC Low Voltage cables in accordance with the latest edition of IEC60502 standard and applicable IEC/IEEE standards. In addition, where power cables are installed on cable ladders/ trays, they shall be strapped together by Trefoil cable cleats at appropriate

intervals and that the cable shield/ screen of each cable shall be grounded in such a manner that prevents flow of circulating currents.

The earthing grid design will be based on, but not limited to, the following criteria:

- The soil resistivity is measured using the Wenner 4 electrode method, as defined in IEEE 81. Measures will be taken on site along the longitudinal, transverse, and diagonal axes. Measurements will be validated by comparing the curves obtained associating resistance measurements according to the distance curves which should correspond closely when measured in the same axis and relatively when measured in different axes.
- The ground fault current to be used for design of the earthing grid shall be the highest obtained for any fault inside substation limits, considering the final configuration of the station. It shall also consider reduced ground current with shield wires.
- The resistance of the grid will be less than the short-circuit impedance in direct sequence (in any voltage level) to ensure that all circuits remain effectively grounded.
- The ground potential rise shall be limited to a maximum of 5 kV according to final equipment configuration of the substation.
- Calculated values of touch, step and transfer voltages shall be less than the permissible values, as defined in the latest edition of the IEEE standard 80.

Characteristics of current and voltage transformers

- The Contractor is responsible for defining the final characteristics of the CT's and VT's cores for protective relaying functions, including ferro-resonance suppression schemes, to satisfy the performance requirements of the offered relays.
- The compliance of the CT's and VTs shall be documented and submitted for the Employer's approval prior to their manufacturing.
- Current transformer requirements shall be determined to ensure high protection performance. The Contractor shall submit a comprehensive technical report that includes the required CT burden calculations. The report shall confirm that CTs will be designed to ensure a saturation-free performance under both transient and steady state fault conditions, taking due account of system X/R ratios, system fault levels and remnant flux conditions in the CT core.
- Typical X/R ratio of 14 or system X/R ratio (whichever is higher) shall be considered for the 400 kV systems. The bus fault levels shall correspond to the respective switchgear ratings, unless specified otherwise.
- Current transformers shall be preferably of the low reactance type (for all secondary taps in case of multiple ratios). The performance shall not be inferior to that defined in the IEC Publications.
- The following minimum requirements apply:
- Maximum secondary resistance to not exceed 50% of the secondary rated burden.
- The wiring of CT and VT circuits and (cores) shall be in separate multi-core cables carefully segregated and screened. The CT neutral shall be earthed in the respective relay panels via an isolation link.
- The minimum cross section of CT circuits inside the protection cubicle / control cubicle shall not be less than 2.5mm² whereas for the inter panel / field cabling it shall not be less than 4.0 mm².
- CT / VT field cables shall have the colour code of Red, Yellow, Blue for phase cores and Black for the neutral core.

The outdoor lighting design shall be based on the following:

- Lighting placement of the substation shall be indicated on the reference location plan to comply with the requirements for light coverage below.

- Luminaires shall be installed on self-supporting posts and on columns of various structures to facilitate circulation in the substation and to illuminate certain control cabinets and junction boxes (including circuit breakers, disconnectors, and transformers).
- Recommended lighting levels are:
- Outdoor; switchgear bays, transformers (on all sides), reactors (on all sides), junction boxes, bay and switchgear marshaling kiosks, power distribution cabinets, Diesel fuel pumps enclosure: 50 lux (min.)
- Substation general area: 20 lux (min.)
- Parking Area: 30 lux (min.)
- Paths, access roads, internal roads, cable trench covers, internal fence(s): 30 lux (min.)
- Perimeter fence around total acquired substation land (as per official substation land boundary GPS coordinates submitted to Contractor): 30 lux (min.)
- Main entrance door : 100 lux (min.)
- Light Consistency Factor: 1.5
- General lighting shall be designed so that personnel can move around safely at night without the use of portable lamps.
- The lighting of the substation shall be supplied by independent automatically controlled circuits with a provision for manual control. One of these circuits will be configured to supply a limited number of luminaires as main lighting and will be controlled by photoelectric cells. Its lighting level will be about 25% of the normal level specified.
- The other circuits of the external lighting of the substation and of the paths shall be controlled by push-button switches. The control of these two circuits will be installed inside the main entrance door of the station.
- The minimum dimension of copper conductors in lighting circuits shall not be less than 1.5 mm².
- Luminaires shall consist of prismatic glass refractor, die-cast aluminium cage, ballast, and corrosion-resistant materials.
- The luminaires shall be watertight.
- The Contractor shall be responsible for establishing the appropriate number of lighting fixtures and determining the power of the bulbs to obtain the appropriate lighting level.
- Lighting poles shall be used at the main entrance gates of the substation, along the access roads outside the substation, along the internal roads inside the substation and along the substation perimeter fence around total acquired substation land (as per official substation land boundary GPS coordinates submitted to Contractor). The location of light poles shall not interfere with ductwork, overhead lines, station equipment and movement of heavy vehicles and equipment.
- The control of the switchyard lighting shall be carried out with electrical circuit breakers and photoelectric cells, with automatic and manual switch for manual control, connected to a permanently powered circuit. Additionally, permanently powered outdoor sockets / receptacles must be provided on light poles, without the need for separate circuits, for maintenance or additional lighting during repair work.
- The photoelectric cells shall be mounted at a high level in a shadow-free position and not facing any light source directly but accessible for maintenance.
- The mounting height of the luminaires shall be accessible by means of step bolts and a step ladder.
- Self-supporting posts for the Luminaires shall be designed and placed in locations with sufficient clearances from the live high voltage system to allow safe maintenance or repair works to be carried out without the need for shutdown on the main circuit.

The indoor lighting design shall be based on the following:

- Design of the interior lighting of the control building and the medium-voltage electrical equipment room
- The luminaires shall be installed on the ceiling of the control building.
- Recommended lighting levels are:
- Rooms for 415V AC main distribution panels, 110VDC and 48VDC battery banks, 110VDC and 48VDC battery chargers and distribution panels, UPS panels, basement cable chamber floor, corridors:
200 lux (min.)
- Rooms for Control Panels, Protection Panels, Metering Panels, SCADA Gateways/RTUs, offices, meeting rooms, MV Switchgear rooms, Telecommunication Panels, control room and office:
400 lux (min.)
- Other rooms: 150 lux (min.)
- Emergency lighting in all substation buildings including Control room building (CRB), guard house, storage facility, pump houses/shelters, most direct internal road route from CRB to main gate:
50 lux (min.)
- Light Consistency Factor: 1.5
- Minimum Maintenance Factor: 0.9
- Enclosure protection class: IP65
- Minimum luminous flux: 20,000 with 18,000 hours of service life
- The minimum size of the copper conductor of the lighting circuits shall not be less than 1.5 mm².
- The minimum size of the copper conductor of the socket circuits shall not be less than 2.5 mm².
- The luminaires in the control room and the office will be double LED tubes, 2x40 watts, prismatic glass.
- The luminaires in the auxiliary services room and in the other rooms shall be industrial, 2x40 watt, LED tubes.
- Single outlets with 240 V single-phase current shall be installed every five (5) meters on the surface of the interior walls of the buildings.
- LED tubes installed in the control room, offices, infirmary, workshop, store, electrical equipment room of the control building, all rooms for the operating personnel, and in all corridors, must be equipped with 2 x 40- watt prismatic lenses For the battery rooms, the luminaires shall be equipped with flameproof energized appliances/ lenses.
- Other rooms or indoor areas may be equipped with industrial equipment with 2 x 40-watt LED bulbs.

If the Contractor decided to start its work without the consent or approval of the Employer, the Contractor shall perform any remedial work required by the Employer because of its review, and he shall not be entitled to any claims or compensation for such remedial work.

1.19 Submittals

Detailed design drawings shall be submitted to the Consultant and Employer for approval before carrying out the work. Detailed design drawings to be submitted include, but are not limited to, the following items:

- Substations single-line diagrams showing the main characteristics of the equipment.
- The overview (plan view) of the substation general arrangement.
- Scaled elevations of different sections and bays of the substation.
- Cable trenches plan view and details.
- Substation outdoor lighting drawings.
- Earthing grid plan view.
- Details of equipment connection to the earthing grid.
- Equipment and gantry installation details.
- Equipment key interlock schematics.

An overview and scaled details of buildings showing equipment arrangement and dimensions, materials list item numbers, connection details, etc.;

Buildings AC and DC distribution drawings.

Substation three-line diagrams.

Protection DC schematics.

Protection relay settings.

Substation Control Monitoring System (SCMS) and telecommunication systems.

Arrangement details of protection panels.

Protection relays logic diagrams.

Arrangement and wiring drawings of junction boxes.

A complete list of connections (cable lists) for each station and each building, which shall include the estimated length and type of each cable (power, control and communication), the origin and destination of each cable and the nature of transmitted signals.

A list of cable quantities indicating the total length of each type of cable and the safety margin applied.

A complete list of materials with equipment identification conforming to the numbering system approved for the project. The number of each piece of equipment will also be used as a general reference for drawings, packaging, billing, customs clearance documents, etc.

The Contractor shall provide a calculation report, which shall include, but not limited to, the following items:

A detailed AC load list, including the validation of the auxiliary services transformer rated power.

A detailed DC load list, including the validation of batteries and chargers' capacity.

A table of measurements taken on site indicating the resistance with respect to distance curves, calculation of the resistivity of the first and of the second layer with the resistivity curves as a function of the distance, the calculation of the earthing grid resistance, the ground potential rise (GPR), the step, touch and transfer voltages.

The ampacity calculations for power cables in trenches.

The ampacity calculations of cable busbars.

Short-circuit withstand calculations for equipment, buried cables and strained busbars.

Lightning protection calculations.

Structural and steel supports design calculations.

Outdoor lighting calculations of substations.

Lighting calculations of buildings.

Optical link calculations.

Protection relay setting calculations.

The Contractor shall submit for approval to the Employer the protection studies for each substation, which shall define the philosophy of protection, and the protective relays proposed settings.

1.20 Completion Submittals

The following documents shall be provided at time of completion:

- The final detailed design as-built; construction, installation and interface wiring drawings..
- The final documents for each type of equipment.
- Calculation notes and final studies.
- The Operation and Maintenance manuals of each indoor and outdoor installation.
- All backup files for SCADA system contained in industrial laptop and flash disk.
- Protection relay setting and configuration files and all related software contained in industrial laptop and flash disk.
- Industrial laptop containing telecommunication software and files.
- Approved; type test reports, Factory acceptance testing reports and site equipment inspection and standalone testing reports, Civil works in-situ testing reports and pre-commissioning test reports.

The final as-built design drawings shall include the same drawings that the construction drawings and shall include all changes during construction and commissioning of the substations.

The operation and maintenance manuals shall include detailed operating instructions for each equipment taking into consideration the substation specific configuration and the results of the commissioning tests.

2. Transmission Substations

This specification sets out the general requirements for the design and engineering of new substations and the extension and modifications to existing substations.

2.1 Reference Documents

The following standards, and all standards quoted therein, shall be applicable:

- IEC 61936-1 – Power installations exceeding 1 kV a.c. – Common rules
- BS 7354 - Code of Practice for Design of High Voltage Open Terminal Substations
- IEC 62271-1 - High voltage switchgear and control gear – Common specifications
- IEC 62271-100 - High voltage alternating current circuit breakers
- IEC 62271-102 - High voltage alternating current disconnectors and earthing switches
- IEC 60099-4 – Metal-oxide surge arresters without gaps for a.c. systems

2.2 General Requirements

2.2.1 Requirements for All Substations

The substation arrangements and layouts shall be as shown on the drawings included in the bid documentation. These drawings are intended to show the basic requirements to be satisfied.

It is the responsibility of the Contractor to prepare a detailed layout showing the manner in which the various items of equipment offered can be accommodated to best advantage within the available area. In preparing the designs, the Contractor shall consider the safety of KETRACO personnel and others employed in the operation and maintenance of the substation, together with the safety of third parties who may approach the extremities of the substation. The Contractor shall also demonstrate the adequacy of the proposed design by calculation where required.

The arrangement shown on the bid drawings may be modified as necessary to accommodate the various items, provided the basic principles are maintained.

The Contractor is at liberty to offer substation arrangements based on significantly different principles where it is considered that these offer economies or technical advantages. It is emphasised, however, that the bidder's main offer should comply with the principles shown in the bid drawings, other arrangements being submitted solely as alternatives to the main offer.

2.2.2 Compliance with the Laws and Statutes of Kenya

It is the responsibility of the Contractor to ensure that any offer made is compliant with the laws and statutes in force at the time of bidding. Any changes occurring between the date of bid and the date of contract award will be dealt with in post-bid discussions.

2.2.3 Design Life of Substations

The structures, buildings and primary electrical equipment shall have a design life of 40 years. Secondary systems such as protection and control equipment shall have a minimum design life of 15 years.

2.2.4 Environmental

The substation and equipment used therein shall be designed to limit the environmental impact to a minimum and all statutory requirements applicable in the territory shall be complied with. Particular care shall be applied in the design of the substation to prevent the contamination of the ground and watercourses by oil or other liquid contaminants. Where gases are used in equipment or for other purposes care shall be taken to limit the release of "greenhouse" gases to a minimum. In particular SF₆ shall not be deliberately released to the atmosphere during construction, testing or maintenance.

Where equipment contains large amounts of flammable material, care shall be taken to limit the spread of fire to adjacent equipment or buildings. Where specified in the schedules large power transformers and shunt reactors shall be fitted with fire protection systems designed to suppress and extinguish fires in transformer compounds, limit the damage to the transformer/reactor and ensure that adjacent transformers/reactors are protected against the spread of fire. Adjacent transformers/reactors shall be protected from the spread of fire by constructing suitable firewalls. The system proposed shall be suitable for the particular conditions in the territory.

Care shall be exercised in the overall design of the installation and in the selection of plant and equipment to minimise the environmental impact of the substation.

2.2.5 Outage Constraints

Unless otherwise agreed by KETRACO the design of the substation shall permit installation, extension, operation and maintenance with one busbar and one circuit only out of service.

2.2.6 Plant and Equipment Identification

It shall be possible to clearly identify any plant, equipment, isolation device and earthing device for operation and maintenance purposes. Within any substation the identification system shall uniquely mark all necessary equipment and shall be consistent with existing identification systems.

The markings used shall be durable and remain legible for the lifetime of the equipment.

The identification system shall include but not be limited to:

- Circuit breaker, disconnector, earth switch mechanism boxes, busbar sections, current and voltage transformers
- Busbar sections, current transformers and voltage transformers
- Pressure gauges or indicators and associated pipework
- Valves
- Control handles, switches or push buttons

- Points of isolation for secondary systems
- Cabinets, cubicles and kiosks

2.2.7 Access for Substation Operation

It shall be possible to gain safe access to the control point and locking-off point of any device that is used by operations staff during their normal duties without the use of portable access equipment. Road access shall be provided to all outdoor air-conditioning plant for ease of repair and maintenance. All operational access shall be suitable for use by a person working unaccompanied.

2.2.8 Maintenance Requirements

It shall be possible to gain safe access to any device that requires in-situ maintenance by maintenance staff during their normal duties, from ground level by fixed access platforms. Similarly, any device that requires disconnection and removal for off-site maintenance or for replacement shall be readily accessible to both personnel and lifting equipment where required.

Adequate space shall be provided to allow access for maintenance equipment, mobile access platforms, mobile cranes to any substation equipment that may need to be maintained. The substation surfaces provided shall be suitable for movement of such equipment and where heavy plant items need to be moved suitable roads shall be provided. Access roads shall also be provided within the substation from the Main Gate to substation main buildings, relay rooms and outdoor air handling equipment.

2.2.9 Cranes and Lifting Equipment

Fixed cranes are not required for outdoor "Air Insulated" installations but care shall be exercised in the design of the installation to allow access for lifting the largest factory assembled sub-component of any equipment without requiring the shutdown of adjacent circuits.

2.2.10 Interlocking

Electrical and mechanical hardwired and software interlocks shall be provided. Padlocking to the requirements of this specification shall be provided for operational security.

2.2.11 Philosophy

All circuit breakers, disconnecting and earthing devices within the substation shall be interlocked in a manner that ensures that they always operate safely. The system employed shall ensure that unsafe switching actions are prevented. Such interlocking shall be achieved by electrical means in a manner that permits the equipment to perform any safe operation. Contacts used for interlocking shall be directly driven auxiliary contacts of the main device.

2.2.12 Principles

The following assumptions shall be made:

- a. Disconnectors are capable of switching the capacitive currents of associated connections.

- b. Disconnectors have neither load making nor breaking capacity.
- c. Disconnectors are not capable of making or breaking transformer magnetising current.
- d. It shall not be possible to operate any earth switch unless the point of application is disconnected from all possible sources of supply, and the operating devices of the disconnectors providing the points of isolation are locked in the open position. Where one of the points of isolation is remote, the isolation of that remote supply will be confirmed by other means, e.g. by monitoring the VT secondary output voltage and a suitably inscribed warning label shall be fitted to the earth switch operating device.
- e. It shall not be possible to operate any disconnectors if an associated earth switch is already closed except where special maintenance provisions have been made.
- f. Where the load-breaking device is situated remote from a disconnector and cannot be fully interlocked the disconnector operating mechanism shall carry a suitably inscribed warning notice.

2.2.13 Substation Auxiliary Cabling

Substation auxiliary cables (power and control) between substation buildings, relay rooms, marshalling points and primary equipment shall be installed in cast concrete trenches or cable tunnels on purpose made corrosion resistant racking. The use of buried cable ducts is acceptable for routes to individual equipment and short lengths of direct buried armoured cable may be acceptable provided the location of such cables is clearly recorded.

Where cables emerge from trenches or ducts, care shall be taken to eliminate tripping hazards and cable trays or racks used above ground shall be designed and installed so as to avoid dangerous edges or projections.

To limit the risk to personnel and equipment from smoke and corrosive fumes all auxiliary cabling shall be of a low fume, zero halogen type.

Spacing between successive cable support brackets within the cable trench shall be maximum 750mm. Extra support brackets shall be provided in case of bends and crossings. Suitable trench covers and their support shall be provided at the bends and crossing of cable trenches. 40% spare space shall be available in individual tiers for laying cables in future. Number of layers in individual tiers shall be decided based on cable capacity calculations and is subject to approval by the Project Manager.

2.2.14 Equipment Ratings

To ensure long-term suitability of equipment and switchgear installations are rated to take into account the projected development of the KETRACO system. The minimum values given are those required after any de-rating factors (from Standard IEC testing conditions) associated with the climatic conditions prevalent in the territory. The contractor shall demonstrate by reference to type test information and calculation or by re-testing at the required ambient temperature that the equipment offered is suitable for the minimum site rating required.

2.2.15 Voltage Ratings

The required voltage ratings are given in the relevant equipment Schedules of Technical Information.

2.2.16 Rated Short Circuit Withstand Current and Time

The required ratings are given in the relevant equipment Schedules of Technical Information.

2.2.17 Rated Continuous Current

The required continuous current ratings are a function of the circuit application. The values for each application are given in the application documents included in the relevant equipment specifications.

2.2.18 Insulation Coordination Studies

It is in the scope of the contractor to conduct the complete insulation coordination studies, including collection of all the data necessary as input for the studies. The dielectric strength of equipment shall be selected accordingly, but minimum the data as given in Tender Documents shall be fulfilled.

According to IEC, insulation coordination is “the selection of the dielectric strength of equipment in relation to the voltages which can appear on the system for which the equipment is intended and taking into account the service environment and the characteristics of the available protective devices”. It shall be carried out in accordance with the methodology and guidelines outlined in IEEE standard 1313.2-1999, IEC 60071-2, 4 and CIGRE WG 33-04 recommendations and IEEE technical papers presented in various forums.

The procedure for Insulation coordination consists of :

- a) Determination of voltage stresses
- b) Selection of the insulation strength to achieve the desired probability of failure.

The voltage stresses can be reduced by the application of surge-protective devices, switching device insertion resistors and controlled closing, shield wires, improved grounding, etc.

The studies shall comprise of three basic steps:

1. Determining the Overvoltages in the system, which are temporary Overvoltages, switching Overvoltages and lightning Overvoltages.
2. Selecting surge arrester ratings and locations or other mitigation equipment or operating restrictions, to ensure that system-imposed Overvoltages do not exceed the insulation strength of the equipment including appropriate protective margins.
3. Deciding the voltage ratings, basic lightning impulse level (BIL), basic switching impulse level (BSL) (wherever appropriate) with required margins or establishing the adequacy of these parameters for equipment by calculating the available protection margins.

The resulting report shall describe the configuration selected for the study, modelling concepts and software used. It shall include lightning stroke current selection, analysis of lightning overvoltage performance for determination of voltage stresses at surge impedance transition points under shielding failure or direct stroke and back flash over conditions and switching surge voltage study for the line energization, line re-energization with trapped charges and also for fault occurrence and fault clearance. The report specifies the selected type, number and location of surge arresters, determines whether the Overvoltages are below the required withstand voltage and the selected

BIL and BSL of the substation and indicates the minimum protective ratio for lightning and switching study as per the standard IEEE C62.22-1997.

2.3 Air Insulated Substations

2.3.1 General Design Requirements

The substation design should be such as to limit the number of levels of conductors and to ensure that the consequences of a failure of one set of high level conductors including earth wire conductors are kept to a minimum. All materials and equipment for use in the substation shall be suitably rated to meet the site conditions specified in the schedules.

All gantry type structure supporting conductors shall include facilities for ready access to all insulator sets. There shall be permanently attached climbing devices with guard-rails and access to high level beams shall not be possible without proper authorisation. Safety screens shall be provided between adjacent circuits to maintain the specified safety clearances and to prevent accidental access to live circuits.

Vehicle access to permit the transport of major switchgear equipment shall be provided. This shall be achieved without the need to de-energise adjacent circuits or busbars. Access for vehicles that require the de-energisation of circuits shall be kept to a minimum.

Each substation shall be adequately protected against direct lightning strikes, either by the use of spikes or earth wires located on the substation structures: the use of spikes is preferred. The height, location, and number of spikes or earth wires shall be such as to protect all equipment installed within the substation to a failure rate of shielding from direct lightning strikes of not greater than 0.1 per cent per annum.

Where the connection to the substation is by overhead line, overhead line conductors will be terminated either at the substation gantry structures or to anchor blocks adjacent to the overhead line terminal towers. The overhead line conductors complete with tension insulators, line tee off clamps, and compression fittings (bimetallic where necessary) shall be supplied and erected under a separate contract unless otherwise stated. The substation gantries shall provide the necessary fittings to connect the OHL conductor tension insulators and the earthwire. The conductors from the line tee off clamps to the substation equipment are included in the scope of works.

Where specified, the overhead earth wire will be extended into the substation and the substation gantry structure shall be arranged to receive this. Otherwise the earth conductor will be terminated at the overhead line terminal tower.

Where disconnectors are of the pantograph type, the contact arrangements shall cater for conditions of maximum wind loading coincident with either the maximum or minimum ambient temperature and shall conform to the requirements of IEC 62271-102.

The primary electrical connections in the substation shall be designed to withstand the combinations of atmospheric, geophysical and electromagnetic forces to which it is subjected at the particular location. The insulators, structures and equipment terminals supporting the connections shall not be subject to forces exceeding their design values and all primary connectors used for the attachment or jointing of conductors must be capable of withstanding the forces applied. The effects of short circuits shall be calculated in accordance with the requirements of IEC 60865. The contractor shall declare the combinations of forces used as the basis for design of the connections and their supporting structures.

All type testing shall be performed in line with the requirements of this Specification, in an manufacturer independent accredited test laboratory and/or witnessed by an independent accredited third party. Accreditation to the testing laboratory/ third party shall be given by an according signatory member of International Laboratory Accreditation Cooperation (ILAC).

2.2.19 Insulation Requirements

All external insulation shall be porcelain, of good quality, dimensionally accurate and rated to suit the application. The external creepage distance shall be based on 31mm/kV of highest phase-to-phase system voltage and the design shall comply with the recommendations of IEC 60815.

2.2.20 Movement of Conductors

The design of the substation shall ensure that the clearances specified are maintained under all conditions of movement of conductors due to wind, short circuit or other external influences. Where necessary additional insulated supports shall be provided to control movement but their influence on substation availability and reliability must be evaluated.

2.2.21 Application of Horizontal Clearance

Wherever possible the appropriate vertical design clearance shall be applied in all directions. In any design where this practice has not been followed, the application of horizontal clearance is to be identified on the drawings submitted for approval.

2.2.22 Conductors Entering the Substation

Where un-insulated conductors cross the substation perimeter fence or wall, care shall be taken to ensure that statutory clearances are not infringed and that care is taken to maintain clearances to street lighting furniture adjacent to the line entry.

2.2.23 Substation Equipment Adjacent to the Perimeter Fence or Wall

Safety working clearance shall be maintained between high voltage equipment and the substation fence (wall).

2.2.24 Insulators and Fittings

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to the development of defects. Hollow insulators shall comply with IEC 62155 and CENELEC document EN 50062.

Insulating material shall not engage directly with hard metal. Where cement is used as fixing medium, cement thicknesses shall be as small and even as possible and proper care shall be taken to centre and locate the individual parts during cementing.

Each insulator shall be legibly and indelibly marked as required by the appropriate IEC together with such other marks as may assist in the representative selection of batches for the purpose of type tests. For glass insulators these marks may be applied by sand blasting. Marking of ceramic insulation by indentations will not be accepted.

2.2.25 Suspension and Tension insulators

Disc insulators may be of ceramic material or toughened glass, and together with their metal fittings shall comply with the requirements of IEC 60383. Their mechanical characteristics and dimensions shall comply with IEC 60305, whilst the ball and socket couplings, retaining pins and locking devices shall comply with IEC 60120 and IEC 60372. The locking pins shall be of phosphor bronze.

The locking devices shall be formed such that when they are set only extreme deformation of the retaining pin or locking device will allow separation of the insulator units or fittings or cause any risk of the retaining pins or locking devices being accidentally displaced. Their design shall allow easy removal or replacement of the insulator units or fittings. When in position the retaining pins or locking devices shall be independent of the degree of opening applied to the retaining pin or locking device after insertion. A common design of retaining pin or locking device shall be used for each complete insulator set.

All ball and socket joints of insulator sets shall be lightly coated with grease.

2.2.26 Busbars, Connections and Structures

The system of conductors connecting high voltage equipment, including supports, structures, insulators and the high voltage equipment itself shall be designed to withstand the maximum force that may be applied to it during its lifetime.

The design of busbars, connections and structures shall be generally as set out in BS 7354: 1990 Section 3, with parameter values appropriate for the KETRACO system. Alternative methods for the design of busbars connections and structures will be considered by KETRACO where it can be shown that such methods offer a technically compliant design. In all cases, supporting calculations must be provided.

2.2.27 Movement of Vehicles

The design of the substation shall permit the safe movement of vehicles up to 2.4 metres high, within the substation on designated routes. Lockable height barriers shall be installed at all entrances to the substation to prevent uncontrolled access of vehicles exceeding the maximum allowable height.

Adequate ground bearing pressure shall be provided on all designated routes and other locations within the substation where it is necessary for vehicles to be manoeuvred, such that any underground installation is unaffected by such movements.

2.2.28 Earthing of Substation Conductors

Sufficient facilities, designed to permit the application of fixed or fully rated portable earthing devices for the safe maintenance of substation equipment shall be provided. The existing earthing principles shall be applied for the extensions and modifications.

The application of portable earthing equipment shall be considered and where a conductor configuration, angle of approach or size prevents the direct application of a portable earth clamp, a supplementary connection facility shall be provided. Provision shall also be made for the connection of the earth end of the portable earth at each location noting that several leads may be required to achieve a fully rated connection.

2.3 Testing and Inspection

All type testing shall be performed in line with the requirements of this Specification, in an manufacturer independent accredited test laboratory and/or witnessed by an independent accredited third party. Accreditation to the testing laboratory/ third party shall be given by an according signatory member of International Laboratory Accreditation Cooperation (ILAC).

2.3.2 Busbar Conductor and Connections

The busbars shall preferably be from standard aluminium conductors in accordance with IEC 60209, supported on porcelain insulators. They shall be suitable for maximum specified short circuit fault rating and for satisfactory continuous operation at the site ambient temperature of +40°C. The busbars shall be arranged so that each busbar can be independently isolated for maintenance.

Satisfactory test evidence to IEC 62271-100 and IEC 62271-1, shall be submitted to confirm the performance of the equipment at all site conditions.

2.3.3 Post Insulators

Where applicable, each type of post insulator being provided shall be type, sample and routine tested in accordance with IEC 60168, IEC 60660 and the following supplementary tests:

2.3.3.1 Radio Influence Voltage Type Test

Each type of post insulator being provided shall be assembled as in service and subjected to radio influence voltage test in accordance with NEMA Publication 107, IEC 60060 and IEC 60437.

2.3.4 Insulator Strings

Where applicable, type and routine tests on insulators of the string type, porcelain or glass, shall be made in accordance with the requirements of IEC 60383 and IEC 60815 and the supplementary type tests stated below.

2.3.4.1 Dielectric Tests

The 50 per cent flashover level as well as withstand shall be determined during the impulse and power frequency tests.

2.3.4.2 Radio Influence Voltage Test

Each type of string insulator shall be assembled as in service and subjected to radio influence voltage tests in accordance with NEMA 107, IEC 60060, IEC 60437 and this Specification.

2.3.5 Large Hollow Porcelains

Where applicable, each type of large hollow porcelain being supplied shall be subjected to the routine and sample tests specified in IEC 62155, modified and supplemented as follows:

2.3.5.1 Routine Pressure Test

Each hollow porcelain being provided shall be subjected to the appropriate routine hydraulic pressure tests in accordance with the requirements of this Specification. The test shall be made on the porcelain complete with irremovable metallic flanges.

2.3.5.2 Temperature Cycle Test

These tests shall be made on the porcelain complete with all irremovable fittings.

2.3.5.3 Routine Bending Test

If the stress expected on the porcelain in service exceeds 20% of the minimum failing load then the following routine test shall be made: -

Each porcelain shall be subjected to a cantilever bending test such that the insulator is fully stressed in all directions, but in the event of a point loading procedure being adopted and the number of points at which the load is applied shall be a minimum of four. The applied bending moment, arrangement for test, and test procedure shall be to the approval of KETRACO.

2.3.5.4 Sample Bending Test

When the porcelain service stress is less than 20 per cent of the minimum failing load then sample bending tests shall be made as specified. Samples shall be selected as specified in IEC 62155.

2.3.5.5 Ultrasonic Tests

Routine tests shall be made on each porcelain insulator being supplied using ultrasonic crack detection techniques. These tests shall be made on the insulator prior to the fitting of metallic flanges.

2.3.6 Structures

Where applicable, a representative sample of each type of support structure being provided shall be assembled prior to despatch to site, and loads applied which simulate the specified design parameters.

Such loads shall be withstood without deformation of any structure member.

2.3.7 Site Tests

After the plant and ancillary equipment have been erected and connected up on site, the Contractor shall carry out to the satisfaction of KETRACO such tests as may be required to prove compliance with the specification, independently of any tests carried out at the manufacturers' works.

Not less than thirteen weeks before any section of the plant is required to enter commercial service, the Contractor shall submit, for the approval of KETRACO, his detailed site test proposals for that section of the plant, together with details of the test equipment and methods that he proposes to use. Subject to approval of the tests, these will be written by KETRACO into an overall programme of tests, which will be issued to all directly concerned prior to the starting date for the tests.

KETRACO shall have the right to witness all tests, and the results must be available to them as the tests proceed. They may recommend waiving of some tests, or may add further tests if considered necessary to prove compliance with the Specification.

Clear records of all tests necessary before the plant can be regarded as ready to be first connected to KETRACO's system shall be maintained by the Contractor and submitted to KETRACO in duplicate. KETRACO requires this information before the plant will be accepted for initial energising.

Initial energising and all subsequent 'live' tests will be directed by KETRACO and carried out jointly by KETRACO and the Contractor. They will be subject to KETRACO's standard safety procedures, and all operational switching will be carried out by KETRACO according to a detailed programme, which KETRACO will prepare and which will be agreed in advance between both parties.

During these 'live' tests the Contractor shall remain responsible for the performance of his plant. A record of the results of the tests in this category will be made available to KETRACO.

The Contractor shall submit to KETRACO for approval a list of recommended settings for all protection and other types of automatic equipment, not less than thirteen weeks before such equipment is required in commercial service. Where the settings involve discrimination with settings of an existing network or plant supplied under a separate contract, the relevant information will be supplied to the Contractor.

The following is a list of minimum site test requirements for HV power cables, LV power and multicore cables and protection equipment. Further test requirements are specified in the respective chapters.

The programme for system tests will be issued by KETRACO.

2.3.7.1 Tests

For site tests, the following shall be performed in particular:

- Voltage drop tests during commissioning.
- CT polarity check
- Humidity tests of SF₆ gas during commissioning, three months after that, before issuance of FAC, and at each refill operation. Critical dew points are subject to the approval of KETRACO.
- RFI discharge test on complete substation by means of a UHF detection.
- Power frequency voltage test for switchgear and auxiliary circuits. In case of a breakdown, the above-mentioned site tests shall be repeated from the beginning.
- Checks on motors, operating mechanism, closing and tripping devices.
- Time measurement for Circuit breakers; spring charging devices, isolators and earth switches.
- Tests on current transformers and voltage transformers
- Tests on surge arrestors and bushings
- Power transformer tests & shunt reactor tests
- Any other tests as required by KETRACO.

For the above, all test results and calculations evidencing the ratings under site conditions have to be submitted for approval to the satisfaction of KETRACO.

The Contractor shall prove that the HV circuit breakers are capable of interrupting

- The capacitive current, to IEC 62271-100 and
- The inductive currents for switching shunt reactors to IEC 62271-110 under site conditions.

Test evidence shall be submitted to confirm that the highest overvoltage during any switching duty does not exceed 2.5 p.u., by either performing the relevant tests or by submitting the relevant type test reports to the satisfaction of KETRACO.

The Contractor shall furthermore advise and guarantee the minimum number of switching operations for the conditions as mentioned above within the arrangement as designed by him.

2.3.8 Documentation with Bid

The Bid shall contain at least the following information and documents, failure of provision of the mentioned documents will lead to disqualification:

- a. General layout drawings of the substations;
- b. Single line diagrams of the substations;
- c. General arrangement drawings of switchyards;
- d. Manufacturing specification of the main equipment;
- e. Catalogues, literature, reference lists of all proposed equipment, sufficiently detailed in such a way that the Client/Consultant may have full and complete knowledge of the Plant and equipment offered.
- f. Type test certificates from an independent testing authority or independently witnessed;
- g. Quality Management System Manual and ISO Certificate of the equipment manufacturer.
- h. Verified bid drawings (General SLD, Layout, SLD of LV Supply Systems, PSLD, SAS, Telecommunication, Civil and Transmission Line);
- i. List of major components of equal or similar design, size, and/or capacity indicating:
 - Location, Title of the project, Total Contract Price. Time for completion
 - Size, number and major parameter of units supplied;
 - Name and address of the Client including contact person and country;
 - Date of contract award & date of commissioning;
 - Client's letter expressing opinion of the work done.
- j. Experience list for any proposed major sub-contractor in particular civil sub-contractor, if any, indicating his experience in major capital projects of this nature and the high quality of workmanship required.
- k. Major sub-suppliers or sub-contractors

- l. Statement of the Tenderer's financial standing (audited statement for last 3 years) including the name and address of his banks and the authorization of Employer to approach Tenderer's bankers for relevant information and comments and audited reports for the last three years.
- m. Project Schedule (Milestones & Gates)
- n. HSE Plan
- o. Risk Register
- p. A detailed program of design, manufacture, shipping, erection, testing & commissioning and the civil works
- q. Methodology and execution plan for completion of construction works within project schedule and put into commercial operation excluding a period for mobilization for each substation.
- r. Additional documents as requested in clause 2.5.1.

2.3.9 Additional Documents to be submitted with the Tender

In addition to the Tender Documents issued for tendering, it is mandatory for the tenderer to provide and properly bind in the Prime Document; the following additional documents shall be submitted in addition.

- a. A copy of each Circular Letter and Addendum, if any, issued by the Internal Tender Committee of Client, appropriately endorsed by the Tenderer.
- b. A statement giving the name(s) of the person(s) authorized to sign Agreements on behalf of the Tenderer including his (their) specimen signature(s).
- c. The proposed Organization Chart, giving details, numbers and categories of the supervisory and technical staff, their qualifications, previous appointments and experience, together with Curriculum Vitae of the supervisory and technical staff and the estimated labor force to be employed in the Works.
- d. CVs for the Key staff proposed for this project. Also bidder shall submit the current assignments of the proposed key staff associated and status of the project. Moreover, bidder shall declare the proposed key staff will be available for this contract in the event of award.

Tenderer must submit with his tender a list of all local and expatriate employees employed in the Company. Giving the name of the employee, job category, and unit rate per month (monthly salary) in the prescribed forms included in the Tenderer's Enclosures. Tenderer engaging a high proportion of local employees shall be given preferential consideration.

- e. A list of all major works which the tenderer has completed within the past five years and of all works which are presently under construction, giving the name of the Client, Consultant, location, value, duration and date of completion.

- f. A list of any proposed sub-contractor and suppliers, including local firms, with particulars of the extent of the work, which it is proposed will be undertaken by them.
- g. A statement signifying that a Site inspection has been made and that the tenderer has no doubts or queries regarding the site, ground conditions, access, permits, or permission required concerning the Contract (if site visit to be mandatory in the tender).
- h. A tender Bond as per Part-1, Section II-Bid Data Sheet in ITB 19-1, 20-1 and Form of Bid Security, obtained from a locally registered insurance Company or Bank.
- i. A list of manufacturer's recommended spare parts and special tools giving description, numbers and unit price as required by Specification and Bill of Quantities.
- j. A statement of unresolved doubts regarding the meaning of anything contained within the Tender Documents and the interpretation relied upon by the tenderer.
- k. A statement confirming that the tenderer is fully aware of Kenya Standards and KETRACO's HSE Policy & Procedures.

2.4 Documentation after Award of Contract

All documents required for KETRACO's approval shall be submitted by the Contractor.

3. Open Terminal Switchgear

3.1 General

All switchgear offered shall be safe and reliable and shall have a minimum of three years of service experience in three different countries.

External parts of the switchgear shall be of porcelain and their profile shed shall be suitable for the worst site conditions.

The switchgear shall be suitable for satisfactory continuous operation at the specified minimum rating, at the maximum site ambient temperature of +40°C, 24 hours a day, 365 days of the year. Satisfactory test evidence shall be submitted to confirm the performance of the equipment at all site conditions.

The switchgear shall be fully type-tested in accordance with IEC 62271-100 and IEC 62271-1. All type tests shall be either carried out by independent testing laboratories not associated with the manufacturers or witnessed by KETRACO Observers. Type-test certificates shall be submitted for approval by KETRACO.

3.2 Circuit Breakers and Operating Mechanisms

3.2.1 Circuit Breakers

This specification defines the minimum technical requirements to design, manufacture, and testing of high voltage circuit breakers to be installed in the Rumuruti, and Kabarnet Substation.

- The 132kV,33kV circuit breakers shall be SF6 circuit breakers of the outdoor type .
- The 132 kV circuit breakers (Line Side) shall be of single pole, double break (double interrupter)per pole type while 132kV circuit breaker for Transformer feeder shall be of 3-pole type..

Codes and Standards

The circuit breakers specified in this technical specification shall be manufactured, tested and shall comply with the latest editions and amendments of applicable IEC and ISO standards including:

IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 60815	Guide for the selection of insulators in respect of polluted conditions
IEC 60947-1	Low-voltage switchgear – Part 1: General requirements
IEC 61869-2	Transformers – Part 2: Additional requirements for current transformers
IEC 62271-1	High-voltage switchgear – Part 1: General requirements
IEC 62271-100	High-voltage switchgear – Part 100: AC high voltage circuit breakers
IEC 62271-110	High-voltage switchgear – Part 110: Inductive load switching
IEC 62271-310	High-voltage switchgear – Part 310: Electrical endurance testing for circuit breakers above a rated voltage of 52 kV
IEC 60376	Specification of technical grade Sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
ISO 9001	Quality management system – Requirements

The applicable additional standards are the ISO, DIN / VDE, CENELEC, BS and US standards or national specific standards listed above, if no relevant IEC / IEC standard exists or if there is insufficient information available in IEC / IEC standards and / or explicitly requested in this standard.

The Bidder shall provide, with its offer, valid certificates which prove that the Manufacturers and suppliers proposed are ISO 9001 certified and conform to RoHS certifications. Manufacturers who do not have sufficient

experience in the manufacture, installation and testing of HV circuit breakers as specified and / or not ISO 9001 certified and that do not comply with RoHS will not be accepted.

The standards listed below are of particular importance for documentation.

IEC 60617	Graphical symbols for diagrams
IEC 61082-1	Preparation of materials used in Electro technology – Part 1: Rules
IEC 61131	Programmable controllers
IEC 61355	Classification and designation of documentation for plants, systems and equipment
IEC 61506	Industrial-process measurement and control – Documentation of application software
IEC 62023	Structuring of technical information and documentation
IEC 81346-1	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules
IEC 81346-2	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations Part 2: Classification of objects and codes for classes
IEC 81714	Design of graphical symbols for use in the technical documentation of products
ISO 5457	Technical product documentation – Sizes and layout of drawing sheets
ISO 7200	Technical product documentation – Data fields in title blocks and headers paper
ISO 14617	Graphical symbols for diagrams

3.2.2 General

The AIS-open terminal SF₆ gas insulated circuit breakers shall be the single-pressure puffer or self-blast or self-blast/rotating arc type, suitable for outdoor installation. They shall be of modern design, reliable and fit for purpose. Pre-insertion resistors to be provided if found necessary as result of the insulation coordination studies that are to be provided.

The circuit breakers shall be designed and fully type tested in accordance with IEC 62271-100, IEC 62271-1, IEC 62271-101, IEC 62271-110, IEC 60270, IEC 60480, IEC 60691 and IEC 60815 and with the requirements of this Specification and shall be suitable for minimum continuous current at an ambient temperature of +40° C.

External parts of the circuit breakers which are under continuous electrical stress shall be of porcelain. The type and the profile of the porcelain insulator shed shall be suitable for the worst environmental conditions specified in the schedules. The creepage and flashover distances of the insulators shall be dimensioned to suit the outdoor service conditions specified in the Schedules.

The design of the circuit breaker shall be such that inspection and replacement of contacts, nozzles and any worn or damaged component can be carried out quickly and easily.

The maximum pole scatter during makes shall be less than 3.3ms and during opening shall be less than 3ms.

The inherent design of the circuit breakers shall be such that one set of contacts and nozzle (or nozzles as the case may be) shall be able to successfully interrupt at least twenty 100% fault currents without excessive erosion. The inherent design of these circuit breakers shall be that when switching capacitive (capacitor banks) and inductive (including reactors) currents, they produce very low over voltages. The over voltages produced on any switching duty must be considerably less than (\ll) 2.5p.u.

The sound pressure levels of the circuit breakers during the mechanical operations shall comply with the local and national health and safety regulations.

A suitably quantity of molecular sieve shall be used in the circuit breaker tank to absorb any moisture, SF₆ degradation product and any contaminant for at least ten years in service.

The circuit breakers shall be suitable for at least 10,000 satisfactory open and close mechanical operations in accordance with IEC 62271-100.

Circuit breakers shall be single-pole SF₆ gas insulated design, suitable for high-speed single phase or three-pole auto-reclose operations. The circuit breakers shall be supplied with a single-pole re-close facility and be equipped with duplicate trip coils. The circuit breakers shall be capable of parallel tripping, when installed in the breaker and a half configuration, without delaying the tripping of either breaker. Circuit breakers shall be electrically and mechanically trip free with either or both of the duplicate trip circuits connected.

The circuit breaker shall be fitted with the open/closed position indicator easily visible from ground level.

3.2.3 Gas Monitoring and Handling

All circuit breakers shall be filled to the design pressure with Technical Grade SF₆ gas to IEC 60376.

Facilities shall be provided in the gas system for constantly monitoring the gas density. A two-stage low pressure alarm and 'block-trip' system with local and remote indications shall be provided on each circuit breaker in fail-safe-mode. The low pressure/density alarm switches shall instantly provide an indication to the operator, 'block-trip' the circuit breaker and subsequently inhibit their further operation until suitable remedial action has been taken. The local control cubicle shall be adequately labelled to allow easy identification of alarms/indications.

In view of the dependence of system security on the reliability of the SF₆ gas-density relays, the gas density relays shall have a high degree of reliability. Consideration shall be given in the design of the relay to allow easy checking of its proper operation.

SF₆ gas taken from the circuit breaker shall be checked and handled in accordance with IEC 60480. The SF₆ gas system shall include the following:

- Pressure relays with lockout and alarm contacts.

- Gas filling valve.
- Gas sampling valve.
- Pressure gauge.
- Filter for SF₆ decomposition by products and humidity.

Each pole of high voltage circuit breaker shall have an SF₆ gas enclosure provided with a two-stage SF₆ gas temperature-compensated monitoring system of independent other poles. The SF₆ gas temperature-compensated monitoring system scale indicator shall be installed in such a way that is easily and clearly readable while standing on normal ground level or fixed raised platform provided by the Contractor.. The first stage shall give an alarm while the second stage shall block the circuit breaker in the position in which the circuit breaker was at the moment when the gas pressure decreased below the level in question. All devices required for fail-safe operation during conditions of low gas pressure shall be provided.

The circuit breaker shall be designed on the puffer principle,. Replenishing of gas shall be also possible while the circuit breaker is in service.

For refilling purposes, the manufacturer shall provide and handover to the Employer one set of mobile gas handling plant for sampling, filling, evacuating and processing SF₆ gas including; two sets of SF₆ gas leakage detectors, cylinders for temporary storage of evacuated SF₆ gas for one 400kV complete three-phase circuit breaker, all accessories, hose pipes, and fittings necessary to connect the plant to the 400kV circuit breakers for each substation.

The manufacturer shall provide the first fill of SF₆ gas for all SF₆ circuit breakers plus additional twenty percent (20%) of the first fill total amount of SF₆ gas as spare. Spare SF₆ gas shall be delivered to site in 45kg cylinders and stored in the hazardous materials storage building/facility constructed by the Contractor for long term storage.

3.2.4 Gas Handling Equipment

The mobile gas handling plant for filling, evacuating, and processing the SF₆ gas in the switchgear, to be supplied as part of the Contract to enable any maintenance work to be carried out and shall be as specified in the schedules. The gas handling plant shall include all the necessary storage tanks or cylinders for temporarily storing the evacuated SF₆ gas as well as spare gas for maintenance purposes and shall be suitable for transportation on public roads.

The capacity of the temporary storage facilities shall be at least sufficient for storing the maximum quantity of gas that could be removed when carrying out maintenance or repair work on the switchgear.

The plants provided shall be suitable for evacuating and treating the SF₆ gas by the use of desiccants, driers, filters etc. to remove impurities and degradation products from the gas. This shall comply with IEC 60480. The capacity of the plant shall be such that a circuit breaker can be evacuated in less than half one hour.

The plant shall also be capable of reducing the gas pressure within a circuit breaker to a value not exceeding 8 millibars within two hours.

It shall be capable of operating satisfactorily to a maximum temperature of +50°C.

3.2.5 Desiccants, Filters, Pipes and Couplings for the Connection of SF₆ Gas

The necessary desiccants, filters for drying and cleaning the gas and all pipes, couplings, flexible tubes and valves for coupling to the switchgear equipment for filling or evacuating all the gases to be used, with all necessary instructions for the storage of this equipment, shall be provided.

3.2.6 Circuit Breaker Operating Mechanisms

3.2.6.1 General

The circuit breakers shall preferably be fitted with power-spring mechanism but other types of reliable mechanisms such as leak-free hydraulic, spring/hydraulic, and spring/SF₆ gas will also be considered, provided they comply with the above circuit breaker mechanical operations requirement. A positively driven open/closed, mechanical indication device to show the position of the main contacts and with local manual operated features for tripping, closing and spring charging, visible without the necessity to open the mechanism door, shall be provided. The drive for the device shall be positive in both directions. A pneumatic mechanism is not acceptable.

The mechanism shall fully close the circuit breaker and sustain it in the closed position against the forces of the rated making current and shall fully open the circuit breaker without undue contact bounce at a speed commensurate with that shown by tests to be necessary to achieve the rated breaking capacity in accordance with IEC 62271-100. The mechanism shall be capable of being locked in either the open or closed position. Circuit breakers may be subject to several single shot auto-reclose duty cycles in quick succession upon the occurrence of multiple faults coupled with short reclaim timer settings. The operating mechanism shall be capable of fully closing and opening again after the auto-reclose time interval specified i.e.: performing a complete O-0.3 sec-CO-3 min-CO duty. The circuit breakers shall be suitable for single phase auto reclose.

Mechanical counters, to record the number of closing operations, shall be provided for each circuit breaker mechanism. Circuit breakers arranged for single-pole operation shall be provided with a counter for each pole. The mechanism and the connected interrupters shall satisfy the mechanical endurance requirements of IEC 62271-100 and all additional requirements specified herein.

Means shall be provided to prevent the mechanism from responding to a close signal when the trip coil is energised or to reclosing from a sustained close signal either after opening due to a trip signal or failure to hold in the closed position, i.e. shall include an anti-pumping device. Any relays to accomplish these provisions shall be continuously rated and mounted at the circuit breaker. The mechanism shall also incorporate manual-trip facility fitted with a guard to preclude inadvertent operation.

Means shall be provided to detect phase discrepancy in the event of one or two phases failing to complete a close or trip operation and to trip all three phases after a time delay of 1 second. Each mechanism shall be fitted with duplicate trip-coils and phase discrepancy remote indication shall also be provided.

The following facilities shall be provided at each circuit breaker local control point: -

- a. LOCAL/REMOTE selector switch. The selection of 'local' operation shall inhibit the operation of the breaker from any remote source including the protection scheme.
- b. OPEN/NEUTRAL/CLOSE control switch or open and close push buttons. Where push button controls are provided the selector switch shall have a neutral position.

- c. EMERGENCY TRIP DEVICE, suitable for manual operation in event of failure of electrical supplies. The device shall be accessible without opening any access doors and distinctively labelled and protected against inadvertent operation.

The selector switch shall be lockable in both positions and the control switch shall be lockable in the neutral position. For maintenance purposes, means shall be provided for manual operation including the slow closing and opening of those circuit breakers whose moving contacts are mechanically coupled to the direct linkage mechanism. Such operation shall be possible without the necessity of gaining access to the interior of the power unit and shall not require excessive physical effort.

3.2.6.2 Spring Mechanisms

Provision should be made for remote indication of 'spring charged' and 'spring charge fail' conditions. A spare normally open spring-drive limit switch shall be provided.

It shall be possible to hand charge the operating springs with the circuit breaker in either the open or closed positions. In normal operation, recharging of the operating springs shall commence immediately and automatically upon completion of the closing operation and shall be completed within 30 seconds. Closure whilst a spring charging operation is in progress shall be prevented and release of the springs shall not be possible until they are fully charged.

- a) The state of charge of the operating springs shall be indicated by a mechanical device which shows 'SPRING CHARGED' when operation is permissible and 'SPRING FREE' when operation is not possible. A local manual spring release device shall be provided and arranged to prevent inadvertent operations. Provisions shall be made to prevent an operation of the breaker when the springs are in the partially charged condition.
- b) Means shall be provided for hand charging the operating springs and moving direction of handle shall be clearly marked.

3.2.6.3 Hydraulic, Spring/Hydraulic, and Spring/SF₆ Mechanisms

Hydraulic and SF₆ gas mechanism shall be leak-free. The hydraulic and SF₆ gas pressure shall be maintained automatically, a numerically graduated gauge being provided to give indication of the pressure. The pressure gauge shall be suitably damped to ensure that it is not subject to transient pressure oscillations either during pumping or during operation of the circuit breaker.

A lockout device with provision for remote alarm indication shall be incorporated in each circuit breaker to prevent operation whenever the pressure of the operating medium is below that required for satisfactory subsequent operation at the specified rating. Such facilities shall be provided for the following conditions: -

- a. Trip lockout pressure.
- b. Close lockout pressure.
- c. Auto-reclose lockout pressure.

Alarm contacts shall be provided to indicate conditions a, b and c. For two trip systems, the trip lockout shall apply to both systems.

A sudden fall in pressure of the operating medium to a level below which a safe operation is not possible shall not result in slow opening or closing of the circuit breaker contacts. The mechanism shall be locked in position and electrical trip and close signals shall be isolated during this period. Facility shall be provided to enable the available operating energy stored by the mechanism to be determined prior to operating the circuit breaker, together with an alarm in the event of the potential energy falling below a minimum rated level. Facility for hand charging of hydraulic systems shall be provided.

Circuit breakers having independent operating mechanisms on each phase shall block tripping, closing, and auto-reclosing of all phases if the operating pressure is below a minimum rated level in one or more of the mechanisms.

A pump or compressor running time meter shall be fitted and an alarm shall be provided to indicate excessive running time.

3.2.6.4 Mechanism Housings

Where heaters are provided, these shall be permanently connected. Where two-stage heaters are provided, one stage shall be permanently connected and the other switched.

Means for locking shall be provided for the doors of each mechanism-housing.

Mechanism housings for use outdoors shall have a minimum IP rating of 54.

3.2.7 Technical Data Schedules

Refer to Technical Data Schedule -Section 2E where characteristics of circuit breakers are specified.

3.2.8 Equipment Submittals

The Manufacturer shall provide a detailed schedule for the design, manufacture, delivery, installation and testing of breakers while ensuring that the sequence and timing is consistent with the overall construction schedule.

Provide literature, specifications and data sheets relating to the product and include the characteristics, performance criteria, physical size, finish and limitations of the product.

The following information and documents shall be submitted for review by the Employer:

- A master drawing index.
- Front view elevation and weight.
- Plan view.
- Schematic diagrams.
- Nameplate diagram.
- Components list.
- Accessory information.
- Key interlock model and serial number.

- Data sheet including:
 - Nominal voltage.
 - Maximum continuous voltage.
 - Continuous current.
 - Interrupting current.
 - Capacitive switching current.
 - Basic Impulse Withstand level (BIL).
 - Minimum and maximum operating temperatures.
 - Breaker operating time.
 - The maximum elevation (asl).
 - Cable terminal sizes.
- Mean Time to Repair factor (MTTR) with supporting documentation.
- List of recommended spare parts, specialized tools and recommended alternative instruments, with catalogue numbers and current prices.
- The Manufacturer shall provide complete seismic anchorage details for the installation of circuit breakers. Manufacturer shall recommend anchors and show detailed anchor locations to ensure that the anchoring system meets applicable requirements.
- Manufacturer's instructions: submit the Manufacturer's installation instructions and special handling criteria per as installation sequences and cleaning and testing procedures.

Quality assurance submittals:

- Provide manufacturing plant QA/QC records, procedures and forms, ISO quality systems or others.
- Submit certificates signed certifying that materials comply with specified performance characteristics and physical properties.

The following product information shall be made available and submitted to the Employer on request.

- Descriptive bulletins.
- Product datasheets.

The equipment shall be handled and stored according to the Manufacturer's instructions. One (1) copy of these instructions shall also be included with the equipment at the time of shipment.

Operation and maintenance manuals shall include the following information:

- Instruction books and/or leaflets.
- Recommended renewal parts list.
- Installation information and drawings.

At time of completion, the contractor shall submit all documents listed in Section 1.20 "Completion Submittals" (2B. GENERAL TECHNICAL REQUIREMENTS) that are applicable to high voltage circuit breakers. Final as-built drawings shall include the same drawing as the construction drawings and shall incorporate all changes made during the manufacturing process.

3.2.9 References

The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of thirty (30) years. A list of references with similar equipment shall be provided to demonstrate compliance with this requirement.

The manufacturer shall submit, during both tender submission stage and detailed design stage, the technical particulars guaranteed together with a type test report of circuit breaker of the required rated voltage and meets the minimum Employer's Requirements stated in; this chapter, the tender technical data schedule and Section 6.1 "Climatic, Electrical, and Mechanical Conditions" (Section 2.4 SERVICE CONDITION of Part 2A, SCOPE OF SUPPLY) and the relevant applicable IEC standards approved by a third party testing laboratory for review and verification to enable issuance of clearance for mass production.

Each high voltage 132kV circuit breaker shall have electrical endurance class E2, mechanical endurance class M2 and capacitor switching class C2.

3.2.10 Delivery, Storage and Handling

Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with Manufacturer's name and address.

Storage and Handling requirements:

- Store and handle the equipment in accordance with Manufacturer's recommendations, in a clean, dry, well-ventilated area.
- Store and protect equipment from damage.
- Replace defective or damaged materials with new.

3.2.11 Complementary Requirements

HV circuit breakers are based on Live Tank type equipment, isolated in SF6 gas, single or three-pole operated.

The circuit breakers shall comply with the latest editions of applicable IEC standards.

HV circuit breakers will be used in the substations to protect transmission lines, transformers, shunt reactors and capacitor banks and used for bus protection and coupling.

3.2.12 Operating Conditions

Circuit breakers shall be designed to operate normally in all operating conditions indicated in the Technical Data Schedules, including rapid changes in load and voltage variations and fault currents limited to nominal characteristics listed.

Circuit breakers and accessories shall be designed to normally operate in an environment described in "Section 2.4 SERVICE CONDITION of Part 2A, SCOPE OF SUPPLY".

Operating Mechanism

The operating mechanism shall be of motor charged spring type. In addition, it shall be possible to charge the operating spring manually. The charging motor of the operating mechanism shall be adequately protected by an appropriate automatic relay and tripping device equipped with alarm contacts. The operating mechanism shall be provided; a padlock with two duplicate keys, lockable local/remote control selector switch, lockable manual/auto control selector switch, close-open electric push buttons, illuminated mechanical open/close main contacts position indicator visible at night, illuminated mechanical charged/discharged operating spring status indicator visible at night, operations counter, SF6 gas alarm and trip lockout alarm LED indicators, mechanical trip/close levers accessible even when the cabinet is closed, accessible terminal blocks with uniquely numbered terminal

points, complete nameplate, door-actuated panel strip light, accessible panel heater, ventilation fan, British standard single-phase 240V AC socket outlet with automatic shutters, manual operating handle facility interlocked with manual/auto and local/remote selector switches, external Earthing terminals, internal tinned copper Earthing bar with bolt holes, DC power on/off supervision LED indicator, manual operating handle, storage clips provision of adequate strength for the manual operating handle and document/drawing folder.

For operating mechanism boxes (cabinets) installed at heights higher than 1.2 meters, raised operating platforms with adequate Earthing terminals shall be provided to enable access to the operating mechanism for manual operation and easy reading of the SF6 gas density monitor without compromising the required electrical clearances. Extra auxiliary contacts indicating the position of the main contacts of the circuit breaker: in total at least two contacts indicating "on" position and two contacts indicating "off" position. The weather exposed steel parts shall be hot dip galvanized. Such insulating structures that are not moisture proof must not be in contact with the open air.

All equipment of the operating mechanism (switches, relays, thermostat, etc.) shall be clearly marked with their corresponding identification codes from the drawings.

The circuit breakers shall have mechanical endurance class M2, electrical endurance class E2 and be built for both fast operations (normal service) during normal service and slow operations during maintenance activities respectively.

The energy stored in a fully charged spring shall be sufficient for one open-close-open operating sequence during normal service (fast operations mode) as specified in the Technical Data Schedules.

An interlock facility shall be provided between the slow and fast operations to prevent both modes of operation being available simultaneously (at the same time).

Each interrupter of the circuit breaker shall be capable of interrupting rated fault short-circuit current at least fifteen (15) times without any re-conditioning. The total breaking time (opening time plus duration of the arc) of the circuit breaker shall be as short as possible, but in no case longer the Employer's Requirement stated in the tender technical data schedules.

An alarm shall be given if the operating mechanism is not fully recharged with fifteen (15) seconds.

Reclosing applies only to circuit breakers used for transmission lines protection.

Also, It shall not be possible to have a closing operation when the circuit breaker is already closed.

3.2.13 Control Circuits

Each circuit breaker shall be equipped with local vermin- and weatherproof control cubicle with IP protection class IP54.

The cubicle enclosing the operating mechanism shall accommodate the auxiliary contacts, the shunt trip coils for "ON" and "OFF" operation, and other items in Section 3.9.

The space heater shall be controlled by a properly configured automatic temperature and humidity-controller with dedicated MCB interfaced to the substation control system order to prevent condensation within the cubicle. The circuit of the lamps of the Interior lighting automatically operated from a door switch shall have an MCB and be fed at 240V AC.

The circuit of the single phase British standard socket outlet have an MCB with 30mA Earth leakage protection and fed at 240V AC.

The AC supply for each operating mechanism shall directly originate from a dedicated MCB/MCCB in the LVAC main distribution panels room via the bay marshalling kiosk of the associated bay.

The DC supply for each operating mechanism shall directly originate from a dedicated MCB/MCCB in the 110VDC main distribution panels room via the bay marshalling kiosk of the associated bay. A copper earth busbar, with tapped holes and screws, shall be provided and connected to the shields or to associated earth continuity conductors of all incoming cables.

Terminal blocks shall be arranged with sufficient space for easy connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 15 cm apart. At least 20% of spare terminals shall be provided in each block.

Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams. All wires shall be identified at both ends according to the interconnection diagrams.

Wiring between terminals of various devices shall be point-to-point, no splicing or "T" connection shall be allowed.

All internal wiring shall be properly ferruled, neatly trunked in wiring troughs in such a manner that the wiring troughs are not over-filled with cables requiring use of cable-ties to hold the covers of the wiring troughs in place.

Access of cables into the operating mechanism cubicle shall be from the bottom plate through appropriate cable glands. All groups of bundled conductors to hinged doors and panels shall use extra flexible wire, arranged so that a twisting rather than a bending motion is imparted to the moving conductor bundle.

Terminal blocks shall be fixed on asymmetric rails and mounted with transparent plastic covers to prevent accidental touch. Wiring shall be performed using copper conductors with a section of at least 2.5 mm². All conductors shall be identified at each end by means of a plastic label in accordance with the schematic diagram of the circuit breaker.

All similar contacts of a three-pole circuit breaker shall close or open within a period of one third of a cycle or less with respect to each other. Failing of this requirement shall be detected.

Operation and fault operation counters shall be installed. All circuit breakers shall be designed for closing and tripping by remote, tele- and local electrical controls. Local electrical controls consisting of a "LOCAL" – "REMOTE" transfer switch and a "CLOSE" – "TRIP" control switch shall be mounted with- in the local control cubicle. The respective position status of each local/remote, manual/auto control selector switches shall be interfaced to, and remotely monitored by, the substation control system. All circuit breakers shall have the necessary number of auxiliary contacts, which shall be easily convertible from normally open to normally closed or vice versa for annunciation locally at the substation control room and for all necessary interlocks. Ten (10) NC and ten (10) NO spare auxiliary contacts shall be provided. Breaker tripping shall be indicated by a switch-discrepancy contact, made up of two signalling contacts. All contacts shall be wired to the terminal blocks for connection to external equipment.

Two (2) independent trip coils and one (1) close coils shall actuate operation of the breaker. The trip circuits shall be duplicated and automatically supervised. The DC power supply to the circuit breaker trip coil and the control circuit wiring shall be provided with shielded cables (e.g. NYCY type) and other measures of protection in order to minimize the hazard of damage to these cables and the subsequent failing of control voltage. Auxiliary circuits, including switches, shall be capable of carrying at least 10 A continuously.

Two (2) pole discrepancy timers shall be provided for each set of single-pole three-phase circuit breakers wired to trip one separate trip coil respectively. The pole discrepancy function shall provide in the Protection system relays. The open/close position status of the each pole of a set of single-pole three-phase circuit breaker shall be independently monitored by the substation control system Point-on-wave Controllers

All 400 kV circuit breakers to be provided for the project, irrespective of their position in the overall installation, shall be provided with point-on wave controllers.

The controllers shall not be installed in the local control cubicle, directly attached to the circuit breaker frame, but in the closest control and protection cubicle.

3.2.14 Auxiliary Contacts

The Manufacturer shall provide, in each circuit breaker operating mechanism, the required number of auxiliary contacts, which shall be easily convertible from normally open (NO) to normally closed (NC) or vice versa for annunciation both locally and at the substation control system and for all necessary interlocks and ten (10) NC and ten (10) NO spare auxiliary contacts.

3.2.15 Structural Support

Each high voltage circuit breaker complete assembly including the operating mechanism cubicle and pole assembly shall be mounted on a separate steel structural support designed and supplied by the manufacturer.

Each high voltage circuit breaker shall be provided with free-standing ground-mounted outdoor central control cabinet installed next the associated circuit breaker for marshalling control, alarm signaling, protection, pole discrepancy, LVAC and DC power supply and interlocking interface wiring. Complete nameplate for the circuit breaker shall be also fixed on the outdoor central control cabinet.

The design and manufacture of the structural supports shall withstand all anticipated mechanical stress during operation and comply with the Technical Data Schedule.

3.2.16 Terminals

HV terminals shall be four-hole spade terminal type as per the NEMA CC-1 standard. At least one of the Earthing terminals provided on each; operating mechanism cubicle, interrupter pole assembly, outdoor central control cabinet, different parts of the raised platform shall be directly connected to the substation grounding Earth mat risers using single piece 70mm² sheathed copper conductors. Horizontal beams shall be connected using 70mm² sheathed copper conductor jumpers on either ends to vertical main members of the steel structural supports which are connected to substation grounding Earth mat. Joints of connecting vertical main members with earthing connection shall also have 70mm² sheathed copper conductor jumpers. Bolt connections of steel members shall not be accepted as electrical connections.

3.2.17 Insulator

Circuit breaker post insulators shall be porcelain and shall meet the requirements specified in the Technical Data Schedule.

3.2.18 Tools

All special tools required to operate, assemble, and maintain circuit breakers shall be supplied, including slow closing tools.

3.3 HV & MV AIS Disconnectors and Earth Switches

3.3.1 Disconnectors

3.3.1.1 General

This specification defines the minimum technical requirements to design, manufacture, and testing of high voltage disconnecting and earthing switches to be installed in the Rumurutu & Kabarnet , (Border) Substation.

This specification covers, without limitation, the following equipment:

- 132kV Disconnector, center-break / double break type, with one (1) earthing switches.
- 33kV Disconnector, center break/ double break type, with one (1) earthing switch

The disconnectors shall be constructed and fully type tested in accordance with the requirements of IEC 62271-102 and this Specification. The design shall incorporate features which shall reduce or eliminate very high frequency voltage transients during disconnector operation.

It is preferred that disconnector contacts can be maintained and replaced with the associated earthing switch closed.

The disconnectors shall be provided with power and manually operated mechanisms. The power operation of the disconnectors shall be capable of being controlled from a local or remote point.

Each power-operated disconnector shall be complete with a lockable LOCAL/REMOTE selector switch and OPEN/NEUTRAL/CLOSE control switch or push buttons. The function of all control and selector switches shall be clearly labelled.

Power operating mechanisms shall be capable of being locked in the open or closed positions; they shall also be suitable for the operation from voltage specified in the Schedules of this Specification.

Manual operation of the disconnectors for maintenance purposes shall be provided.

The number of normally open (NO) and normally closed (NC) auxiliary switches required shall be as dictated by the particular scheme of application plus 30% extra as spare. Where any particular scheme requires special timing of auxiliary contacts, these shall be provided. The design of the NO and NC auxiliary contacts shall allow for equipment intermediate position i.e. a state in which both NO and NC contacts do not make.

The number of the NO and NC contacts shall be as per the schedules of technical information

The auxiliary contacts shall comprise of NO, NC as well as MBB (Make before break) type auxiliary Contacts

Electrical control circuits shall be so arranged that once initiated, an operation shall be completed unless prevented by loss of supply or operation of the motor protection. On restoration of supply the operation shall be completed. Emergency hand operation shall be provided on power-operated disconnectors and the power drive shall be mechanically disconnected during hand operation. It is required that the manual effort to operate the disconnectors or earth switches shall be less than 150N. There shall be adequate access for the manual operation.

In the case where the operating mechanism comprises an energy storage system followed by triggering for completion of the operation, the design shall exclude any possibility of operation by accidental triggering. Switch operation shall be effective only after full charging of the operating mechanism and after deliberate operator action.

Operating motors shall be provided with thermal overload protection and in the case of 3 phase motors, phase unbalanced protection.

All operational interlocks shall function through the electrical bolt interlock circuit. Electrical bolt interference interlocks shall be provided and energised, in the case of hand operation, only when the operating handle of the hand mechanism is brought into the working position or in the case of power operation, when the motor is called upon to operate. A means of overriding the electrical interlock, in the event of loss of auxiliary supplies, shall be provided; the override shall be lockable.

The operating handles for manual operation of power-operated mechanisms may be detachable, in which case only two handles of each type are required per substation.

The disconnector switch control circuit shall be designed such that in the event of loss of motor supply (MCB trip at equipment control cubicle, yard marshalling kiosk or DC distribution board) the Control circuit shall not be complete i.e. the open and/or close contactors not to be actuated in the event of loss of motor supply.

3.3.1.2 Codes and Standards

The disconnectors and earthing switches specified in this technical specification shall be manufactured, tested and generally shall comply with the latest editions or amendments to applicable IEC and ISO standards including:

IEC 60071-1	Insulation coordination - Part 1: Definitions, principles and rules I
IEC 60071-2	Insulation coordination – Part 2: Application guide
IEC 60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 60815	Guide for the selection of insulators in respect of polluted conditions
IEC 60947-1	Low-voltage switchgear - Part 1: General requirements
IEC 62271-1	High-voltage switchgear - Part 1: General requirements
IEC 62271-102	High-voltage switchgear – Part 102: Alternating current disconnectors and earthing switches
IEC 62271-103	High-voltage switchgear – Part 103: Switches for rated voltages above 1 kV up to and including 52 kV

IEC 60529	Degrees of protection provided by enclosures (IP Code)
ISO 9001	Quality management system - Requirements

The applicable additional standards are the ISO, DIN / VDE, CENELEC, BS and US standards or national specific standards listed above, if no relevant IEC / IEC standard exists or if there is insufficient information available in IEC / IEC standards and / or explicitly requested in this standard.

The Bidder shall provide, with its offer, valid certificates which prove that the manufacturers and suppliers proposed are ISO 9001 certified and conform to RoHS certifications. Manufacturers who do not have sufficient experience in the manufacture, installation and testing of HV disconnect and earthing switches as specified and / or are not ISO 9001 certified and that do not comply with RoHS will not be accepted.

The standards listed below are of particular importance for documentation.

IEC 60617	Graphical symbols for diagrams
IEC 61082-1	Preparation of documents used in electro technology – Part 1: Rules
IEC 61131	Programmable controllers
IEC 61355	Classification and designation of documents for plants, systems and equipment
IEC 61506	Industrial-process measurement and control - Documentation of application software
IEC 62023	Structuring of technical information and documentation
IEC 81346-1	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 1: Basic rules
IEC 81346-2	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 2: Classification of objects and codes for classes
IEC 81714	Design of graphical symbols for use in the technical documentation of products
ISO 5457	Technical product documentation - Sizes and layout of drawing sheets
ISO 7200	Technical product documentation - Data fields in title blocks and document headers
ISO 14617	Graphical symbols for diagrams

3.3.1.3 Technical Data Schedules

Refer to “Section 2E for Technical Data Schedule” where the required characteristics of disconnect switches are specified.

3.3.1.4 Equipment Submittals

The Manufacturer shall provide a detailed schedule for the design, manufacture, delivery, installation and testing of disconnect and earthing switches while ensuring that the sequence and timing is consistent with the overall construction schedule.

Provide literature, specifications and data sheets relating to the product and include the characteristics, performance criteria, physical size, finish and limitations of the product.

The following information and documents shall be submitted for review by the Employer:

- A master drawing index.
- Front view elevation and weight.
- Plan view.
- Schematic diagrams.
- Nameplate diagrams.
- Components list.
- Accessory information.
- Key interlock model and serial number.
- Data sheet including:
 - Nominal voltage
 - Maximum continuous voltage.
 - Continuous current.
 - Interrupting current.
 - Capacitive switching current.
 - Basic Impulse Withstand level (BIL)
 - Minimum and maximum operating temperatures.
 - Opening and latching times.
 - Maximum elevation (a.s.l.).
- Mean Time to Repair factor (MTTR) with supporting documentation.
- Cable terminal sizes.
- List of recommended spare parts, specialized tools and recommended alternative instruments, with catalogue numbers and current prices.
- The Manufacturer shall provide complete seismic anchorage details for the installation of disconnect and earthing switches. Manufacturer shall recommend anchors and show detailed anchor locations to ensure that the anchoring system meets applicable requirements
- Manufacturer's instructions: submit the manufacturer's installation instructions and special handling criteria per as installation sequences and cleaning and testing procedures.

Quality assurance submittals:

- Provide manufacturing plant QA/QC records, procedures and forms, ISO quality systems or others.
- Submit certificates signed certifying that materials comply with specified performance characteristics and physical properties.

The following product information shall be made available and submitted to the Employer on request

- Descriptive bulletins.
- Product datasheets.

The equipment shall be handled and stored according to the manufacturer's instructions. One (1) copy of these instructions shall also be included with the equipment at the time of shipment.

Operation and maintenance manuals shall include the following information:

- Instruction books and/or leaflets.
- Recommended renewal parts list.

- Installation information and drawings.

The following information shall be submitted at time of completion:

- Final as-built drawings and information for items listed in the previous section.
- Wiring diagrams.
- Certified production test reports.
- Installation information.
- Seismic certification and equipment anchorage details.

Final as-built drawings shall include the same drawing as the construction drawings and shall incorporate all changes made during the manufacturing process.

3.3.1.5 References

The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. A list of references with similar equipment shall be provided to demonstrate compliance with this requirement.

The manufacturer shall submit, during both tender submission stage and detailed design stage, the technical particulars guaranteed together with a type test report of Disconnectors and Earthing Switches of the required rated voltage and meets the minimum Employer's Requirements stated in; this chapter, the tender technical data schedule and Section 6.1 "Climatic, Electrical, and Mechanical Conditions" (II. GENERAL REQUIREMENTS) and the relevant applicable IEC standards approved by a third party testing laboratory for review and verification to enable issuance of clearance for mass production. Each high and medium voltage Disconnector and Earthing Switches shall have mechanical endurance class M2.

3.3.1.6 Delivery, Storage and Handling

Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with manufacturer's name and address.

Storage and Handling requirements:

- Store and handle the equipment in accordance with manufacturer's recommendations, in a clean, dry, well-ventilated area.
- Store and protect equipment from damage.
- Replace defective or damaged materials with new.

3.3.1.7 Complementary Requirements

The disconnectors suitable for outdoor operation shall be – if not otherwise stated in the Technical Data Sheets- of the center break type or pantograph type below the busbars, equipped with motorized drives for both phase contacts and earthing blades. Manual operation shall be possible in case of emergency. Because the project deals with the extension of the substation, the Contractor shall coordinate the exact type of disconnector during the design phase and shall use the same type which is implemented in the substation.

For 400 kV Disconnectors and Earthing Switches, each single-phase disconnector with/without associated Earthing switch shall be complete assembly on the same steel structural support including the disconnecting/earthing assembly and separate operating mechanism cubicles for the respective disconnector and earthing switch mounted on the opposite sides of the same steel structural support. Each three-phase set of 400kV high voltage Disconnectors and Earthing Switches respectively shall be provided with a separate outdoor central control cabinet installed as either mounted on the outer phases (red phase for the Disconnector and blue phase for

the Earthing Switch) facing each other or ground-mounted and free-standing next to the associated disconnecter for marshalling control, alarm signaling, LVAC and DC power supply and interlocking interface wiring. Complete nameplate for the Disconnector or Earthing Switch shall be also fixed on the respective outdoor central control cabinet.

The design and manufacture of the structural supports shall withstand all anticipated mechanical stress during operation and comply with the Technical Data Schedule.

Subject to their position in the respective substation feeder the isolators shall be equipped with one, two or none earthing switches.

Neither visible corona nor audible corona shall occur on the disconnect switch at the rated operating voltage. The requirement is valid for the open and closed positions.

Disconnector high voltage terminals compatible with Aluminium shall be provided.

Earthing Switch terminals, marked with appropriate clearly visible permanent graphical symbol, compatible with copper leads up to 150 mm² for the earthing of the voltage exposed parts shall be provided. The weather exposed steel part shall be hot dip galvanized.

For 132kV and 33kV Disconnectors and Earthing Switches, the respective poles of the Disconnectors and Earthing Switches shall be mechanically coupled so as to ensure synchronism of the switching motions under all conditions.

Disconnectors shall be suitable for off-load, live (energized) isolation (operation) at the maximum permissible continuous operating voltage and capable of switching line charging current of open busbars and connections or currents from parallel circuits and withstanding the specified short circuit mechanical forces.

The Earthing switches shall be capable of discharging trapped charges of the associated transmission line that is open at both ends.

The Disconnectors and Earthing Switches shall be designed to withstand the specified short circuit fault currents. The HV contact parts shall be maintenance-free. High specific contact force and good self-cleaning ability shall be assured. The moving parts with ball bearings shall be greased for life.

Each high voltage Disconnector shall be electrically interlocked with the all it corresponding circuit breaker and all other Disconnectors and Earthing Switches to ensure safe operations. Also, each high voltage Earthing Switch shall be electrically interlocked with the all it corresponding circuit breaker and all other Disconnectors and Earthing Switches to ensure safe operations.

Furthermore, each three-phase disconnector shall be mechanically interlocked with its associated earthing switch (on the same structure) in such a manner as to allow the disconnector to be closed only if the earthing switch is open and to allow the earthing switch to be closed only if the disconnectors are open.

In addition, each three-phase HV and MV line or feeder earthing switch shall be provided with an outdoor three-phase under-voltage relay connected to the line's capacitive voltage transformers (CVTs) that shall be used to permit its associated line earthing switch to close only it signals (indicates) a dead overhead line (OHL). Each outdoor three-phase under-voltage relay shall be connected to the same CVT core as the distance protection relay for the associated transmission line bay. The Manufacturer shall provide, in each respective operating mechanisms of the disconnectors and earthing switches, the required number of auxiliary contacts, which shall be easily convertible from normally open (NO) to normally closed (NC) or vice versa for annunciation both locally and at the substation control system and for all necessary interlocks and ten (10) NC and ten (10) NO spare auxiliary

contacts. The Disconnectors and Earthing Switches shall be designed to withstand the specified short circuit fault currents.

A detailed nameplate of stainless steel, with engraved black ink text and clearly visible and readable from the ground level shall be fitted on the frame and on the respective operating mechanisms cubicles and central control cabinets for the disconnectors and earthing switches.

Within the operating mechanism's cubicle, a wiring diagram will be fitted in a durable (long lasting) transparent envelope. The nameplate shall be in English language.

3.3.1.8 Operating Conditions

Disconnect and earthing switches shall be designed to operate normally in all operating conditions listed in the Technical Data Schedules, including rapid changes in load and voltage variations and fault currents limited to nominal characteristics listed.

Disconnect, earthing switch and their accessories shall be designed to normally operate in an environment described in SECTION 2.4 "SERVICE CONDITION-PART 2A-SCOPE OF WORK".

3.3.1.9 Operating Mechanism

Each motor of the operating mechanisms for Disconnector and Earthing Switches shall be adequately protected by an appropriate automatic relay and tripping device equipped with alarm contacts.

The operating mechanism for Disconnector and Earthing Switches shall be provided; a padlock with two duplicate keys, lockable local/remote control selector switch, lockable manual/auto control selector switch, close-open electric push buttons, illuminated open/close main contacts position LED indicators visible at night, operations counter, emergency stop push button accessible even when the cabinet is closed, accessible terminal blocks with uniquely numbered terminal points, detailed nameplate, door-actuated panel strip light, accessible panel heater, ventilation fan, British standard single-phase 240V AC socket outlet with automatic shutters, manual operating handle facility, external Earthing terminals, internal tinned copper Earthing bar with bolt holes, DC power on/off supervision LED indicator, manual operating handle, storage clips provision of adequate strength for the manual operating handle and document/drawing folder.

The manual operating handle facility shall be both mechanically and electrically interlocked with manual/auto and local/remote selector switches in order to prevent local manual operation when the local/remote control switch is in remote position and/or manual/auto control switch is in auto position.

The operating mechanism for each Disconnector and Earthing Switch shall be send the open, close and intermediate position status signal to the substation control system. The closed position status signal shall be sent when operating mechanism has made full contact to enable the each Disconnector or Earthing Switch to carry its rated current. The open position status signal shall be sent when operating mechanism contact has travelled from closed contact position (0%) and reached a minimum contact-to-contact clearance of eighty percent (80%) of the final open position clearance (isolation clearance).

The operating mechanism for each Disconnector and Earthing Switch shall be in intermediate position when moving contact has travelled from closed contact position (0%) but has not reached the required minimum eighty percent (80%) of the final fixed-contact-to-moving-contact clearance (isolation clearance). The intermediate position status shall be detected and derived by the substation control system basing on the absence of both open and close position status signals at the same time.

The operating mechanism for Earthing Switch shall also have "Safe-to-Close" LED indicator with clearly visible permanent label which shows that the main conductor phases are de-energized and any other applicable interlocks are satisfied prior to enabling the close operation.

For operating mechanism cabinets for Disconnecter and Earthing Switches installed at heights higher than 1.2 meters, raised operating platforms with adequate Earthing terminals shall be provided to enable access to the operating mechanism for manual operation and easy reading of the SF6 gas density monitor without compromising the required electrical clearances.

The motor supply circuit and control circuit in operating mechanism cabinets for Disconnecter and Earthing Switches shall have two-pole MCBs respectively. The motor operating system must be pulse operated. The mechanism shall complete its action although the interlocking voltage is off circuited during the operation. There must be separate electrical circuits for motor, control and interlocking. An actuated control pulse must not affect any operation (neither later) when the motor circuit is non-energized.

132kV and 33kV Earthing switch shall be mounted on the hinge side of its associated Disconnecter switch and provided with its separate operating mechanism cubicle from that of the disconnecter switch.

Each Earthing blade of the Earthing switch shall have an Earthing terminal and the Contractor shall connect that Earthing terminal directly to the substation grounding earth mat using single piece 70mm² copper conductor..

Line grounding switches shall allow for safe operation considering electrostatic coupling of the two-line circuits and possible resonance with the line shunt reactors. The contractor shall propose in his bid suitable switches with an appropriate mechanism and current switching capability. This will have to be demonstrated by tests acceptable to the Employer.

The operating mechanism linkage shall be supplied with joints and adjustment devices, bearings and earthing sleeves near the crank for connection to the grounding grid via the equipment support. The mechanism shall include field adjustable stops for both the opened and closed positions.

3.3.1.10 Interlocks

Mechanical and electrical interlocks shall be supplied to avoid the following conditions:

- The HV and MV AIS Disconnectors are not intended to make or break current for off-load, live (energized) isolation (operation) at the maximum permissible continuous operating voltage and capable of switching line charging current of open busbars and connections or currents from parallel circuits.
- The HV and MV AIS Earthing switches shall be capable of discharging trapped charges of the associated transmission line that is open at both ends. Key interlocking between disconnect switches and earthing switches to ensure that earthing switches cannot be closed onto an energized circuit and disconnect switch cannot be closed, unless the earthing switch is open. Both ON/OFF statuses of the key interlocking shall be monitored by the substation control system (SCS). Key interlocking between disconnect switches and two adjacent earthing switches shall allow the operation of the disconnect switch when both earthing switches are closed on both sides of the disconnect switch. Both ON/OFF statuses of the key interlocking shall be monitored by the substation control system. Ensuring that a circuit breaker is closed only if its either its associated disconnecter switches are both either open during testing (when manual/auto control selector switch is in manual position) or closed during normal fast operation testing (when manual/auto control selector switch is in auto position); Prevent both N.O. and N.C. auxiliary contacts to be close or open simultaneously.
- Prevent electrical motor operation during manual operation.
- Prevent electrical operation while operating handle is inserted.

- Operation conditioned by an external permissive contact.

3.3.1.11 Local Control Cubicle

A local control cubicle shall be provided for each three-pole disconnector group with enclosure minimum IP54. Each three-phase set of 400kV single-phase high voltage Disconnectors and Earthing Switches respectively shall be provided with a separate outdoor central control cabinet installed as either mounted on the outer phases (red phase for the Disconnector and blue phase for the Earthing Switch) facing each other or ground-mounted and free-standing next to the associated disconnector for marshalling control, alarm signaling, LVAC and DC power supply and interlocking interface wiring. Complete nameplate for the Disconnector or Earthing Switch shall be also fixed on the respective outdoor central control cabinet. The switchgear Local Control Cubicle shall; enclose the operating mechanism, accommodate the auxiliary contacts, terminal blocks, open/close and manual/auto control selector switches for electrical operation and manual handle operating facility, operating handle and storage clips for the manual local operation of the Disconnector and Earthing Switches.

Remote and local control switches, open and closed LED indicators externally visible at even at night shall also be installed switchgear Local Control Cubicle.

Also, open/closed LED indicators, remote/local, open/close and manual/auto control selector switches shall also be installed in the outdoor central control cabinets of the three-phase sets of 400kV Disconnectors and Earthing Switches for electrical operation.

3.3.1.12 Control Circuits

The control cubicle shall be fitted with anti-condensation heaters, wired to separate terminal blocks.

The anti-condensation heaters shall have a an MCB monitored by the substation control system and automatically operated by humidity and temperature controller. The control and motor supply circuit shall be of 110V DC. The cubicle spaces shall be fitted with rain and insect protected holes for ventilation fans and draining eyelets. Interior lighting, operated from a door switch shall be provided within each cubicle assembly. Lamps shall be fed by 240 V AC. A 240V, 10A British standard three-pin single-phase socket outlet with approved fuse and automatic safety shutters to fit standard plugs and protected by a 30mA Earth leakage protection MCB shall be installed inside each switchgear Local Control Cubicle and outdoor central control cabinets

A copper earth busbar shall be provided with tapped holes and screws and shall be connected to the shields or associated earth continuity conductors of all incoming cables.

The control cubicle shall be fitted with encased moisture proof terminal blocks, 10...16 mm², for external connection of auxiliary circuits. There shall be at least 4 extra terminal blocks.

Terminal blocks shall be arranged with sufficient space for easy connection of incoming cables. At least 20% of spare terminals shall be provided in each block.

Terminal studs and wires shall be numbered or otherwise marked in accordance with the applicable schematic and wiring diagrams. All wires shall be identified at both ends according to the interconnection diagrams.

Only one cable core is allowed to be connected to one terminal.

Wiring between terminals of various devices shall be point to point, no splicing or "T" connection shall be allowed.

All internal wiring shall be properly ferruled, neatly trunked in wiring troughs. All groups of bundled conductors to hinged doors and panels shall use extra flexible wire arranged so that a twisting rather than a bending motion is imparted to the moving conductor bundle.

Please refer to the Technical Data Sheets for the full presentation of the required technical characteristics of disconnectors and earthing switches.

Operating conditions (control level hierarchy) for Disconnectors and Earthing Switches and their associated circuit breakers are as follows:

Level 1: System control from main and backup National Dispatch Centers (NCCs)

Level 2: Station control at Substation operator's workstation interfaced to the Substation Control System (SCS) HMI server computer (Location: Control Room)

Level 3A: Bay control with Bay Control Unit (BCU) (Location: Control and Protection Panels Room or Relay house in the field)

Level 3B: Bay control via control-switches at mimic diagram at Bay Control Panel (Location: Control and Protection Panels Room or Relay house in the field)

Level 4: Bay control via control-switches at mimic diagram at switchyard Bay marshalling kiosk and at switchyard switchgear central control panels for sets of single-pole three-phase switchgear. (Location: near HV-Equipment in the field).

Level 5: Switchgear operating mechanism box (emergency electric or manual control operations) (Location: HV-Equipment in the field).

Provision has to be made that if one control level is selected all other levels are blocked (priority: 5-4- 3-2-1).

Control circuits shall be designed to take into consideration the following items:

- Control circuit supplied with:
- "Open / Close" push buttons.
- "Local / Remote" and "Manual / Electric" selector switches.
- "Open / Closed" interlocked contactors.
- Test switches.
- Limit switches.

Internal cabling shall be done using isolated stranded copper conductors with a minimum cross section of 2.5 mm². Motor operator will allow electrical local and remote operation, while the manual operating crank will allow local operation only. Two contacts from "Manual / Electrical" and "Local/Remote" switches shall be cabled to terminal blocks for Employer's use. Selector switch contacts shall open both negative and positive terminals of the control circuit.

3.3.1.13 Auxiliary Contacts

Auxiliary contacts shall be adjustable individually without affecting settings from other contacts.

All operating mechanisms of Disconnectors and Earthing Switches shall have the necessary number of auxiliary contacts, which shall be easily convertible from normally open (NO) to normally closed (NC) or vice versa for annunciation locally and at the substation control room and for all necessary interlocks. Ten (10) NC and ten (10) NO spare auxiliary contacts shall be provided. Earthing switch auxiliary contacts shall be located in a separate weatherproof cabinet with entry plates suitable for cable entry.

Auxiliary contacts interrupting capacity shall be sufficient to switch control circuits at nominal voltage (110V dc).

3.3.1.14 Padlock

Disconnect and earthing switch operating mechanisms shall be padlock able.

3.3.1.15 Structural Support

The design and manufacture of the structural supports of each HV and MV AIS Disconnecter and Earthing Switch complete assembly shall be done by the equipment manufacturer to withstand all anticipated mechanical stress during operation and comply with the Technical Data Schedule.

The installation height of the operating mechanism cubicles/boxes and/or structure-mounted switchgear central control panels for sets of single-pole three-phase switchgear of each HV and MV AIS Disconnecter and Earthing Switch complete assembly shall be 1.2 metres from normal ground level.

3.3.1 Terminals

HV terminals shall be four-hole spade terminal type as per the NEMA CC-1 standard.

At least one of the Earthing terminals provided on each; operating mechanism cubicle, disconnecter phase limb, Earthing switch blade/limb, shall be directly connected to the substation grounding Earth mat risers using single piece 70mm² sheathed copper conductors.

Horizontal beams shall be connected using 70mm² sheathed copper conductor jumpers on either ends to vertical main members of the steel structural supports which are connected to substation grounding Earth mat. Joints of connecting vertical main members with earthing connection shall also have 70mm² sheathed copper conductor jumpers. Bolt connections of steel members shall not be accepted as electrical connections.

3.3.1.1 Insulators

Disconnect switches insulators shall be porcelain and shall meet the requirements specified in Technical Data Schedule.

3.3.1.2 Tools

All special tools required to operate, assemble, and maintain the disconnect switches shall be supplied.

3.3.2 Earth Switches and Maintenance Earthing Devices**3.3.2.1 Earth Switches**

Earth switches shall comply with IEC 62271-102 and the requirements of this Specification. They shall be fitted with power and manually operated mechanisms. The electrical operations shall be performed from their control cubicles. The position indicators shall be clearly visible from the permanent working platform level.

Earth switches on line circuits shall be capable of interrupting the current induced in the line by a parallel fully loaded line.

The earth switch operating mechanism shall be capable of being locked in the open or closed position.

The earth switch control circuit shall be design such that in the event of loss of motor supply (MCB trip at equipment control cubicle, yard marshalling kiosk or DC distribution board) the Control circuit shall not be complete i.e. the open and/or close contactors not to be actuated in the event of loss of motor supply.

The number of normally open (NO) and normally closed (NC) auxiliary switches required shall be as dictated by the particular scheme of application plus 30% extra as spare. Where any particular scheme requires special timing of auxiliary contacts, these shall be provided. The design of the NO and NC auxiliary contacts shall allow for equipment intermediate position i.e. a state in which both NO and NC contacts do not make.

The number of the NO and NC contacts shall be as per the schedules of technical information.

The auxiliary contacts shall comprise of NO, NC as well as MBB (Make before break) type auxiliary Contacts.

Electrical operation of the earth switch shall be enabled only for equipment local level, substation control system and BCU levels. Electrical operation from NCC/RCC shall not be permitted.

3.3.2.2 Portable Maintenance-Earthing Devices

Where portable-earthing is required, provision shall be made for applying fully rated portable maintenance-earthing devices to the primary conductors of the equipment.

3.4 Testing and Inspection

3.4.1 Principal Standards for Type and Routine Tests

All type testing shall be performed in line with the requirements of this Specification, in an manufacturer independent accredited test laboratory and/or witnessed by an independent accredited third party. Accreditation to the testing laboratory/ third party shall be given by an according signatory member of International Laboratory Accreditation Cooperation (ILAC). The following Standards shall apply:

- IEC 62271-100, IEC 62271-1, IEC 62271-207 and IEC 60270 for the switchgear and control gear.
- IEC 62271-100 plus Application Guide, IEC 62271-1, IEC 62271-101, IEC 62215, IEC 60270, IEC 60376, IEC 60691, IEC 60815, IEC 62271-110 and IEC 60480 for the circuit breakers.
- IEC 62271-102, IEC 62271-1 and IEC 62271-100 for HV Disconnectors and Earth Switches.
- IEC 60044-1, IEC 60186, IEC 62271-1, BS 7626 and IEC 60044 for current and voltage transformers.
- IEC 60376 and IEC 60480 for the SF₆ gas.
- IEC 60099-4, IEC 60099-1, IEC 60099-5, IEC 62271-1, IEC 60137 and IEC 60815 for Metal Oxide Surge Arresters and additional tests for the SF₆ encapsulated types when required.
- IEC 60137, IEC 62271-1, IEC 60120, IEC 60305, IEC 60372, IEC 60383, IEC 60383 for bushings and insulators.
- IEC 60060, IEC 60383, IEC 60305, IEC 60044-1 and others, as well as VDE standards, if applicable.

Partial discharge measurements as factory tests are obligatory and to be performed as routine tests.

3.4.1 Type tests

As a minimum, the following Type Tests shall be performed on the switchgear:

- Dielectric test on main circuit – lightning impulse voltage tests, power frequency voltage withstand tests, partial discharge and radio interference voltage (r.i.v) tests
- Dielectric test on auxiliary and control circuit
- Temperature rise test
- Measurement of the resistance of the main circuit
- Short-time and peak withstand current, Short-circuit making and breaking, out-of-phase making and breaking, critical current and capacitive and inductive (reactor) current switching tests
- Mechanical endurance, environmental operation tests
- Thermal stability and Electromagnetic compatibility (EMC) tests
- Verification of the degree of protection
- Tightness and Pressure relief device tests.

3.4.2 Short circuit tests

Circuit Breaker, Disconnecter and Earth Switch shall be subjected to the Short Circuit tests in accordance with IEC 62271-100, IEC 62271-1 and in the schedule. The over voltages produced on any switching duty must be considerably less than (\ll) 2.5 p.u.

3.4.3 Dielectric tests

Circuit Breaker, Disconnecter and Earth Switch shall be subjected to the dielectric tests in accordance with IEC 62271-100, IEC 62271-1 and in the schedule. There shall be no self-restoring or non-self-restoring disruptive discharges during the fifteen positive and negative impulse test series.

3.4.4 Radio interference voltage tests

Where an external bushing is produced a radio influence voltage measurement shall be made in accordance with NEMA Publication 107. The level shall not exceed that specified in the Schedules and IEC 60137.

3.4.5 Thermal stability tests

All insulating parts of the Switchgear which uses organic material shall be subjected to a thermal stability test, the test procedure being that specified in IEC 60137.

3.4.6 Pressure relief devices

The ability of the devices to relieve pressure in the event of an internal arc shall be demonstrated in accordance with IEC 62271-203.

3.4.7 Verification of the degree of protection

Tests shall be performed on all auxiliary circuits to demonstrate that the degree of protection provided is in line with that specified in the IEC Standards.

3.4.8 Routine tests

As a minimum, the following routine tests shall be performed in accordance with their respective IEC Standards to ensure compliance with this Specification and to provide the necessary operating data:

- Dielectric test on main circuit – power frequency voltage withstand tests, partial discharge and radio interference voltage (r.i.v) tests
- Dielectric test on auxiliary and control circuit
- Measurement of the resistance of the main circuits
- Mechanical operation tests
- Pressure tests of enclosures
- Gas tightness test
- Design and visual checks.
- Inspection of the general condition
- Timing tests of the main contacts and auxiliary switches
- Complete electrical functioning tests including interlocking
- Closing and opening check at reduced voltage and other necessary tests and verifications.
- Chattering time of the arc contact of circuit breaker shall be measured and recorded at no-load operations
- Instrument transformer Core saturation test

The Contractor or his sub-Contractors shall supply to KETRACO, as soon as practicable after works tests, commissioning and site tests have been witnessed, six copies of the relevant test certificates. These shall contain details of each test performed as required by KETRACO – records, results and calculations of all electrical tests.

The subsequent section of this schedule list specific inspections, works and site tests, which KETRACO requires, but this shall not preclude KETRACO's right to call for further tests if it considers these necessary.

After the plant has passed the site tests required under this Contract and has become available for commercial operation, certain additional tests may be carried out in order to investigate the response and recovery of the system during events such as the switching of various items of plant, system faults and load rejection.

3.4.9 Site tests

As a minimum, the following tests after installation on site shall be performed in accordance with their respective IEC Standards:

- Power frequency voltage tests on the main circuits
- Partial discharge measurements and records
- Dielectric tests on auxiliary circuits
- Measurement of the resistance of the main circuits
- Gas tightness tests
- Design and visual checks
- Measurement of gas condition
- Mechanical operation tests
- Complete electrical functioning tests including the function of all interlocks.
- Instrument transformer knee voltage test

3.4.10 Circuit Breakers

3.4.10.1 General

General

All type tests for each type of circuit breaker and type tests to be performed depending upon the application, rating or design shall be as per the relevant standard, including but not limited to; IEC 62271-100 and IEC 62271-310 shall be proven through submission of type test reports approved by third party certified testing laboratory.

Only type tested circuit breakers are accepted. All routine tests and outstanding type tests of HV and MV circuit breakers Switches, as per IEC 62271-100, shall be performed during the factory inspection and acceptance testing witnessed by the Employer. All Employer's costs and out-of-pocket daily allowances related to witnessing the factory inspection and acceptance testing as enumerated in Section 15.1 "Workshop Inspection and Tests" (I. SCOPE OF SUPPLY AND SERVICES) shall be included in the Contract price and covered by the Contractor. The specific clauses set out in this technical specification take priority over the clauses of the IEC standards mentioned above.

The Employer shall attend factory testing of all of HV and MV AIS Disconnectors and Earthing Switches. Recommendation and clearance for shipment to site of the successfully tested equipment shall be only issued by the Project Consultant and/or the Employer after submission and approval of complete duly signed factory

inspection and acceptance testing reports including the inspection test plan, test results, minutes of meeting(s) and photos in both hard and soft copies.

Specific Tests

In addition, the following tests shall be performed on HV circuit breakers:

- Minimum control voltage at which the circuit breaker can operate.
- Current in tripping and closing coils at nominal and minimum voltage.
- The total opening time of the circuit breaker (in cycles).

The mechanical performance of each circuit breaker shall be verified by a circuit breaker analyser:

- Analyzer charts shall indicate dashpot action, operation of the auxiliary switch contact in the trip circuit, auxiliary switch contact in the close circuit and an auxiliary switch contact for automatic re- closing relay operation.
- In addition to the normal analyser charts, consistency charts shall be provided showing five (5) consecutive operations superimposed on one chart.

Measurements shall also be taken of coil resistances, control voltages and control currents of operating solenoids.

For the purpose of the following tests, the operating pressures for hydraulic operating mechanisms and SF₆ gas circuit breakers of all types shall be as follows:

1. Making and breaking current capacity type tests at minimum operating (lock-out) pressures.
2. Inductive (reactor) current interrupting type test at maximum operating pressures.
3. Capacitive current interrupting type tests at minimum operating (lock-out) pressures.

3.4.10.2 Type tests

As a minimum, the following type tests shall be performed in accordance with their respective IEC Standards and cognisance of the subsequent sub-clauses shall be taken:

1. Dielectric test on main circuit – lightning impulse voltage tests, power frequency voltage withstand tests, partial discharge and radio interference voltage (r.i.v) tests
2. Dielectric test on auxiliary and control circuit
3. Temperature rise test
4. Measurement of the resistance of the main circuit
5. Short-time and peak withstand current and Short-circuit making and breaking, terminal fault, short-line fault, out-of-phase making and breaking, critical current and capacitive and inductive (reactor) current switching tests
6. Insulation co-ordination tests
7. Synthetic testing

8. Mechanical endurance, environmental operation tests
9. Thermal stability test
10. Electromagnetic compatibility (EMC) tests
11. Verification of the degree of protection
12. Tightness tests and Pressure relief device tests.

3.4.10.3 Short circuit making and breaking current tests

Each type of circuit breaker being supplied shall be short circuit tested in accordance with the requirements of IEC 62271-100, IEC 62271-1 and IEC 62271-101 and shall include the following: -

1. The type tests shall be made on the full pole [maximum number of making or breaking units in series].
2. The rate of rise and peak value of the inherent recovery voltage applicable to each test duty shall be the values specified in IEC 62271-100 or in the Schedules.
3. Prior to the commencement of any series of short circuit tests, a complete series of no-load timing tests shall be made on the circuit breaker as specified in IEC 62271-100.
4. Test duty 4 make-break [CO] test must be performed at 100 per cent make peak current © and symmetrical break (0) at lock-out operating pressure and include longest arc duration.
5. Test duty 5 break test (O) must be performed at 100 per cent asymmetrical break (0) at lock-out operating pressure and include minor loop break and longest arc durations.
6. Test evidence shall be provided to show that one set of contacts and nozzles are capable of successfully interrupting at least twenty times the rated short circuit current.

3.4.10.4 Breaking and making current capacity under out- of- phase conditions

Circuit breakers for operation under out-of-phase conditions shall be rated and tested in accordance with IEC 62271-100.

3.4.10.5 Short time current test

The short time current test shall be carried out in accordance with IEC 62271-100.

3.4.10.6 Capacitive current switching tests

The capacitive current switching duty specified in the Schedules the circuit breaker shall be tested in accordance with IEC 62271-100. Test evidence shall be submitted to confirm that the highest over- voltage during any switching duty does not exceed < 2.5 p.u. The relevant switching type tests shall be to the satisfaction of KETRACO.

3.4.10.7 Low inductive current switching tests

A series of switching tests shall be made to IEC 62271-110 on each type of circuit breaker being supplied in order to demonstrate its performance when switching transformer magnetising currents and reactor currents. Test

evidence shall be submitted to confirm that the highest over voltage during any switching duty (including reactor) does not exceed < 2.5 p.u. The relevant switching type tests shall be to the satisfaction of KETRACO.

In addition to the above, additional, low inductive/reactor current switching test evidence of 10, 50, 100 amp currents, in accordance with IEC 62271-110 is required to confirm that the highest over voltage during any switching duty does not exceed < 2.5 p.u. These switching tests under site conditions are required for comparing the performance of different circuit breaker interrupter designs.

These tests shall preferably be made on a complete three phase or single-phase unit, at the rated SF₆ gas pressure, rated control voltage and at maximum operating conditions of the mechanism with the agreement of KETRACO.

3.4.10.8 Synthetic testing

The use of synthetic test circuits shall be in accordance with IEC 62271-101. Tests shall be performed single-phase or three-phase, with maximum arc durations at lockout operating pressures. Test duties with failure in the middle of arcing window shall not be acceptable.

3.4.10.9 Short line fault tests

Each type of circuit breaker shall have satisfactory proven capability of interrupting short- line-faults [SLF90, SLF 75 and SLF 60] to IEC 62271-100.

3.4.10.10 Auto-reclosing tests

When a circuit breaker is intended for auto-reclosing duties, the following supplementary tests shall be made:

- O-t-CO duty cycle at 10% rating and O-t-CO duty cycle at 100% rating

The time interval 't' shall be that specified in IEC 62271-100 and the Schedules for delayed and high speed auto-reclosure.

The TRV shall be as specified in IEC 62271-100. The operating pressure shall be the lockout / 'block-trip' value appropriate to the above duty cycle.

3.4.10.11 Dielectric tests

Each type of circuit breaker being provided shall be assembled complete as in service and subjected to the dielectric type tests specified in IEC 62271-100, IEC 60060 and IEC 62271-1 and in the Schedules and there shall be no self-restoring or non-self-restoring disruptive discharges during the fifteen positive and fifteen negative impulse test series.

3.4.10.12 Insulation co-ordination

Insulation coordination tests on circuit breaker shall be performed in accordance with IEC 60071-1, IEC 60071-2, IEC 60691 and IEC 60815.

3.4.10.13 Radio influence voltage and partial discharge tests

Where applicable, circuit breakers shall be subjected to RIV and PD type tests in accordance with and IEC 62271-1 and the values obtained shall not exceed the value guaranteed in the Schedules.

Test reports covering RIV and PD tests shall give full details of temperature, barometric pressure, humidity and correction factor applied as well as the test values obtained.

3.4.10.14 Mechanical endurance type tests

Mechanical endurance type tests shall be carried to demonstrate that the mechanism fitted to the circuit breaker is suitable for 10,000 satisfactory mechanical operations in accordance with IEC 62271-100.

3.4.10.15 Type test certificate

All type test certificates must stand on the test evidence alone and not require interpretations. It shall include relevant calibration, detailed drawings, construction, necessary dimensions and details of material etc. The contractor or sub-contractor shall supply to KETRACO two complete sets of the type test certificates.

3.4.10.16 Routine tests on works assembled circuit breakers

Each circuit breaker shall be assembled completed with its mechanism box, auxiliary switches and subjected to the routine tests in accordance with IEC 62271-100

and IEC 62271-1 It shall be noted that at least one local control cubicle (LCC) will have to be tested together with the circuit breaker during the factory acceptance tests.

As a minimum, the following routine tests shall be performed and cognisance of the subsequent sub-clauses shall be taken:

1. Dielectric test on main circuit – power frequency voltage withstand tests
2. Voltage withstand tests on auxiliary and control circuits
3. Measurement of the resistance of the main circuits
4. Mechanical operation tests.

3.4.10.17 Site tests

As a minimum, the following tests after installation on site shall be performed:

1. Inspection of general condition
2. Mechanical operation tests
3. Timing tests of the main contacts and auxiliary switches
4. Complete electrical functioning tests
5. Closing and opening check at reduced voltage
6. Contact resistance measurements.

3.4.11 Disconnectors and Earthing Switches

Each type of disconnector and earthing switch being provided shall be subjected strictly to the Type and Routine tests specified in IEC 62271-102, IEC 62271-1 and shall comply fully with the following supplementary type and routine tests.

3.4.11.1 Type tests

In order to demonstrate the insulation co-ordination of the disconnection the critical flashover levels to earth and across the open gap shall be determined in accordance with IEC 60071-102 and IEC 62271-1. The 'up and down' method described in IEC 60060 shall be used for these tests.

As a minimum, the following type tests shall be performed:

1. Dielectric test on main circuit – lightning impulse voltage tests, power frequency voltage withstand tests, partial discharge and radio interference voltage (r.i.v) tests and Dielectric test on auxiliary and control circuit
2. Temperature rise test
3. Measurement of the resistance of the main circuit
4. Short-time and peak withstand current tests and Short-circuit making performance of earthing switches
5. Bus transfer current switching capability tests (If applicable)
6. Insulation co-ordination tests
7. Mechanical endurance, environmental operation tests.

3.4.11.2 Routine tests

Routine tests on the Disconnector and earthing switch shall be in accordance with IEC 62271-102, IEC 62271-1.

As a minimum, the following routine tests shall be performed:

1. Dielectric test on main circuit – power frequency voltage withstand tests on disconnector and auxiliary and control circuits
2. Measurement of the resistance of the main circuits
3. Mechanical operation tests.

3.4.11.3 Site tests

As a minimum, the following tests after installation on site shall be performed:

1. Inspection of general condition

2. Operation timing tests
3. Manual and electromechanical closing and opening tests
4. Complete electrical functioning tests including the function of all interlocks
5. Closing and opening tests at reduced voltage.

3.4.11.4 Sulphur Hexafluoride

Samples of SF₆ from each consignment shall be tested and shall comply with the tests specified in IEC 60376 and IEC 60480, before any SF₆ gas is despatched.

Use and handling of SF₆ shall be in accordance with IEC 62271-303

3.5 Special Tools and Equipment

One complete set each of special tools in new condition as needed for operation, maintenance and repairs as well as for changing out components of substations and overhead lines and for storing dismantled parts shall be included in the delivery

- all standard accessories and auxiliary equipment normally belonging to the supplied items or that are required for commissioning of components
- servicing aids for protection systems as required for analysis, configuration and parameterization (hardware and software).

3.6 Spare Parts

The recommended spare parts shall comply with the requirements stated in the relevant Schedules of Technical Information and this Specification and shall be stated in the price schedules.

4. Current Transformers

4.1 General

This specification is part of the minimal technical requirements specific to the design, the manufacturing, and the tests in factory of high voltage Current transformers to be installed in the 132/33kV Rumuruti and 132/33kV Kabernet Substations..

The instrument transformers shall withstand the specified short circuit fault currents.

The Contractor shall submit for review and approval a calculation note setting out the appropriate sizing and characteristics of the secondary windings of the different instrument transformers.

The transformation ratio shall be labelled clearly, and the secondary shall be easily accessible. For all instrument transformers, the Contractor shall provide calculations, which demonstrate that the offered protection system will work together with the offered equipment under the actual short circuit and overload conditions and shall be submitted to the Employer for approval.

The calculations of cabling relevant to instrument transformers shall be provided for Employer's approval. The minimum cable size for interfacing connection shall not be less than 4 mm² for current transformer (CT) circuits. Internal wirings shall not be less than 2.5 mm² for CT.

For the electricity metering points, based on the real consumption of electricity meter proposed the contractor shall prepare and provide for approval the following:

- Calculation of CTs secondary burden
- Calculation of cross-section of secondary current circuits

The high precision metering cores shall work in the burden rate from 25 % to 100 % of the respective nominal burden.

The maximum acceptable voltage drop is 0.1 %.

The calculation shall be prepared and presented for approval to Employer in a form of design calculation in which all the inputs and calculation formulas or other methods used shall be clearly indicated.

The calculations shall be submitted for approval before the start of production.

All interfacing cables shall be multi-core type, screened. Screen shall be earthed at only one end/point. All multi-core cables shall be provided with – as a minimum- four (4) spare core.

The CT circuit shall be earthed only at one point. For protection circuits, the earthing shall be made at relay side. The metering cores shall be earthed only at CT/marshalling kiosk sides. The CT circuits shall be provided with earthing facilities at the CT boxes.

The CT circuit terminals shall offer facilities for insulations-sliding links, earthing, shorting per phase, complete facilities for forming of star points and maintenance.

4.2 Codes and Standards

Instrument transformers specified in this document shall be manufactured and tested in accordance with the latest editions and amendments to applicable IEC and ISO standards including:

IEC 60071-1	Insulation coordination – Part 1: Definitions, principles and rules
IEC 60071-2	Insulation coordination – Part 2: Application guide
IEC 60376	Specification of technical grade Sulphur hexafluoride (SF ₆) for use in electrical

	equipment
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles
IEC 62869-1	Instrument transformers – Part 1: General requirements for instrument transformers
IEC 61869-2	Instrument transformers – Part 2: Additional requirements for instrument transformers
IEC 61869-3	Instrument transformers – Part 3: Additional requirements for inductive voltage transformers
IEC 61869-5	Instrument transformers – Part 5: Additional requirements for capacitor voltage transformers
IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications
IEC 60529	Classification of degree of protection provided by enclosures Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60815	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear.
IEC 60296	Coupling capacitor and capacitor dividers – Part 1 General rules Classification of degree of protection provided by enclosures.
IEC 60358-1	Coupling Capacitors and Capacitive Dividers
IEC 60529	Degrees of protection provided by enclosure (IP Code)
ISO 9001	Quality management systems – Requirements

The applicable additional standards are the ISO, DIN / VDE, CENELEC, BS and US standards or national specific standards listed above, if no relevant IEC standard exists or if there is insufficient information available in IEC standards and / or explicitly requested in this standard.

The Bidder shall provide, with its offer, valid certificates which prove that the Manufacturers and suppliers proposed are ISO 9001 certified and conform to RoHS certifications. Manufacturers who do not have sufficient experience in the manufacture, installation and testing of equipment as specified and / or not ISO 9001 certified and that do not comply with RoHS will not be accepted.

The standards listed below are of particular importance for documentation.

IEC 60617	Graphical symbols for diagrams
IEC 61082-1	Preparation of documents used in electro technology – Part 1: Rules
IEC 61131	Programmable controllers
IEC 61355	Classification and designation of documents for plants, systems and equipment
IEC 61506	Industrial-process measurement and control – Documentation of application software
IEC 62023	Structuring of technical information and documentation

IEC 81346-1	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules
IEC 81346-2	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes
IEC 81714	Design of graphical symbols for use in the technical documentation of products
ISO 5457	Technical product documentation – Sizes and layout of drawing sheets
ISO 7200	Technical product documentation – Data fields in title blocks and document headers
ISO 14617	Graphical symbols for diagrams

4.3 Technical Data Schedules

Refer to Section 2E for Technical Data Schedule where characteristics of instrument transformers are specified.

4.4 Ratings

The current transformers shall be designed and tested in accordance with the requirements of IEC 62271-1 and IEC 61869-1/-2 and any additional requirements of this Specification.

The required quantities, locations, sequence, ratio, rating and class of the current transformers are a function of the circuit application. The requirements for each application are included in the Schedules of Technical Information and bid drawings.

Current transformers shall be of outdoor, oil immersed multi core hermetically sealed type.

The following facilities shall be provided for each current transformer: -

- Visual means of determining the level of oil from the ground level with the transformers; this shall be by means of an internal bellows type oil gauge.
- Oil drain cock and sampling device.
- Earth terminal of adequate dimensions so arranged that the earth connection cannot be inadvertently removed.

If not otherwise stated, the rated extended primary current is 120% of the rated primary current.

Rated output of measuring cores shall be chosen from preferred standard values in such a manner that secondary burden is between 25% and 100% of the rated burden. Preliminary values of rated output for bidding purposes are indicated in the Technical Data Sheets. During design stage the contractor needs to confirm these values by calculation.

Each current transformer secondary winding circuit shall be earthed at only one point. Wherever possible the connection to earth shall be at S2 terminals. Current transformers shall have a secondary terminal, outside the

high voltage housing, mounted in suitable accessible, earthed boxes. All secondary leads must be wired to shorting type terminals on the terminal strip in the local control cubicle.

Current transformer secondary shorting and disconnecting links shall be provided in a position secure but readily accessible position for testing purposes.

The static withstand load shall be selected from either load class I or II of IEC 61869-1, based on an assessment of the possible loads under local site conditions.

Changing/selection of current transformer ratio shall be possible only through the secondary circuit. This shall not be implemented at the primary terminal.

4.5 Current Transformers for Tariff Metering

Tariff Metering shall be provided on all overhead lines.

Separate sets of 3-phase CT cores shall be provided, one set for the Main Meter and one set for the Check Meter.

CT cores shall be class 0.2s conforming to IEC 61869-2 and have a minimum burden of 5VA. Preliminary values of rated output for bidding purposes are indicated in the Technical Data Sheets. CT dimensioning calculation shall be provided to demonstrate the supplied burden is adequate and will operate within the accuracy parameters defined in IEC 61869-2.

The secondary current shall be 1A.

Wiring terminations shall be provided with integral earthing, isolation and shorting links to facilitate maintenance and testing.

4.6 Special Tools and Equipment

One complete set each of special tools in new condition as needed for operation, maintenance and repairs as well as for changing out components of substations and overhead lines and for storing dismantled parts shall be included in the delivery

- all standard accessories and auxiliary equipment normally belonging to the supplied items or that are required for commissioning of components
- servicing aids for protection systems as required for analysis, configuration and parameterization (hardware and software).

4.7 Equipment Submittals

The Contractor shall provide a detailed schedule for the design, manufacture, and delivery of the instrument transformers and all related equipment, ensuring that the sequence and timing are consistent with the construction schedule.

Provide Manufacturer's printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical sizes, finish and limitations.

The following information and documents shall be submitted for review by the Employer:

- Master drawing index.
- Front view elevation and weight.
- Plan view.
- Schematic diagrams.
- Nameplate diagram;
- Components list;
- Accessory information;
- Data sheets for current transformers including:
 - Nominal voltage;
 - Continuous current;
 - Short time current;
 - Dynamic current;
 - Basic impulse level (BIL);
 - Accuracy class;
 - Rated burden;
 - Ratio;
 - Thermal factor;
 - Secondary resistance;
 - Excitation current;
 - Ration correction curves;
 - Maximum and minimum operating temperatures;
 - Maximum elevation (m a.s.l.);
 - Creepage;
- Data sheets for capacitor voltage transformers including:
 - Nominal voltage;
 - Maximum system voltage;
 - Rated burden;
 - Basic impulse level (BIL);
 - Accuracy class;
 - Thermal burden;
 - Coupling capacitance (when applicable);
 - Maximum and minimum operating temperatures;
 - Maximum elevation (m a.sl.);
 - Creepage
 - Cable terminal sizes
- List of recommended spare parts, tools and instruments with catalogue numbers and current prices

The Contractor shall provide full details of the seismic anchorages for the installation of the Instrument transformers. The supplier must recommend the anchorages and detail the location of the anchorages to ensure that the anchor system meets the applicable requirements.

Manufacturer's Instructions: submit Manufacturer's installation instructions and special handling criteria per installation sequences and cleaning and testing procedures.

Quality Assurance Submittals:

- Provide manufacturing plant QA/QC records, procedures and forms, ISO quality systems or others;

- Submit certificates signed certifying that materials comply with specified performance characteristics and physical properties.

The following product information shall be made available and submitted when requested by the Employer:

- Descriptive bulletins;
- Product sheets.

Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of these instructions shall also be included with the equipment at the time of shipment.

Operation and maintenance manuals shall include the following information:

- Instruction books and/or leaflets;
- Recommended renewal parts list;
- Installation information and drawings.

The following information shall be submitted at time of completion:

- Final as-built drawings and information for items listed in previous section;
- Wiring diagrams;
- Certified production test reports;
- Installation information;
- Seismic certification and equipment anchorage details.
- Commissioning test report.

The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

4.8 References

The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of thirty (30) years. A list of references with similar equipment shall be provided demonstrating compliance with this requirement.

4.9 Delivery, Storage and Handling

Delivery and acceptance requirements: deliver materials to the site in its original factory packaging, identified with the name and address of the Manufacturer.

Storage and handling requirements:

- Transport, storage and handling of equipment in accordance with the Manufacturer's recommendations, indoors, in a clean, dry and well-ventilated area;
- Each section shall be placed on a wooden pallet to be able to move the equipment with a forklift;
- Each section shall be vacuum packed. Dehydrating bags should be included with each packaged section;
- Protect equipment from damage;
- Replace defective or damaged materials with new materials;
- Two (2) impact indicators shall be provided and installed on the package for shipment.

4.10 Operation Conditions

Instrument transformers shall be designed to operate normally under all operating conditions listed in the Technical Data Schedules, including rapid changes in load and voltage and faults limited to the nominal characteristics listed.

Instrument transformers shall be designed to normally operate in an environment described in SECTION 2.4 "SERVICE CONDITIONS" (PART 2A, SCOPE OF WORK).

4.11 Design and Manufacture of HV Current Transformers

The current transformers shall be single-phase, oil type, installed on separate steel support structures. For measuring and protection purposes, the same current transformer, with multiple secondary cores shall be used. Transformers shall be designed, manufactured, and tested taking into account the electrical characteristics given in the Specification Sheet and following the Standards given above.

No visible or audible external corona must occur on the current transformer at a voltage of $U_m/\sqrt{3}$.

Between the primary terminals there must be a protective device capable of protecting the insulation even for steepest surges and limiting the overvoltage transferred to the secondary circuit to a moderate value. After sparking over, the protective device must reseal at the first zero of the highest short circuit current.

The current transformer shall be completely oil-tight and hermetically sealed by means of bellows, a membrane or an inert gas cushion so that the variations in ambient temperature and loading do not cause severe changes in the internal pressure. The expansion space shall be amply dimensioned to allow for, in addition to temperature fluctuations, oil leakage and filling error. In the case of bellows or a membrane there must be neither air nor inert gas space inside them. There must be neither gaskets nor valves, in the inert-gas cushion space.

Taps shall be mandatory provided on the secondary windings of the different cores in order to provide different ratios required for Protection and Measurement functions in accordance to the approved calculation notes setting out the appropriate sizing and characteristics of CTA bellows or membrane position indicator shall be provided in a current transformer fitted with bellows or a membrane. A current transformer provided with an inert gas cushion shall be fitted with a liquid level indicator.

There shall be an earthed metallic shield between the primary and secondary winding in order to prevent the high voltage entering into the secondary winding in the case of internal flashover and to reduce the interference voltages transferring to the secondary.

A suitable terminal for earthing of the voltage exposed parts, marked with the appropriate graphical symbol shall be provided.

The current transformer must not be fitted with protective spark gaps between phase and earth.

The control boxes for the current transformers shall house adequate terminals of the secondary windings, which shall be of short circuit type. The box shall be sealable for prevention of any accidental or voluntary influence on the measurement equipment. The enclosure of the boxes shall have a class of protection of IP54.

The terminals of the windings shall be marked according to IEC standard requirements. The connection terminals shall be installed on a DIN rail and shall be split in two sections respectively for measuring and for protection.

The connection terminal of the high accuracy class coil for metering shall have transparent cover which shall be sealable. The cover shall prevent any unauthorized access to the bolts of the terminals and connections between cables and terminals. The sealing shall be realized as indicated on Drawings with the respective separate terminal fixing and sealing plates.

Care shall be taken to avoid formation of humidity, by providing adequate space heaters temperature and humidity controlled.

Suitable metallic cable glands shall be provided in order to enable fixation of cables and cables run through.

Each current transformer shall have the following accessories:

- Expansion chamber and diaphragm;
- Pressure gauge or oil level gauge;
- A gas or oil fill valve;
- Low-voltage terminal box,
- Grounding terminal supplied with a connector.

The vessel or support shall be made of metal, waterproof and hermetically sealed and shall withstand the transformer rigidly.

The connection box must be weatherproof with a hinged door and a removable plate on the outside base of the cabinet to allow cable entry. Each terminal box must be equipped with terminals for the secondary conductors. The connection box must be supplied with a voltage limiting device. The terminal block shall have facilities for shorting and isolation.

The HV terminal shall be in the form of a four-hole terminal in accordance with ANSI / NEMA CC-1. The grounding terminal shall be in the form of a two-hole terminal of 14.5 mm and spaced 45 mm

The Contractor shall design the windings for the protection of the current transformer in order to meet the transient performance requirements set out in the Technical Data Schedule and related to IEC61869-2. The Contractor shall submit, together with the drawings for approval, a calculation notes setting out the appropriate sizing and characteristics of the windings.

Current transformers shall be mounted on lattice steel supports with single piece vertical main members connected to the Substation grounding Earth mat (minimum two diagonal Earthing connections). The design and manufacture of the structural supports shall withstand all anticipated short circuit mechanical forces. The steel support base finishing shall prevent water ponding in and around the foundation.

4.12 Spare Parts

The recommended spare parts shall comply with the requirements stated in the relevant Schedules of Technical Information and this Specification and shall be stated in the price schedules.

4.13 Type tests

Satisfactory evidence must be provided that the equipment offered has passed all design tests required by IEC standards.

All type tests for each type of HV and MV outdoor current transformer shall be as per the relevant standard IEC 61869-2.

Only type tested instrument transformers are accepted.

All standard factory production tests specified in the latest revision of the IEC Standards listed above shall be carried out on all equipment supplied in accordance with this specification. Employer shall witness the factory test.

In order to demonstrate that all transformers made to the same specification comply with the requirements, the type tests in accordance with IEC 61869-1/-2 shall be performed.

As a minimum, the following type tests shall be performed:

- Short time current tests
- Temperature rise tests
- Lightning impulse test
- Switching impulse test
- Wet test for outdoor type of transformer
- Determination of errors

4.14 Routine tests

Routine tests on the current transformers shall be in accordance with IEC 61869-1/-2.

As a minimum, the following routine tests shall be performed:

- Verification of terminal marking
- Power frequency withstand test on primary winding
- Partial discharge measurement
- Power frequency withstand test on secondary winding
- Inter-turn overvoltage test
- Determination of errors

4.15 Site tests

As a minimum, the following tests after installation on site shall be performed in accordance with their respective IEC Standards:

- Inspection of general condition (supporting structure, secondary wiring, earthing, primary connection, oil level & leakage test etc)
- Primary test – Ratio test with primary injection
- Secondary injection & excitation curves of CT for each core
- Winding resistance measurement for each core
- Isolation (Megger test) with applied voltage of 1000V dc
- Polarity check
- CT loop resistance measurement

5. Voltage transformers

5.1 General

This specification is part of the minimal technical requirements specific to the design, the manufacturing, and the tests in factory of high voltage voltage transformers to be installed in the 132/33kV Rumuruti and 132/33kV Kabernet Substations.

The instrument transformers shall withstand the specified short circuit fault currents.

The Contractor shall submit for review and approval a calculation note setting out the appropriate sizing and characteristics of the secondary windings of the different instrument transformers.

The transformation ratio shall be labelled clearly, and the secondary shall be easily accessible. For all instrument transformers, the Contractor shall provide calculations, which demonstrate that the offered protection system will work together with the offered equipment under the actual short circuit and overload conditions and shall be submitted to the Employer for approval.

The calculations of cabling relevant to instrument transformers shall be provided for Employer's approval. The minimum cable size for interfacing connection shall not be less than 2.5 mm² for voltage transformer (VT) circuits. Internal wirings shall not be less 1.5 mm² for VT.

For the electricity metering points, based on the real consumption of electricity meter proposed the contractor shall prepare and provide for approval the following:

- Calculation of VTs secondary burden
- Calculation of Voltage drop from VT's secondary outlets to meter.
- Calculation of cross-section of secondary voltage circuits.

The high precision metering cores shall work in the burden rate from 25 % to 100 % of the respective nominal burden.

The maximum acceptable voltage drop is 0.1 %.

The calculation shall be prepared and presented for approval to Employer in a form of design calculation in which all the inputs and calculation formulas or other methods used shall be clearly indicated.

The calculations shall be submitted for approval before the start of production.

All interfacing cables shall be multi-core type, screened. Screen shall be earthed at only one end/point. All multi-core cables shall be provided with – as a minimum- four (4) spare core.

The VT circuit terminals shall offer facilities for insulations-sliding links, earthing, shorting per phase, complete facilities for forming of star points and maintenance.

5.2 Codes and Standards

Instrument transformers specified in this document shall be manufactured and tested in accordance with the latest editions and amendments to applicable IEC and ISO standards including:

IEC 60071-1 Insulation coordination – Part 1: Definitions, principles and rules

IEC 60071-2	Insulation coordination – Part 2: Application guide
IEC 60376	Specification of technical grade Sulphur hexafluoride (SF6) for use in electrical equipment
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles
IEC 62869-1	Instrument transformers – Part 1: General requirements for instrument transformers
IEC 61869-2	Instrument transformers – Part 2: Additional requirements for instrument transformers
IEC 61869-3	Instrument transformers – Part 3: Additional requirements for inductive voltage transformers
IEC 61869-5	Instrument transformers – Part 5: Additional requirements for capacitor voltage transformers
IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications
IEC 60529	Classification of degree of protection provided by enclosures Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 60815	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear.
IEC 60296	Coupling capacitor and capacitor dividers – Part 1 General rules Classification of degree of protection provided by enclosures.
IEC 60358-1	Coupling Capacitors and Capacitive Dividers
IEC 60529	Degrees of protection provided by enclosure (IP Code)
ISO 9001	Quality management systems – Requirements

The applicable additional standards are the ISO, DIN / VDE, CENELEC, BS and US standards or national specific standards listed above, if no relevant IEC standard exists or if there is insufficient information available in IEC standards and / or explicitly requested in this standard.

The Bidder shall provide, with its offer, valid certificates which prove that the Manufacturers and suppliers proposed are ISO 9001 certified and conform to RoHS certifications. Manufacturers who do not have sufficient experience in the manufacture, installation and testing of equipment as specified and / or not ISO 9001 certified and that do not comply with RoHS will not be accepted.

The standards listed below are of particular importance for documentation.

IEC 60617	Graphical symbols for diagrams
IEC 61082-1	Preparation of documents used in electro technology – Part 1: Rules
IEC 61131	Programmable controllers
IEC 61355	Classification and designation of documents for plants, systems and equipment

IEC 61506	Industrial-process measurement and control – Documentation of application software
IEC 62023	Structuring of technical information and documentation
IEC 81346-1	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules
IEC 81346-2	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes
IEC 81714	Design of graphical symbols for use in the technical documentation of products
ISO 5457	Technical product documentation – Sizes and layout of drawing sheets
ISO 7200	Technical product documentation – Data fields in title blocks and document headers
ISO 14617	Graphical symbols for diagrams

5.3 Technical Data Schedules

Refer to Section 2E for Technical Data Schedule where characteristics of instrument transformers are specified.

5.4 Ratings

The capacitive voltage transformers shall be designed and tested in accordance with the requirements of IEC 62271-1 and IEC 61869-1/-5 and any additional requirements of this Specification.

The required quantities, locations, sequence, ratio, rating and class of the voltage transformers are a function of the circuit application. The requirements for each application are included in the Schedules of Technical Information and bid drawings.

Rated output shall be chosen from preferred standard values in such a manner that the secondary burden is between 25% and 100% of the rated burden. Preliminary values of rated output for bidding purposes are indicated in the Technical Data Sheets. During design stage the contractor needs to confirm these values by calculation.

The secondary circuits shall be earthed at one point only. A separate earth link shall be provided to each secondary winding.

The secondary terminals must be located in an accessible, earthed weatherproof terminal box located on the base of the voltage transformer. The secondary connections must be protected with MCB and wired on the terminal strip in the local control cubicle.

The static withstand load shall be selected from 'Voltage terminals' or 'Through current terminals' Load Class I or II of IEC 61869-2 and IEC 61869-5 depending on an assessment of the connections and possible loads under local site conditions.

5.5 Capacitor Type Voltage Transformers

These voltage transformers shall be designed to operate devices which require a potential source of approximately constant voltage ratio and negligible phase shift with respect to the high-voltage circuit.

The voltage transformers shall be high capacitance type.

The capacitor unit shall be hermetically sealed.

A bushing shall be provided to enable a high frequency signal to be coupled to the capacitor unit. The bushing shall be fully protected against rain and vermin when in use so as to avoid the possibility of being shorted to earth.

5.6 Voltage Transformers for Tariff Metering

The voltage transformer may be of the wound or capacitive design principle.

The VT shall provide separate secondary windings for connection to main and check metering.

The VT secondary shall be of class 0.2 conforming to IEC 61869-3 for a wound VT and IEC 61869-5 for a capacitive voltage transformer. VT dimensioning calculation shall be provided to demonstrate the supplied burden is adequate and will operate within the accuracy parameters defined in IEC 61869.

The secondary voltage shall be $110V/\sqrt{3}$.

VT secondary winding-1 shall connect to the Main Meter and secondary winding-2 to the Check Meter.

Wiring terminations shall be provided with integral earthing and isolation links to facilitate maintenance and testing.

The VT shall be protected by a suitably rated MCB with an auxiliary contact. This contact shall be wired out to a terminal block and raise upon operation "Metering VT MCB trip" alarm.

5.7 Special Tools and Equipment

One complete set each of special tools in new condition as needed for operation, maintenance and repairs as well as for changing out components of substations and overhead lines and for storing dismounted parts shall be included in the delivery

- all standard accessories and auxiliary equipment normally belonging to the supplied items or that are required for commissioning of components
- Servicing aids for protection systems as required for analysis, configuration and parameterization (hardware and software).

5.8 Equipment Submittals

The Contractor shall provide a detailed schedule for the design, manufacture, and delivery of the instrument transformers and all related equipment, ensuring that the sequence and timing are consistent with the construction schedule.

Provide Manufacturer's printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical sizes, finish and limitations.

The following information and documents shall be submitted for review by the Employer:

- Master drawing index.
- Front view elevation and weight.
- Plan view.
- Schematic diagrams.
- Nameplate diagram;
- Components list;
- Accessory information;
- Data sheets for current transformers including:
 - Nominal voltage;
 - Continuous current;
 - Short time current;
 - Dynamic current;
 - Basic impulse level (BIL);
 - Accuracy class;
 - Rated burden;
 - Ratio;
 - Thermal factor;
 - Secondary resistance;
 - Excitation current;
 - Ration correction curves;
 - Maximum and minimum operating temperatures;
 - Maximum elevation (m a.s.l.);
 - Creepage;
- Data sheets for capacitor voltage transformers including:
 - Nominal voltage;
 - Maximum system voltage;
 - Rated burden;
 - Basic impulse level (BIL);
 - Accuracy class;
 - Thermal burden;
 - Coupling capacitance (when applicable);
 - Maximum and minimum operating temperatures;
 - Maximum elevation (m a.sl.);
 - Creepage
 - Cable terminal sizes
- List of recommended spare parts, tools and instruments with catalogue numbers and current prices

The Contractor shall provide full details of the seismic anchorages for the installation of the Instrument transformers. The supplier must recommend the anchorages and detail the location of the anchorages to ensure that the anchor system meets the applicable requirements.

Manufacturer's Instructions: submit Manufacturer's installation instructions and special handling criteria per installation sequences and cleaning and testing procedures.

Quality Assurance Submittals:

- Provide manufacturing plant QA/QC records, procedures and forms, ISO quality systems or others;
- Submit certificates signed certifying that materials comply with specified performance characteristics and physical properties.

The following product information shall be made available and submitted when requested by the Employer:

- Descriptive bulletins;
- Product sheets.

Equipment shall be handled and stored in accordance with Manufacturer's instructions. One (1) copy of these instructions shall also be included with the equipment at the time of shipment.

Operation and maintenance manuals shall include the following information:

- Instruction books and/or leaflets;
- Recommended renewal parts list;
- Installation information and drawings.

The following information shall be submitted at time of completion:

- Final as-built drawings and information for items listed in previous section;
- Wiring diagrams;
- Certified production test reports;
- Installation information;
- Seismic certification and equipment anchorage details.
- Commissioning test report.

The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

5.9 References

The Manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of thirty (30) years. A list of references with similar equipment shall be provided demonstrating compliance with this requirement.

5.10 Delivery, Storage and Handling

Delivery and acceptance requirements: deliver materials to the site in its original factory packaging, identified with the name and address of the Manufacturer.

Storage and handling requirements:

- Transport, storage and handling of equipment in accordance with the Manufacturer's recommendations, indoors, in a clean, dry and well-ventilated area;
- Each section shall be placed on a wooden pallet to be able to move the equipment with a forklift;
- Each section shall be vacuum packed. Dehydrating bags should be included with each packaged section;
- Protect equipment from damage;
- Replace defective or damaged materials with new materials;
- Two (2) impact indicators shall be provided and installed on the package for shipment.

5.11 Operation Conditions

Instrument transformers shall be designed to operate normally under all operating conditions listed in the Technical Data Schedules, including rapid changes in load and voltage and faults limited to the nominal characteristics listed.

Instrument transformers shall be designed to normally operate in an environment described in SECTION 2.4 "SERVICE CONDITIONS" (PART 2A, SCOPE OF WORK).

5.12 Design and Manufacture of HV Capacitor Voltage Transformers

All voltage transformers, for line feeders and busbars, shall be of the coupling capacitive voltage transformer type (CCVT). Capacitive voltage transformers shall be used and thus shall be suitable, for both measuring and protection purposes. Transformers shall be designed, manufactured and tested considering the electrical characteristics provided in the Technical Data Schedules and in accordance with the indicated Codes and Standards.

The voltage-capacitor transformer consists of a series of capacitive elements placed in a high-strength porcelain insulator made of low-loss, high-quality insulating materials. The bottom part of the CVT must be installed on an oil-filled metallic base housing where the transformer must be placed with the series reactor, protective spark gap or varistor and the grounding switch.

The capacitor elements shall be enclosed in containers of brown glazed porcelain, which are assembled to set up the capacitor forming one uniform self-supporting stack. The voltage transformer shall form an integral assembly with the capacitor.

The voltage transformers shall be single-phase, with one end of the primary winding directly earthed. The seal shall be of metallic diaphragm.

The single-phase capacitive voltage transformers shall be installed on separate steel support structures. The Contractor shall also install complete facility with bypass Earthing switch connected interconnected to the respective single-phase capacitive voltage transformer on the steel support for the middle phase of each of the two circuits of the same transmission line in order to enable telecommunication using power line carrier equipment.

The secondary windings shall be provided with a miniature circuit breaker with auxiliary contacts located in a secondary connection terminals box and interfaced to the substation control system to monitor their position.

Each CVT shall have an Earthing/grounding terminal directly connected to the substation Earth mat using a single piece 70mm² insulated copper conductor. The connection terminals shall be installed on a DIN rail and shall be split into two sections respectively for measuring and for protection. The connection terminal and the MCB of the high accuracy class coil for measuring shall have transparent cover which shall be sealable. The cover shall prevent any unauthorized access to the bolts of the terminals and connections between cables and terminals.

The sealing shall be realized with the respective separate terminal fixing and sealing plates. The MCB for protection of measuring core shall also be sealable.

Transformers shall be placed in a sealed envelope filled with SF₆ gas or insulating mineral oil and the conductors of the secondary windings shall be fed to a waterproof terminal box and accessible for inspection.

Each CVT is formed of sections, depending on its nominal voltage. Each capacitor section shall include an expansion chamber to permit changes in the volume of the fluid at different temperatures and to allow fluid to escape to the exterior of the porcelain if there is excessive build-up of pressure due to failure of the insulation.

In addition to the secondary connection terminals box at the base of each voltage transformer's base, one weatherproof CVT terminal marshalling cabinet, for each three-phase group of voltage transformers shall be provided. This marshalling cabinet shall be mounted on the middle phase CVT steel support structures with its Earthing/grounding terminal directly connected to the substation Earth mat using a single piece 70mm² insulated copper conductor, in a position accessible from ground level. The secondary connection terminals box and the CVT marshalling cabinet shall ensure adequate prevention of any accidental or voluntary influence on the measurement equipment. The marshalling cabinets shall contain all necessary terminals to terminate each voltage transformer secondary winding, three-phase and neutral circuit.

Please refer to the Technical Data Sheets for the full presentation of the required technical characteristics of capacitor voltage transformers.

The CVT shall be designed to have excellent transient response performance which should include, among others, Ferro resonance suppression characteristics such as a damping circuit with reactance and resistance. The Ferro resonance characteristics shall not produce sustained frequency oscillations or overvoltage at less than 10 Hz of the nominal frequency. The equipment must not amplify existing oscillations on the primary circuit.

The spark gap or protective device (voltage limiter) shall not operate at a voltage less than twice the normal operating voltage.

Each capacitive voltage transformers shall contain the following accessories:

- An expansion chamber and a diaphragm;
- A gas density indicator (manometer) or oil level gauge;
- Arrangement for a gas access valve or oil drain valve;
- A valve for gas filling or oil filling;
- A grounding terminal supplied with a connector.

The tank shall be a hermetically sealed, weatherproof tank which must rigidly support the unit of capacitance and contain the intermediate transformer.

The connection box must be weatherproof with a hinged door and a removable plate on the outside base of the cabinet to allow cable entry. Each connection box must be equipped with the following elements:

- Terminals for transformer secondary conductors
- Heating element

The HV terminal shall be in the form of a four-hole terminal in accordance with ANSI / NEMA CC-1. The grounding terminal shall be in the form of a two-hole 14.5 mm terminal spaced 45 mm apart.

A shunt discharge device shall be installed to protect the secondary of the transformer against large voltage shocks.

A medium voltage grounding switch must be connected between the primary of the intermediate transformer and the ground. This grounding switch will allow the intermediate transformer to be switched off for maintenance purposes. The operation handle must be located outside the enclosure.

The series reactor must be in the tank to keep the secondary winding voltage in phase with the line voltage.

The secondary winding shall maintain an accuracy of 0.2% without adjustments for loads between 0 and 100% of the unit rating.

- Provide a three-phase, weatherproof CVT marshalling cabinet installed on the support of the central/middle phase capacitive voltage transformer, containing the three-phase and neutral connections and accessible from the ground (at the same installation height as that of the operating mechanism boxes for Disconnectors and Earthing Switches). The three-phase CVT marshalling cabinet must include: A separate set of terminal blocks for the control cables from the measuring devices and a separate set of terminal blocks for the control cables from the protection devices;
- A set of three-pole circuit breakers in a moulded casing for connecting the voltages of the measuring windings;
- Miniature single-pole circuit breakers with high clearing speed for the connection of protective windings; single-pole circuit-breakers shall be provided with auxiliary contacts for alarms interfaced to the substation control system; the selection of circuit breakers shall be compatible with the design of line protections;

- A neutral grounding terminal for each secondary winding securely connected;
- A 240 VAC panel heater automatically controlled by a temperature and humidity controller to prevent condensation.
- Door-actuated panel light LED strip.
- British standard three-pin socket outlet with automatic safety shutters and 30mA Earth leakage protection MCB.

Provide a report of the sizing of the MCBs and MCCBs and ensure that they shall not trip when the voltage circuits are switched on. Capacitive Voltage transformers shall be mounted on lattice steel supports with single piece vertical main members connected to the Substation grounding Earth mat (minimum two diagonal Earthing connections).

The design and manufacture of the structural supports shall withstand all anticipated short circuit mechanical forces.

The steel support base finishing shall prevent water ponding in and around the foundation.

5.13 Spare Parts

The recommended spare parts shall comply with the requirements stated in the relevant Schedules of Technical Information and this Specification and shall be stated in the price schedules.

5.14 Type tests

Satisfactory evidence must be provided that the equipment offered has passed all design tests required by IEC standards.

All type tests for each type of HV and MV outdoor capacitive voltage transformer shall be as per the relevant standard IEC 61869-5.

Only type tested instrument transformers are accepted.

All standard factory production tests specified in the latest revision of the IEC Standards listed above shall be carried out on all equipment supplied in accordance with this specification. Employer shall witness the factory test.

In order to demonstrate that all voltage transformers made to the same specification comply with the requirements, the type tests in accordance with IEC 61869 shall be performed.

As a minimum, the following type tests shall be performed:

- Accuracy check
- Temperature rise tests
- Capacitance and $\tan\delta$ measurement at power frequency
- Short circuit withstand capability
- Lightning impulse test
- Wet test for outdoor type of transformer
- Ferro-resonance test
- Accuracy test

5.15 Routine Tests

Routine tests on the current transformers shall be in accordance with IEC 61869:

As a minimum, the following routine tests shall be performed:

- Tightness of capacitor voltage divider
- Capacitance and $\tan\delta$ measurement at power frequency
- Power frequency withstand test
- Partial discharge measurement
- Verification of terminal marking
- Power frequency withstand test on the electromagnetic unit
- Power frequency withstand test on secondary winding
- Ferro-resonance check
- Accuracy check determination

5.16 Site Tests

As a minimum, the following tests after installation on site shall be performed in accordance with their respective IEC Standards:

- Inspection of general condition (supporting structure, secondary wiring, earthing, primary connection, oil level & leakage check etc.)
- Ratio test
- Winding resistance measurement for each core
- Isolation (Megger test) with applied voltage of 1000V dc for secondary winding
- Polarity check

6. Surge Arresters

6.1 General

This specification is part of the minimal technical requirements specific to the design, the manufacturing, and the tests in factory of the high voltage surge arresters installed in the 132/33 kV Rumurutu and 132/33kV Kabernet substation.

Surge arresters shall be of the metal-oxide, gapless type (MOAs). Suitable outdoor type surge arresters shall be offered. The application and rating of surge arresters shall be determined by insulation co-ordination studies.

The design of the surge arresters shall be in accordance with the requirements of IEC 60099-1, IEC 60099-4, IEC 60099-5, IEC 62271-1, IEC 60137, IEC 60815 and any additional requirements of this Specification. Each pressure vessel for housing the metal-oxide discs shall comply with the requirements of the appropriate CENELEC Document and European standard. The testing of the equipment shall be in accordance with the requirements of IEC 60099, (IEC 60099-1, IEC 60099-4, IEC 60099-5), IEC 62271-1, IEC 60060 and IEC 60270.

The surge arresters shall be designed to incorporate a pressure relief device to prevent shattering of the blocks/or housing, following prolonged current flow or internal flashover. They shall be designed to ensure satisfactory operation under the atmospheric conditions given, and under such sudden variation of voltage as may be met with under working conditions on the system.

The creepage distance shall be as specified in the Technical Data Sheet and surge arresters shall be equipped with a grading ring.

The surge arresters form part of the overall contract for the engineering of the substations and the supply of equipment, therefore they shall be positioned as near to the equipment to be protected so that they can provide maximum protection in accordance with IEC 60099.

6.2 Technical Requirements

Each surge arresters shall be of gapless, zinc-oxide, heavy duty type equipped with a pressure relief device to prevent shattering of the arrester housing as well as provide a path for flow of rated fault currents in the event of arrester failure.

Each 400kV surge arresters shall be designed for a nominal discharge current of 20kA and line discharge class 4 on two consecutive operations.

Each 132kV and 33kV surge arresters shall be designed for a nominal discharge current of 10kA and line discharge class 3 on two consecutive operations.

The end fittings of the surge arrestors shall be made of corrosion resistant material and preferably non-magnetic.

Each surge arrester shall have minimum two Earthing terminals.

The Contractor shall submit for review and approval a calculation note setting out the selection of each type of surge arrester to be installed at the different locations within the substation. For each surge arrester, a surge counter for monitoring the number of operations shall be provided.

The surge arresters shall be hermetically sealed, ensuring a permanently reliable performance of the arresters, irrespectively of the ambient atmosphere.

The impulse spark overvoltage shall be higher than the power frequency spark overvoltage in order to discharge overvoltage due to earlier switching.

However, it must be lower than the impulse test voltage of the switchgear.

The surge arresters shall be capable of diverting the impulse voltage caused by lightning strikes and overvoltage due to switching.

The design and manufacture of the surge arresters and their structural supports shall be capable of withstanding all anticipated stresses arising in service without causing damage or thermal runaway. The housing of the counter shall be of enclosure type IP54 (dust-tight and hose waterproof) and directly connected using a single piece 70mm² insulated copper conductor of adequate length exothermically welded to the substation grounding earth mat.

The design of the surge monitor shall be such that it is possible to tilt downwards by an angle of up to 45 degrees from the horizontal plane.

The surge arrestors shall not fail due to arrester insulator contamination.

The arrester housing shall so be coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to the maximum design value of the arrester. It shall further be installed in the earth conductor of the arrester to make it possible to determine how many times the arrester has sparked over.

Each single-phase surge arrester shall be installed on separate steel structure support in each phase of each bay at incoming and outgoing line gantries and also connected as close as possible to each high, medium and/or low voltage bushing terminal of autotransformers, power transformers, shunt reactors, neutral grounding reactor and station auxiliary transformers as applicable.

Please refer to the Technical Data Sheets, Section VI, for the full presentation of the required technical characteristics of the arresters. The values presented thereby must be considered as a rough guide. The Contractor, during engineering stage, shall design and size them in accordance with the insulation coordination study, subject to the Employer's approval.

6.3 Surge Counters and Leakage Current Meters

A combined surge counter and leakage current meters shall be provided with each surge arrester. The surge counter shall be operated by the discharge current passed by the surge arrester. Surge counters shall be of the electro-mechanical type and designed for continuous service.

Internal parts shall be unaffected by atmospheric conditions on Site. Alternatively, a weatherproof housing to IP65 shall be provided as part of the Contract and this shall be designed to allow the recording device to be read without exposing the internal parts to the atmosphere.

The surge counter shall be connected in the main earth lead from the diverter in such a manner that the direction of the earth lead is not changed or its surge impedance materially altered. A bolted link shall be provided so that the surge counter may be short circuited and removed without taking the arrester out of service.

The leakage current meters shall be provided for installation in the earth connection of the surge arresters and shall be designed for continuous operation. The internal parts shall be weatherproofed to IP65 with a transparent cover to provide an unobstructed view of the ammeter.

6.4 Equipment Submittals

The Contractor shall provide a detailed schedule for the design, manufacture, and delivery of the surge arresters and all related equipment, ensuring that the sequence and timing are consistent with the construction schedule.

Provide manufacturer's printed product literature, specifications and datasheets and include product characteristics, performance criteria, physical sizes, finish, and limitations.

The following information and documents shall be submitted for review by the Employer:

- Master drawing index;
- Front view elevation and weight;
- Plan view;
- Schematic diagrams;
- Nameplate diagram;
- Components list;
- Accessory information;
- Data sheets including :
 - Nominal voltage;
 - Maximum system voltage;
 - Basic impulse level (BIL);
 - Temporary overvoltage curves;
 - Maximum residual voltages for the discharge current of 10 and 20 kA (in kV peak);
 - Maximum continuous operating voltage (MCOV);
 - Protection level against surges (in kV peak).
- Cable terminal sizes;
- List of recommended spare parts, tools and instruments with catalogue numbers and current prices

The Contractor shall provide full details of the seismic anchorages for the installation of the surge arresters. The supplier must recommend the anchorages and detail the location of the anchorages to ensure that the anchor system meets the applicable requirements.

Manufacturer's Instructions: submit manufacturer's installation instructions and special handling criteria per installation sequences and cleaning and testing procedures.

Quality Assurance Submittals:

- Provide manufacturing plant QA/QC records, procedures and forms, ISO quality systems or others;
- Submit certificates signed certifying that materials comply with specified performance characteristics and physical properties.

The following product information shall be made available and submitted when requested by the Engineer:

- Descriptive bulletins;
- Product sheets.

Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall also be included with the equipment at the time of shipment.

Operation and maintenance manuals shall include the following information:

- Instruction books and/or leaflets;
- Recommended renewal parts list;
- Installation information and drawings.

The following information shall be submitted at time of completion:

- Final as-built drawings and information for items listed in previous section;
- Wiring diagrams;
- Certified production test reports;
- Installation information;
- Seismic certification and equipment anchorage details.
- Commissioning test report.

The final (as-built) drawings shall include the same drawings as the construction drawings and shall incorporate all changes made during the manufacturing process.

6.5 References

The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of thirty (30) years. A list of references with similar equipment shall be provided demonstrating compliance with this requirement.

The manufacturer shall submit, during both tender submission stage and detailed design stage, the technical particulars guaranteed together with a type test report of surge arrester of the required rated voltage and meets the minimum Employer's Requirements stated in; this chapter, the tender technical data schedule and SECTION 2.4 "SERVICE CONDITIONS" (PART 2A-SCOPE OF WORK) and the relevant applicable IEC standards approved by a third party testing laboratory for review and verification to enable issuance of clearance for mass production.

Surge arresters shall be designed to normally operate in an environment described in SECTION 2.4 "SERVICE CONDITIONS" (PART 2A-SCOPE OF WORK)

6.6 Delivery, Storage and Handling

Delivery and acceptance requirements: deliver materials to the site in its original factory packaging, identified with the name and address of the manufacturer.

Storage and handling requirements:

- Transport, storage and handling of equipment in accordance with the manufacturer's recommendations, indoors, in a clean, dry and well-ventilated area;
- Protect equipment from damage;
- Replace defective or damaged materials with new materials.

6.7 Complementary Requirements

Surge arresters shall comply with the latest editions of the applicable IEC standards.

The HV metal oxide surge arrester without spark gap must be supplied with a porcelain insulator and equipped with an insulating base.

A pressure relief device shall be provided with each surge arrester to ensure that a defect in the surge arrester will not cause an explosion which would project fragments of the outer casing of the surge arrester.

The pressure relief device shall be capable of supporting the symmetrical fault current of the system as specified in the Technical Data Schedule.

The pressure relief device shall be designed to ensure the safety of operating personnel or other equipment placed near the surge arrester.

6.8 Operating Conditions

Surge arresters shall be designed to normally operate in an environment described in SECTION 2.4 "SERVICE CONDITIONS" (PART 2A-SCOPE OF WORK).

6.9 Terminals

The HV terminals shall be in the form of a four-hole terminal and in accordance with international norms.

The grounding terminals shall be in the form of a two-hole terminal in accordance with international norms.

6.10 Accessories

Surge arresters shall have a discharge counter and an integrated milliamper meter to continuously monitor the leakage / internal current of the surge arrester.

The discharge counter shall record the number of discharges automatically by means of a five-digit counter. The discharge counter must be a non-resettable type capable of registering up to 5 discharges per second.

The internal and external leakage current shall be measured and indicated on a display. The scale of the display shall be 0 to 50mA_p/√2.

The discharging counter and leakage / internal current indicator shall be sealed, weatherproof and maintenance free.

A connection with insulated cables shall be provided between the grounding terminal of the surge arrester and the discharge counter. The insulation of the cable must be kept to a minimum of 5 kV. A shunt bypass must be provided to establish a grounding continuity of the lightning arrester grounding terminal for easy maintenance.

6.11 Testing and Inspection

6.11.1 Type Test

Type, routine and standard acceptance tests on metal oxide surge arresters shall be carried out in accordance with the IEC 60099-4 and IEC 60099-1. Type test certificates will be accepted subject to KETRACO approval.

Only type tested surge arresters are accepted.

As a minimum, the following type tests shall be performed:

1. Dielectric test on main circuit – lightning impulse voltage tests, power frequency voltage withstand tests and internal partial discharge tests
2. Active part withstand tests
3. Residual voltage tests
4. Long duration current impulse withstand tests

5. Operating duty tests
6. Short-circuit tests
7. Current distribution test.

6.11.2 Routine Tests

All routine tests and outstanding type tests of HV and MV outdoor surge arresters, as per as per IEC 60099-4, shall be performed during the factory inspection and acceptance testing witnessed by the Employer.

As a minimum, the following routine tests shall be performed:

1. Measurement of reference voltage
2. Residual voltage tests
3. Internal partial discharge test
4. Current distribution test.

6.11.3 Standard Acceptance Tests

As a minimum, the following standard acceptance tests shall be performed:

1. Power frequency voltage test on the complete arrester
2. Lightning impulse residual voltage test on the complete arrester
3. Internal partial discharge test
4. Thermal stability test.

6.11.4 Tests on Surge Counters

- Minimum Current Operation Tests

The rated minimum operating current of the counter, stated in the schedules, shall be passed ten times and the counter shall correctly register these operations.

- Maximum Current Withstand Tests

The maximum rated current stated in the schedules with an 8/20 μ sec wave shape shall be applied to the counter ten times without any cooling periods and the counter shall register and withstand without distress.

6.11.5 Site Tests

The site tests of surge arrestors shall be mainly based on visual inspection of the surge arrestors, in order to ensure that all components are mechanically assembled and installed properly and that there are no imperfections that shall be performed.

The following site test to be conducted:

- Tests of insulation resistance
- Tests of surge counting device and leakage current meter
- Measurement of AC leakage current at rated system voltage & maximum continuous operating voltage
- Measurement of DC leakage current at the voltage equivalent to the peak of rated system voltage & maximum continuous operating voltage
- Tests of Watt loss (10 kV AC) & Test on insulation power factor (10 kV AC)

7. Protection and Indication System

7.1 Protection Equipment and Auxiliary Relays

7.1.1 General Requirements for Protection Relays

This section contains the general requirements applicable to all protection relays.

Each element of the main plant, transmission and distribution systems shall be provided with high-speed discriminative protection (main protection), capable of detecting all "credible" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. "Credible" faults shall include all faults whether phase/phase or phase/earth irrespective of whether maximum or minimum plant is connected, account being taken of the fault impedance. "Non-credible" faults are those involving a second order plant failure, for example, a broken conductor lying on high resistance ground and for which extended fault clearance time may be acceptable.

There shall be two sets of main protection such that the loss of one set or the failure of one set to clear a fault will not result in time delayed tripping for an electrical fault. Redundant auxiliary supplies shall be used and there shall be redundant tripping systems. For distribution level this is named as Main and Backup protections.

High-speed discriminative protection systems shall be engineered as complete schemes, with due account being taken of current and/or voltage transformer performance. Attention shall be paid to the total performance including the behaviour pattern in the presence of system transients for faults "in zone", faults "out-of-zone", and during the period immediately following a switching operation irrespective of whether that operation is to eliminate a network short-circuit or is to energise or to de-energise any part of the network.

In the event of an uncleared external fault or any other abnormal operating condition which may cause damage to plant, time delayed tripping shall be initiated as a back-up action to prevent plant damage.

With reference to the above the protection systems must therefore be designed, manufactured, applied, set and commissioned to offer the highest level of security against incorrect operation for faults beyond the protected circuit or during disturbances or temporary overload conditions from which the power system should recover.

The diameters protection cubicles shall be arranged in Control Rooms. The houses shall be installed beside of each diameter with each house accommodating the protection cubicles for two adjoining bays. The substation control building shall house the busbar protection central units and the superior substation automation system, to which the protection relays shall be connected with fibre optic cables.

7.1.2 Codes and Standards

For design and type testing of the protection and control equipment, the following standards shall be applicable:

IEC 60255:	Electrical relays
IEC 60038:	IEC Standard voltages
IEC 60068:	Environmental testing
IEC 60664:	Insulation coordination for equipment within low-voltage systems

IEC 60870: Telecontrol equipment and systems

CISPR 11 and following Electromagnetic compatibility CE-marking.

EN 50081-2 Emissivity (Industry)

EN 50082-2 Immunity (Industry)

7.1.3 Technical Data Schedules

Refer Technical Data Schedule where characteristics of protection equipment are specified.

7.1.4 Equipment Submittals

- The contractor shall submit a full design of the protection and control panels to the Employer for approval. It shall comprise (non- limitative) the following.
- Protection and metering single line and three-line diagram.
- Trip matrix
- Panels layout drawings
- AC and DC schematic diagrams
- Wiring diagrams for each panel
- Cabling list and cable connection diagram for panels and all substation equipment
- Logic diagram for automation
- List of input/output data
- Protection settings calculation report
- Protection and other IEDs settings sheet
- IEDs configuration files (Contractor to provide free of charge any software license to read and edit the files)
- IEDs manuals in English language

7.1.5 References

The protection equipment supplied under this Contract and the associated software shall have at least thirty (30) years of manufacturing experience and twenty (20) years in operation in KETRACO grid network. The Contractor shall quantify the number of installations for the protection equipment and associated software version which have been installed at similar voltage levels and environmental conditions over the last three years

A list of references with similar equipment shall be provided to demonstrate compliance with this requirement.

7.1.6 Delivery, Storage and Handling

Delivery and Acceptance Requirements: deliver materials to site in original factory packaging, labelled with Manufacturer's name and address.

Storage and Handling requirements:

- Store and handle the equipment in accordance with Manufacturer's recommendations, in a clean, dry, well-ventilated area;
- Store and protect equipment from damage;
- Replace defective or damaged materials with new.

7.1.7 Complementary Requirements

This Specification covers the design, manufacturing, factory tests, delivery to sites, erection, setting, parameterization and architecture configuration, field testing, commissioning and warranty of 132kV and 33kV substation protection systems at 132/33kV Rumuruti and Kabarnet substations respectively.

Since the project comprises addition of bays on the existing 132kV busbars at 132/33kV Rumuruti and Kabarnet substations respectively, the Contractor shall check, investigate, propose and update.

(modify or replace or add) the new project scope of supply and installation that is compatible with the existing protection and control systems.

Before starting with the detailed design, the Contractor shall present to the Employer a site investigation report with his findings and proposed upgrades that needs to be made. The contractor must bear in mind that the substation is in live conditions thus any activities which he intends to performer must be approved by the Employer. Therefore, the Contractor must submit well in advance a method of statement for the activities, works, changes he intends to perform. The Contractor can commence the activities only after the approval of the method of the statement and receiving permission to enter the substation from the Employer.

7.1.8 Operating Conditions

Protection equipment shall be designed to operate normally under all operating conditions listed in the Technical Data Schedule, including rapid changes in load and voltage and defects limited to the nominal characteristics listed.

Protection equipment shall be designed to operate normally indoors in an environment with an ambient temperature.

7.1.9 Protection Technology

All relays performing a measuring function shall be of numerical design with continuous self-monitoring. Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication function may be based on standard attracted armature or other electromechanical techniques.

In order to maximise the cost-benefit of the protection in all groups and to reduce lifetime costs, all protection relays shall be of numerical design wherever practical. The main numerical relays shall offer instrumentation, disturbance recording and event logging functions in addition to providing protection. Periodic routine test requirements shall be limited to basic function testing only, through the provision of comprehensive, continuous self-monitoring with alarm and diagnostic functions.

Numerical relays and schemes provided shall all be suitable for connection to a local communication network (either interfaced directly to the substation LAN or to the local BCU) to allow the complete relay scheme to be interfaced to a central computer work station (engineering workstation). The communication bus, necessary switches and interface units and all associated software shall be provided as part of the contract. With the resulting system it shall be possible to interrogate all numerical relays and schemes to monitor and extract recorded data (including settings, measurement parameters and disturbance records). It shall also be possible to enable remote adjustment of relay settings if required.

Numerical relays shall also be provided with a local communications port to allow direct interfacing to a laptop PC, to facilitate local interrogation, setting-up and recorded data extraction. Individual protection units shall be provided with an integral user interface to facilitate setting changes and observation of indications without the use of remote communications. The interface cables for communication with the relays through a laptop PC shall be provided.

Protection relays shall be from approved suppliers and they shall be type-tested according to relevant sections of the current IEC 60255 standards and copies of type test certificates shall be provided. Relays shall be CE-marked in accordance with European Union requirements related to Electromagnetic Compatibility and Low Voltage Equipment safety. Equipment complying with other national standards may be accepted at KETRACO's discretion and where the vendor provides copies of the relevant standards.

Protection relays shall have a minimum of two year's satisfactory service history in similar applications with at least 5 utilities. The history is to be supported by reference lists and supporting letters from the utilities.

Relays must be offered on the basis of a minimum service life of 15 years. Statements must be obtained from the relay manufacturer(s) to this effect, with confirmation that a spares and repairs service will be available for the stated minimum service life.

7.1.10 Protection Discrimination

On the occurrence of an electrical fault on the power systems, the high speed discriminating protection systems (main protection) shall rapidly detect the fault and initiate the opening of only those circuit breakers which are necessary to disconnect the faulted plant or circuit from the network. Protection equipment associated with adjacent plant or circuits may detect the fault, but there must be discrimination between this protection and that of the faulted plant or circuit. Time delayed tripping is not permitted except where main protection has failed to clear a fault or where plant damage would otherwise occur.

All back-up protection systems shall be able to discriminate with main protection systems, circuit breaker fail protection and with other back-up protection systems installed elsewhere on the electrical system.

7.1.11 Protection Settings

A protection setting study shall be performed as part of the contract and a list of the settings to be applied to all protection equipment, together with all associated calculations (e.g. load flow, short-circuit) and relay co-ordination curves on log paper, shall be provided for review and approval not less than 3 months prior to the first programme date for commissioning. Any limitations imposed on the power system operation as a result of the settings proposed shall be explicitly stated. In the absence of system data required for calculation purposes, assumptions may be made, providing these are clearly identified as such in the relevant calculations.

Copies of all data files used for the studies shall be submitted for approval on suitable media to be agreed with the Engineer on completion of the study work, together with the report detailing the study results. The studies shall include, amongst others:

- Magnitude of secondary ARC current and associated recovery voltage
- Level during single pole auto reclosure operation (SPAR)
- Time required for arc extension during SPAR operation
- Insulation coordination
- Switching overvoltage during line energization
- Switching overvoltage during SPAR operation

Based on these studies the contractor shall confirm that adequate protective margin exists between the calculated switching overvoltage and the short duration power frequency withstand voltage. The required dead time during SPAR shall also be provided.

7.1.12 Constructional Requirements

Means shall be provided to positively lock each withdrawable module, circuit board or unit in the “service” position within the relay case. It shall not be possible to withdraw the analogue input module from its case before short-circuiting the current transformer connections.

All relay cases shall be earthed except where insulated cases are provided for special requirements.

A list of all of the protection and control equipment being offered under the contract shall be provided together with a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and control equipment.

7.1.13 Equipment Accommodation

Protection and control cubicles shall be front access, swing-rack design. Cubicles with front and rear access are acceptable for extensions to existing substation where this is the present arrangement. However, there should not be a mixture of both cubicle types in the same substation control/relay room.

7.1.13.1 Operator Interface

All numerical protection systems shall be provided with an integral local user interface, to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local user interface. No exceptions to this requirement shall be permitted.

Relay serial communication facilities shall allow all information, which is available locally at the relay front panel, to be accessed remotely. It shall also be possible to carry out bulk transfer of settings and fault record information using appropriate PC based software. The necessary software for communication with each relay type shall be provided as part of the contract.

Each protection relay shall also comply with the following requirements.

7.1.13.2 Identification and LCD Display

Each protection relay shall have a unique identifier that is clearly visible. The software reference and issue level shall be identified. The marking of all relays shall comply with Clause 12 of IEC 60255-6 (1988).

Each protection relay shall be provided with an LCD display facilities on which shall be shown:

1. The current transformer ratio (if applicable), including all ratios of multi-ratio transformers and the ratio selected.
2. Voltage transformer ratio (if applicable).

The display shall allow for indication of measurement data, fault data and setting values. Buttons shall be available to navigate through the menus and to enter setting parameters. LEDs are showing important alarms (e.g. trip indication) and the status of the numerical relay (power on, alarm, out of service).

7.1.13.3 Settings

Each protection relay shall provide a means by which the user can easily apply the required settings, which is also secure from inadvertent operation. A display of the selected settings shall be provided on the protection relay.

7.1.13.4 Indications

Each relay or protection scheme shall be provided with an adequate number of LED indications to ensure that the appropriate faulted phase, zone, operated element, etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover. It shall not be possible to operate the relay when resetting the indication. Unless otherwise approved, indications shall only be given by the protection(s) causing the relay to trip.

Numerical relays shall include continuous self-monitoring and supervision of all parts of the relay hardware, firmware and software and any failure shall be annunciated via the relay and any remote control facility. An alarm contact shall close for any detected failure.

The record of relay indications shall be maintained following any DC auxiliary supply interruption and the status of the DC power supplies shall be permanently indicated.

7.1.13.5 Output Contacts

All protection relays shall be provided with an adequate number of contacts of suitable rating to perform the required tripping functions, alarm indications, fault recorder functions and such supplementary signalling functions as may be necessary for initiation of automatic switching control, inter-tripping etc. In all cases contacts intended for tripping duty shall be designed such that:

- a. They cannot inadvertently interrupt trip coil current.
- b. They initiate the circuit breaker trip coil directly without the interposition of auxiliary relays or reinforcing contacts.

7.1.13.6 Test and Isolation Facilities

Each functional protection relay shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection scheme to enable the protection and control equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled. The type of test terminal block shall be SIEMENS type 7XG22 or similar. The test terminal blocks shall be provided including the test plugs.

Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labelled. The labels on the isolation points shall either describe the function or be uniquely numbered.

7.1.14 Service Life and Service Support

The protection systems shall be designed for a service life of 15 years, allowing for only routine testing that is limited to basic functional testing in accordance with manufacturers recommendations.

The service life of the protection system equipment in relation to that of the main HV plant and apparatus shall be stated so that the cost of any replacement during the life of the substation can be assessed.

The period for which lifetime support will be provided for the protection system equipment shall be stated. Recommendations for the provision of spare parts are required.

Circuit diagrams for each protection system and the associated tripping system(s) shall be supplied. The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

A service to enable any faulty item of protection equipment to be rectified or replaced within a stated period after the fault being reported shall be provided. The repair/ replacement period shall be defined.

Training for the Engineer's personnel in the operation and maintenance of the protection equipment shall be offered.

7.1.15 Protection Testing

7.1.15.1 Type Tests

A type test certificate shall be provided for each relay type, which shall confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255 as detailed in this specification. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies or users.

Should the certificates be invalid or unacceptable to KETRACO, the type tests shall be performed by a recognised and KETRACO approved independent laboratory, at the expense of the contractor.

7.1.15.2 Routine Tests

A routine testing programme shall be determined between the Engineer and the Contractor before the tests are undertaken at the premises of the equipment supplier. Notwithstanding, the routine testing shall comprise, as a minimum, of the following tests being performed on one tenth of each relay type, but minimum one: -

- 1) Functional tests.
- 2) Dielectric Test (a.c. power frequency high voltage test) with 2 kV, 50Hz for 1 min as per IEC-60255-5.
- 3) Electrical disturbance test (for static relays only) to IEC 60255-22.

The tests shall be conducted in the presence of KETRACO or their representative.

The Contractor shall submit a report to the Engineer detailing the routine tests and the test results.

Inspection and taking over in the factory do not relieve the Contractor from his obligations as per the contract documents and guarantee of performance.

7.1.15.3 Site Tests

The Contractor shall perform the following site tests on the protection relays: -

- 1) Relay auxiliary D.C. supply checks
- 2) CTs and associated secondary wiring tests
- 3) VTs and associated secondary wiring tests
- 4) Application of relay settings as determined in the Protection Setting Report
- 5) Secondary injection testing to determine relay settings and operation within manufacturers stated parameters.
- 6) Primary injection tests where appropriate
- 7) Checks of all alarm circuits
- 8) Functional testing of all relays. This includes testing protection relays, aided by secondary as necessary, a scheme operation of relevant CBs
- 9) Signal-test together with the substation control system

The Contractor shall submit for approval a Commissioning Programme prior to the tests being performed. The Commissioning Programme shall include, as a minimum, the following: -

- 1) List of the site test for all protection systems/relays and associated power equipment (CTs/VTs etc.)
- 2) Procedures and methods for each commissioning test including those to be performed on-load.
- 3) Testing equipment and instruments necessary for performing of each test

- 4) Format of site test reports for each test.
- 5) Installation, operation and maintenance manuals

Each site test shall be witnessed and signed off by a KETRACO Engineer or their representative.

One month before the site tests and commissioning start the Contractor shall submit to KETRACO the approved Protection Setting Report.

Commissioning will be deemed complete when all relevant equipment is energised, loaded and all necessary on-load tests, measurements and checks are complete and signed for by the Engineer.

7.1.16 Environmental Requirements

7.1.16.1 Atmospheric Environment

Temperature:

The standard nominal range of ambient temperature shall be -10°C to +55°C.

The protection system shall operate satisfactorily when tested to the following requirements:

1. IEC Publication 60068-2-1 with severity class -10°C, 96 hours.
2. IEC Publication 60068-2-2 with severity class 55°C, 96 hours.

The protection system shall be able to withstand the temperature requirements for storage and transportation and shall be tested to the following requirements:

1. IEC Publication 60068-2-1 with severity class -25°C, 96 hours.
2. IEC Publication 60068-2-2 with severity class 70°C, 96 hours.

Relative humidity:

The protection system shall operate correctly with a relative humidity of 93 % and shall be tested to IEC Publication 60068-2-3 with severity class 56 days.

Enclosure:

The protection relay shall meet the requirements of the tests detailed in IEC Publication 60529 with classification IP50 (dust protected). If the individual enclosure of the relay is to a class less than IP50 then the Contractor shall provide a cubicle to classification IP50 to accommodate the relay.

7.1.16.2 Mechanical Environment**Vibration:**

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-1 with severity class 1.

Shock and bump:

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-2 with severity class 1.

Seismic:

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-3 with severity class 1.

7.1.16.3 Electrical Environment**DC auxiliary energising quantity:**

The protection systems shall be capable of being energised from a DC auxiliary energising voltage of 110 V (nominal).

The protection system or its associated power supply for use in a 110 V (nominal) DC supply system shall operate correctly over a voltage range of 88 V to 150 V.

Numerical protection systems shall meet the requirements of IEC Publication 60255-11 with interruptions to the DC auxiliary energising quantity of 20 ms.

Frequency:

The rated frequency shall be 50 Hz. The nominal range of operating frequency shall be -5 % to +5 % of nominal.

Thermal rating:

Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or 2 times the setting value, whichever is the more onerous.

Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design.

The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for a duration of 1 s.

Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30 s.

Insulation:

- Rated Insulation Voltage

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 250 V.

All open contacts of the protection system shall withstand a voltage of 1000 V.

- Dielectric Tests:

The protection system shall comply with the dielectric test requirements of IEC Publication 60255-5. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested form Series C of Table 1 of IEC Publication 60255-5.

- Impulse Voltage:

The protection system shall comply with the impulse test requirements of IEC Publication 60255-5 with test voltage of 5 kV.

7.1.16.4Electromagnetic Compatibility

The requirements of this section of the specification are applicable to electronic protection systems whether these are based on analogue digital or numerical design techniques. The requirements may also be applied to electromechanical relays that may radiate electromagnetic interference during their operation.

- 1 MHz Burst Disturbance:

The protection system shall comply with the requirements of IEC Publication 60255-22-1 with severity Class III.

- Electrostatic Discharge

The protection system shall comply with the requirements of IEC Publication 60255-22-2 with severity Class III.

- Radiated Electromagnetic Field Disturbance:

The protection system shall comply with the requirements of IEC Publication 60255-22-3 with severity Class III. The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz

- Electromagnetic Emissions:

The protection system shall comply with the requirements of IEC Publication 60255-25.

- Fast Transient Disturbance:

The protection system shall comply with the requirements of IEC Publication 60255-22-4 with severity level IV.

7.2 Protection System Particular Requirements

7.2.1 Transmission Systems (400kV, 220kV and 132kV)

7.2.1.1 Protection Performance Requirements

a. Protection redundancy

The protection systems for the transmission systems must provide fast and highly dependable clearance of any electrical fault in order to minimise the duration of severe voltage dips to a large number of customers and to avoid loss of transmission system capacity due to back-up tripping of any other circuits. A forced shutdown of a transmission circuit for any single item of protection equipment failure shall not be required. For a limited period, it shall be possible to operate a transmission circuit with only one group of protection in service, while the other group is out of service for testing or while it is awaiting repair. During this period any fault must still be cleared quickly and the plant must still be protected against damage if exposed to abnormal operating conditions. To meet these dependability and redundancy requirements, all transmission plant and circuits shall be provided with two fully independent, high-speed protection systems for detecting and clearing electrical faults.

Unless otherwise specified, each independent protection group shall also be driven from independent current transformers and independent VT secondary circuits.

b. Protection clearance time

Each main protection scheme shall independently clear any credible fault within 100ms from fault inception.

c. Provision of back-up protection

Back-up protection (e.g. inverse-time overcurrent and earth fault protection or thermal overload protection) shall be provided to trip protected plant and circuits in the event of a sustained external fault condition or of a sustained power system abnormality that would otherwise damage or significantly reduce the life expectancy of the protected plant.

Where applicable, each set of feeder protection shall include "Zone 2" under impedance remote back-up protection for busbars to ensure that, in the event of busbar protection failure, a remote-end busbar fault will be cleared within the switchgear internal arcing fault withstand time.

d. Circuit breaker failure

Each protection system includes the circuit breaker(s). Beyond the circuit breaker trip coils, the duplication of the protection system ends. Circuit breaker fail protection shall be provided to cater for the possibility of a single circuit breaker failing to clear fault current when commanded to do so, by either of the two main protection systems. The breaker fail protection shall initiate a first stage CB re-trip followed by a second stage rapid back-trip/intertrip of adjacent circuit breakers, as necessary, and within KETRACO's required transmission breaker failure fault clearance time of 260 ms.

e. Auxiliary DC supplies

The auxiliary power and tripping supplies for each independent protection group shall be derived from independent DC auxiliary supply systems comprising two separate batteries and battery chargers as detailed in LV Service Equipment specification. This is in line with the existing KETRACO practice at substations where the upper voltage level is transmission.

f. Protection supply and trip circuit supervision

The protection systems shall continuously supervise the DC auxiliary supplies and the integrity of all circuit breaker tripping circuits with the CB in the closed or open state. The circuit shall be arranged so, that any failure of the supervising relay coil (short or open circuit or earth-fault) will not prevent a trip signal opening the breaker or cause inadvertent opening of the circuit breaker. Resistors, if needed, shall be located close to the circuit breaker auxiliary contacts. The trip circuit supervision relay shall operate when the trip supply fails or the circuit breaker trip coil or trip circuit becomes open circuited. Operation shall occur after a settable time delay. The design of the supervision must allow for latched contacts (from lock-out-relay). The trip circuit supervision functionality shall be realized by separate supervision relays, independent from the protection relays. All protection relays shall incorporate comprehensive continuous self-monitoring and diagnostic facilities. All supervision relays shall provide an alarm signal into the SCS/SAS system.

g. High speed tripping relays

With immunity to operation with DC wiring capacitance discharge currents, high-speed tripping relays shall be used to interface protection relay trip contacts to circuit breaker trip circuits. These are to ensure that output contacts within the protection relays will not be damaged in the event of the circuit breaker failing to interrupt its trip coil current before the protection relay contact(s) open (e.g. in the event of fault clearance by breaker fail protection). They will also form a single point of interfacing between the protection schemes and the circuit breaker. The tripping relays shall either be of the self-reset type or of the latching type, with circuit breaker lockout contacts, according to protection scheme requirements. Lockout relays shall be electrically resettable, locally and from SAS.

h. Protection trip, alarm and disturbance records

The protection systems shall provide comprehensive records for trip and alarm conditions, with local indications of which element has initiated a trip or alarm and of voltage and current vector parameters at the time of trip initiation.

Voltage and current waveform disturbance recording and event-logging shall be included as part of the protection system.

i. Test facilities

The protection systems shall include comprehensive maintenance isolation and test facilities. SIEMENS type 7XG22 or equivalent. test and associated terminal blocks and shall be provided.

7.2.1.2 New Overhead Line Feeders**a. Protection arrangements**

The protection and control arrangements are illustrated in the single line schematic diagrams in Part 2-D.

The circuit protection shall be housed in relay panels as defined in the Protection General Requirements.

The illustrated control arrangement is one Bay Control Unit (BCU) per CB and shall be located in a dedicated panel per diameter basis. The contractor may propose alternative BCU configurations.

Busbar protection bay module (including breaker-fail protection) shall be located within a dedicated suite of busbar protection relay panels.

b. Bay control and monitoring

The BCU associated with the CB adjacent to the busbar shall be configured to control the circuit disconnect and earth switch. For mid diameter circuits having no busbar CB then one BCU of the associated CBs shall control the circuit disconnect and earth switch. The contractor may propose alternative BCU configurations.

BCU shall provide mid-diameter CB failure functionality.

The BCUs shall perform the check synchronisation function and shall provide 3ph voltage signals to the SAS pertaining to each busbar and each mid-diameter section. The appropriate busbar and circuit VT secondary voltages shall be supplied to the BCU via a diameter voltage selection scheme according to the status of the AIS switchgear.

BCU shall also provide fault recording functions however the separate Fault Recorder is the principle system.

For communication purposes, all numerical protection devices shall be capable of being connected to the substation LAN via protocol IEC 61850. In exceptional cases, provided the approval of KETRACO, single numerical protection devices can be connected via a serial link to the BCU, using a protocol different from IEC 61850, but this shall only be the case if no comparable device with IEC 61850 is available on the market.

The BCU shall normally be powered from DC1 auxiliary supply and upon loss of this supply automatic changeover to DC2 shall occur within the tolerable BCU dc interruptions ride through time.

Bay control unit requirements are fully detailed in the SAS specification.

It shall be possible to confirm the operation of a primary plant switchgear equipment before the operation i.e. the BCU shall have the "Confirm before execute" functionality same as the SAS HMI system.

c. Main protection

The new overhead line feeder circuits shall be provided with fully duplicated main protection systems that comprise:

Main 1 - one set of numerical distance protection operating in BLOCKED, POTT, PUTT or other tele protection mode, whichever is the most applicable signalling scheme and final mode to be decided at design review meeting. The Main 1 distance relay shall also incorporate Directional Earth Fault protection which shall operate in blocked mode. Upon opening of the line disconnect the distance protection function shall be blocked and a stub protection function integral to the main protection relay shall be invoked. The Contractor shall ensure the OHL feeder is adequately protected by high speed main protection at the remote terminal should it be energised from the remote terminal up to the local line disconnect. The line distance protection relays shall communicate via the telecommunication multiplexer equipment i.e. direct relay to relay communication between distance protection relays at opposite substations shall not be permitted.

Main 1 - one set of optical fibre current differential protection, with integral distance protection elements to provide Zone-2 remote busbar back-up protection and Zone-3 remote circuit back-up protection (if required). Zone 1 of the impedance protection shall be deactivated whenever the line differential protection function is active/communication link is active. This zone shall be activated whenever a communication failure appears or deactivation of the line differential protection function. The operate time for the impedance zones shall be delayed by 80ms as compared to operate times for the similar zones in the Main 1 protection relay. The current differential protections shall remain stable during charging current inrush and with the presence of steady-state charging current. For current differential protection via fibre optic pilots, upon opening of the feeder disconnect the current differential function shall be blocked and a stub protection function integral to the main protection relay shall be invoked. This will also block the remote end terminal differential function and in this respect the Contractor shall ensure the feeder is adequately protected by high speed protection should the feeder be energised from the remote terminal up to the local line disconnect.

Main 2 - one set of optical fibre current differential protection, with integral distance protection elements to provide Zone-2 remote busbar back-up protection and Zone-3 remote circuit back-up protection (if required). Zone 1 of the impedance protection shall be deactivated whenever the line differential protection function is active/communication link is active. This zone shall be activated whenever a communication failure appears or deactivation of the line differential protection function. The operate time for the impedance zones shall be delayed by 80ms as compared to operate times for the similar zones in the Main 1 protection relay. The current differential protections shall remain stable during charging current inrush and with the presence of steady-state charging current. For current differential protection via fibre optic pilots, upon opening of the feeder disconnect the current differential function shall be blocked and a stub protection function integral to the main protection relay shall be invoked. This will also block the remote end terminal differential function and in this respect the Contractor shall ensure the feeder is adequately protected by high speed protection should the feeder be energised from the remote terminal up to the local line disconnect. For each line the contractor shall match the differential relays at both ends.

The contractor shall ensure that he matches for Main 2 protection the existing line differential relays that are in use in the terminal substation as the station will be the remote end for the transmission lines.

Main 1 and Main 2 protections shall be provided by different manufacturers. Each main protection shall be located in its own panel.

The main 1 (87L) and main 2 (21, 21-85) protection relay must support tele-protection for 85-67N scheme

Reference to be made to the schedules of technical information for detailed description of the protection system.

d. Back-up protection

The fully redundant protection systems applied at transmission present a negligible probability of the OHL short-time withstand limit being exceeded but in order to provide additional security back-up, the protection scheme design shall include directional overcurrent (67), directional earth fault (67N), time-delayed overcurrent (51), overvoltage (59), undervoltage (27) and thermal overload (49) protection. The back-up protection functions shall be provided as stand-alone protection relays. There shall be one back up protection relay for each main protection panel. The overvoltage protection shall be configured with three stages as per KETRACO's practice.

e. Distance Protection Signalling

Distance tele-protection signalling shall be via a digital tele-protection signalling unit or Multiplexer. Direct Signalling between distance protection relays shall not be installed.

For Multiplexer schemes a separate intertrip channel shall be provided via dedicated intertripping equipment

f. Current Differential Protection Signalling

Current differential protection signalling shall be via a digital tele-protection signalling unit or Multiplexer. For remote substations with identical differential relays (including firmware) then direct fibre signalling may be proposed.

For Multiplexer schemes a separate intertrip channel shall be provided via dedicated intertripping equipment. For direct fibre connections the current differential protection shall be provided with an integral, two-way, high-speed, high-security intertripping channel where the energisation of an intertrip send opto-input of one relay will cause dedicated intertrip receive contacts of the remote relay to operate.

In the case of relay fibre optic direct connection, the OPGW (if available) shall provide a pair of fibres plus a pair of spares for each main protection.

g. Intertrip signalling

Intertrip signals to and from the remote terminal shall be blocked upon opening of the local OHL disconnector.

Upon receipt of the intertrip signal, intertrip receive relays shall trip and lockout the circuit breakers. There shall be one intertrip receive relay per signalling channel that individually trips each circuit breaker trip coil.

h. Auto Reclose

Faults occurring on an overhead line feeder are mostly transient and following a short delay after tripping the line can reclose and the supply of power re-established. The majority of transient faults on overhead line feeders are earth faults that are usually the result of lightning strikes, vegetation or animal contact. Following the initial fault, the insulation of the line is re-established once arc products have dispersed and the line can be re-energised.

The KETRACO transmission network OHL feeders principally use single pole AIS circuit-breakers configured to provide single phase auto-reclose.

Earth faults are statistically the most common fault and in this respect single pole auto-reclose is beneficial in respect to less interruption and maintaining of synchronism between two systems via the healthy phases. The disadvantages are increased complexity of protection and control circuitry as well and protection setting considerations for the period when the faulted phase is open.

Single-pole auto reclose is the standard operational mode however the option of choosing three phase auto-reclose shall be provided by means of a selector switch. The Auto-reclose selector switch shall provide the following auto-reclose modes:

1. 1ph AR
2. 1+3ph AR
3. 3ph AR
4. OFF

The auto-reclose relay shall operate in a single phase auto-reclose mode (unless selected otherwise) for all line faults detected in the protected zone with respect to current differential protection and instantaneous elements of the distance protection.

The auto reclose relay shall be a separate stand-alone relay, i.e. not integrated in the main or back-up protection relays.

For 1+1/2 (and 1+1/3) CB substation arrangements it is necessary to control two CBs hence a separate numerical auto-reclose relay is required. A separate auto reclose relay allows for either main protection to be out of service without affecting the auto-reclose availability and avoids complex race issue between systems. It may not be desirable for the network to operate with auto-reclose in service if one of the main protections is out of service. In this case the network operators can switch the auto reclose relay out of service if required. IN/OUT switching shall be available both locally at the relay panel and by remote operation via the SAS system.

The Auto reclose scheme shall be one shot only and shall trip 3ph and go to lockout mode if a second fault occurs within the reclaim time following the first shot reclose.

The Auto reclose sequence shall be blocked by distance protection time delayed impedance zones, operation of main protection Switch-onto-fault (SOTF) function, operation of busbar protection and circuit breaker failure protection. Auto-reclose shall also be blocked when the line disconnecter is open and/or the stub protection is invoked.

Circuit breaker low stored energy signals shall inhibit the auto-reclose sequence until the elapse of a timer resulting in AR lockout. Should the stored energy recover before the elapse of the timer then auto reclose sequence will continue.

In the case of three phase auto-reclose sequence, there is a possibility that the power system may be split and one part of the system may lose synchronism with respect to the other part. Any resulting CB auto reclose, without a check synchronism reference may result in an out of synchronism closure that damages the power system both electrically and mechanically. The severity of the damage depends on the degree of out of synchronism at the instant of closure. For these reasons all three-phase auto-reclose shall be performed with a check synchronism.

For existing substation where a central check synchronism relay is used, the availability of a signal from this scheme shall be investigated and if practical be utilised. Alternatively, if the central check synchronisation scheme cannot provide the necessary signals, then an auto reclose relay with an integral check synchronism function shall be provided.

An intertrip receive signal shall inhibit the AR sequence until either the intertrip signal is reset or a persistent intertrip timer elapses and the AR relay goes to lockout.

The circuit breaker at the line end that recloses first shall upon detection of a permanent fault issue a persistent intertrip that prevents the remote end CB from reclosing onto the fault.

The auto reclose relay shall be provided with a manual close inhibit feature that prevents AR for a settable period of time following manual CB closure e.g. following CB maintenance.

The Auto-reclose relay shall provide CB maintenance alarm and lockout functionality.

The auto-reclose relay shall be provided with indications and alarms for: -

- In/out of service
- Auto reclose relay healthy
- Auto reclose in progress
- Auto reclose lockout
- Auto reclose complete

The alarms shall be available locally on the relay and via the SCS.

i. Circuit breaker failure

This shall be configured with two stages/timers. Stage 1 shall be re-trip stage with stage 2 being the back-up trip stage.

For CBs adjacent to the busbars, the breaker fail protection shall be integral to the busbar protection scheme and so arranged to trip the mid diameter and intertrip the circuit remote terminal CB.

For the mid diameter CB (Tie CB), separate breaker fail protection shall be provided and the appropriate trip and intertrip scheme designed to open all adjacent CBs upon stage-2 operation. This may be implemented in the BCU for the Tie CB.

j. Trip Relays

In order to permit auto-reclose functionality on OHL circuits, self-resetting trip relays shall be provided for each trip coil and for each phase.

k. Fault recording

For new build substations a standalone substation fault recorder shall be provided and all appropriate feeder analogue and digital signals shall be extended to this device. Additional fault recording shall be provided by the numerical protection relays. All fault records shall be retrieved via the SAS Engineering Workstation.

For existing substations, where practical, the existing fault recorder shall be adopted for the new circuits.

7.2.1.3 Modifications of Existing Overhead Line Feeders due to LILOs

a. Protection arrangements

The existing protection panels shall be maintained. The relays' settings shall be upgraded and protection panels shall be renamed accordingly for each bay.

b. Bay control and monitoring

The existing control scheme shall be maintained in the Existing substations. However, any modification of the control system resulting from renaming of the OHL bays and change of the line protection system shall be included the Contractor's scope.

c. Main protection

The existing system is composed of line distance and line differential protection. In this scope the contractor will implement main A and main B of line differential protection. The contractor will maintain the existing differential protection and replace the existing distance protection and panels with a new differential protection scheme and panels.

The existing distance protection and panels shall be decommissioned and handed over to KETRACO.

d. Back-up protection

The existing back-up protection functions shall be maintained in the Existing substations. However any modification of the back-up protection resulting from renaming of the OHL bays and change of the line protection system shall be included the Contractor's scope.

e. Distance Protection Signalling

This will be decommissioned for the line distance protection that will be decommissioned.

f. Current Differential Protection Signalling

This current differential signalling shall be reconfigured accordingly for the existing and new line differential protection to be implemented.

g. Intertrip signalling

The existing intertrip signalling shall be reconfigured accordingly since the remote ends for the OHL have changed to ensure the new remote ends are correctly captured.

h. Auto Reclose

This scheme shall be maintained in the Existing substations. However, any modification of the auto-reclose scheme resulting from renaming of the OHL bays and change of the line protection system shall be included the Contractor's scope.

i. Circuit breaker failure

This scheme shall be maintained in the Existing substations. However, any modification of the circuit breaker failure scheme resulting from renaming of the OHL bays and change of the line protection system shall be included the Contractor's scope.

j. Trip Relays

This scheme shall be maintained in the Existing substations. However, any modification of the trip relays scheme resulting from renaming of the OHL bays and change of the line protection system shall be included the Contractor's scope.

k. Fault recording

This shall be modified to incorporate the changes.

7.2.1.4 Power Transformers (Primary side)

a. Protection arrangements

The protection and control arrangements are illustrated in the single line schematic diagram in Part 2-D, for transformer circuits.

The circuit protection shall be housed in relay panels as defined in the Protection General Requirements.

The illustrated control arrangement is one Bay Control Unit (BCU) per CB and shall be located in a dedicated panel per diameter basis. The Contractor may provide alternative BCU arrangements.

Busbar protection bay module (including breaker-fail protection) shall be located within a dedicated suite of busbar protection relay panels.

b. Bay control and monitoring

The BCU associated with the CB adjacent to the Busbar shall be configured to control the circuit disconnect and earth switch. For mid diameter circuits with no busbar CB then one BCU of the associated CBs shall control the circuit disconnect and earth switch. The contractor may propose alternative BCU configurations.

BCU shall provide mid-diameter CB failure functionality.

The BCUs shall perform the check synchronisation function and shall provide 3ph voltage signals from each busbar and each mid-diameter section to the SCS. The appropriate busbar and circuit VT secondary voltages shall be supplied to the BCU via a diameter voltage selection scheme according to the status of the AIS switchgear.

For communication purposes, all numerical protection devices shall be capable of being connected to the substation LAN via protocol IEC 61850. In exceptional cases, provided the approval of KETRACO, single numerical protection devices can be connected via a serial link to the BCU, using a protocol different from IEC 61850, but this shall only be the case if no comparable device with IEC 61850 is available on the market.

The BCU shall normally be supplied from DC1 auxiliary supply and upon loss of this supply automatic changeover to DC2 shall occur within the tolerable BCU dc interruptions ride through time.

Bay control unit requirements are fully detailed in the SAS specification.

c. Transformer protection

The transformers shall be provided with a single numerical main protection system.

The transformer is protected by the main protection transformer biased differential and restricted earth fault protection featuring magnetising inrush restraint and inhibition of current differential operation upon transient over fluxing.

The Main protection is to be located within the primary side transformer protection panel. Operation of the main protection relay shall operate separate primary side and secondary side trip relays on each protection channel.

The main protection shall be complemented with thermal overload and overflux protection functions.

d. Primary side connections protection

The transformer HV connections shall be provided with two sets of numerical main protection systems connected to two sets of current transformers.

Primary side connections-1 shall comprise current differential protection of either the low or high impedance principle. For low impedance protection, the protection relays shall provide separate CT inputs to ensure a bias characteristic across all CT inputs. Upon opening of the HV transformer disconnecter the connection protection shall be blocked from tripping the LV side CB's. This protection relay inherently provides stub-protection-1 function.

Primary side connections-2 shall be provided by a second protection arrangement as specified for HV connections-1 above.

The primary side connection protection is to be located within the primary side transformer protection panel. Operation of a connection protection relay shall operate separate primary side and secondary side trip relays on each protection channel except when the Transformer HV side disconnecter is open.

e. Back-up protection

Primary side back-up protection shall include inverse-time through fault overcurrent protection to ensure that the transformer will not be operated beyond its short-time withstand limits. Back-up protection may also provide stub-protection when the primary side disconnecter is open.

A transformer neutral connected standby earth fault relay shall provide system back-up earth fault protection and provided tertiary winding protection (subject to tertiary phase connection to main winding neutral).

f. Transformer auxiliary (mechanical) protection

Each transformer shall be fitted with a range of auxiliary protection and alarm devices as illustrated in the protection single line diagrams. The auxiliary protection trips shall be integrated into the transformer protection tripping scheme. The auxiliary protection trips shall be wired to trip the CBs directly from trip relay contacts as well as through protection relay trip binary outputs. The operation of these devices shall be logged by the SCS.

g. Circuit breaker failure

For CBs adjacent to the busbars, the breaker fail protection shall be integral to the busbar protection scheme and so arranged to trip the mid diameter CB and intertrip the circuit remote terminal CB.

For the mid diameter CB's, separate breaker fail protection shall be provided and the appropriate trip and intertrip scheme designed to open all adjacent CBs upon stage-2 operation.

h. Trip Relays

Dual trip lockout relays (86) shall be provided with each separately operating CB trip-coil 1 and trip-coil 2. These relays shall be electrically resettable, locally and via the SCS.

i. Fault recording

For new build substations a standalone substation fault recorder shall be provided and all appropriate primary side feeder analogue and digital signals shall be extended to this device. Additional fault recording shall be

provided by the numerical protection relays. All fault records shall be retrieved via the SAS Engineering Workstation.

For existing substations, where practical, the existing fault recorder shall be adopted for the new circuits.

7.2.1.5 Power Transformers (Secondary side)

a. Protection arrangements

The protection and control arrangements are illustrated in the single line schematic diagram in Part 2-D.

The circuit protection shall be housed in relay panels as defined in the Protection General Requirements.

The illustrated control arrangement is one Bay Control Unit (BCU) per CB and shall be located in a dedicated panel per diameter basis. The Contractor may provide alternative BCU arrangements.

Busbar protection bay module (including breaker-fail protection) shall be located within a dedicated suite of busbar protection relay panels.

b. Bay control and monitoring

The BCU associated with the CB adjacent to the Busbar shall be configured to control the circuit disconnect and earth switch. For mid diameter circuits with no busbar CB then one BCU of the associated CBs shall control the circuit disconnect and earth switch. The contractor may propose alternative BCU configurations.

BCU shall provide mid-diameter CB failure functionality.

The BCUs shall perform the check synchronisation function and shall provide 3ph voltage signals from each busbar and each mid-diameter section to the SCS. The appropriate busbar and circuit VT secondary voltages shall be supplied to the BCU via a diameter voltage selection scheme according to the status of the AIS switchgear.

For communication purposes, all numerical protection devices shall be capable of being connected to the substation LAN via protocol IEC 61850. In exceptional cases, provided the approval of KETRACO, single numerical protection devices can be connected via a serial link to the BCU, using a protocol different from IEC 61850, but this shall only be the case if no comparable device with IEC 61850 is available on the market.

The BCU shall normally be supplied from DC1 auxiliary supply and upon loss of this supply automatic changeover to DC2 shall occur within the tolerable BCU dc interruptions ride through time.

Bay control unit requirements are fully detailed in the SAS specification.

c. Transformer protection

The transformers shall be provided with one numerical main protection systems.

Main protection schemes are detailed in the primary side particular requirements specification and are to be located in the primary side protection cubicle.

Operation of the main protection relay shall operate separate secondary side and primary side trip relays on each protection channel.

d. Back-up protection

Secondary side back-up protection shall include inverse-time through fault overcurrent protection to ensure that the transformer will not be operated beyond its short-time withstand limits. Back-up protection may also provide stub-protection when the secondary side disconnecter is open.

e. LV Connections protection

The transformer LV connections (Secondary side) shall be provided with two sets of numerical main protection systems connected to one set of current transformers.

LV (Secondary side) connections-1 shall comprise current differential protection of either the low or high impedance principle. For low impedance protection, the protection relays shall provide separate CT inputs to ensure a bias characteristic across all CT inputs. Upon opening of the LV circuit disconnecter the connection protection shall be blocked from tripping the HV CB's. This protection relay inherently provides LV stub-protection-1 function.

LV (Secondary side) connections-2 shall be provided by a second protection arrangement as specified for LV connections-1 above.

The Secondary side connection protection is to be located within the Secondary side transformer protection panel. Operation of a connection protection relay shall operate separately the Primary side trip relay and secondary side trip relay each on the associated protection channel except when the circuit disconnecter is open.

f. Circuit breaker failure

For CBs adjacent to the busbars, the breaker fail protection shall be integral to the busbar protection scheme and so arranged to trip the mid diameter CB and intertrip the circuit remote terminal CB.

For the mid diameter CB's, separate breaker fail protection shall be provided and the appropriate trip and intertrip scheme designed to open all adjacent CBs upon stage-2 operation.

g. Automatic Voltage Regulator

Automatic Voltage Regulation (AVR) shall be provided by a dedicated numerical relay provided solely for control of the transformer On-Load Tap-Changer (OLTC). The AVR shall provide selectable local/remote, manual/automatic, parallel/independent and selectable Master/follower control. The AVR shall be connected via IEC 61850 to the substation LAN.

See separate Transformer and SCS specifications for further AVR details.

h. Trip Relays

Dual trip lockout relays (86) shall be provided with each separately operating CB trip-coil 1 and trip-coil 2. These relays shall be electrically resettable, locally and via the SAS.

i. Fault recording

For new build substations a standalone substation fault recorder shall be provided, and all appropriate secondary side feeder analogue and digital signals shall be extended to this device. Additional fault recording shall be provided by the numerical protection relays. All fault records shall be retrieved via the SAS Engineering Workstation.

7.2.1.6 Transmission level Busbar Protection

The busbar protection arrangements are illustrated in the individual transmission circuit single line schematic diagrams.

The busbar protection scheme shall be current differential protection of numerical design of low impedance centralised principle. The bay units shall be installed in the OHL or power transformer protection cubicles, which are located in the Control Rooms. The central units are to be installed in the substation control building having fibre optic connection to all bay units. Each busbar shall have its own central unit protection cubicle.

The central module shall be powered from two station DC auxiliary supplies, via dual power supply units, such that failure of one power supply unit will not result in loss of busbar protection. There shall be a high degree of continuous self-supervision, where the failure of any bay module, communication link or loss of auxiliary supply to a bay module will be alarmed and will not result in any incorrect tripping.

The bay modules shall acquire the appropriate current signals and shall monitor the position of the busbar disconnector switch auxiliary contacts for each line and transformer feeder. The disconnector switch MBB type (Make before break) contacts shall be utilised for bus bar protection. The bay module shall also provide the breaker fail protection functionality for each busbar CB.

Existing substations having separate breaker fail protection shall maintain that design arrangement.

Check zone functionality shall be integral to the numerical busbar protection scheme and hence a separate relay providing check zone functionality is not required.

The busbar protection shall include checking techniques to detect analogue input errors that might provoke an incorrect trip under load. In addition, the sensitivity of the busbar protection shall be settable such that it cannot trip for any current measuring error under load conditions whilst still providing adequate sensitivity under minimum plant conditions.

Provision shall be made for future substation extension by including in the delivery two spare bay units per busbar, to ensure there will be no future problems with software versions.

Dual trip lockout relays (86) shall be provided with each separately operating CB trip-coil 1 and trip-coil 2. These relays shall be electrically resettable, locally and via the SCS.

The bidder shall include in his bid a detailed description about his proposed way of reliable and effective testing of the busbar protection against the background that central units and bay units are not installed in the same place.

7.2.2 Distribution Systems (33kV)

7.2.2.1 Protection Performance Requirements

7.2.2.1.1 Protection redundancy

The requirements for protection system redundancy are less stringent than those applied to the higher voltage systems. A single set of main protection shall be applied to each new circuit with separate local back-up protection relay. The Main protection shall be comprised of distance protection of at least two (2) zones. Remote back-up protection should be provided by protection relays of other circuits.

Each protection group shall also be driven from separate current transformers and independent VT secondary circuits.

7.2.2.1.2 Provision of back-up protection

Back-up protection (e.g. inverse-time overcurrent and earth fault protection or thermal overload protection) shall be provided to trip protected plant and circuits in the event of a sustained external fault condition or of a sustained power system abnormality that would otherwise damage or significantly reduce the life expectancy of the protected plant.

Where applicable, each set of feeder protection shall include "Zone-2" under impedance remote backup protection for busbars to ensure that, in the event of busbar protection failure, a remote-end busbar fault will be cleared within the switchgear internal arcing fault withstand time.

7.2.2.1.3 Circuit breaker failure (if required)

The provision of numerical busbar protection (if any) enables the inherent application of circuit breaker fail protection and shall cater for the possibility of a single circuit breaker failing to clear fault current when commanded to do so, by either of the main protection systems. The breaker fail protection shall initiate a first stage circuit breaker re-trip followed by a second stage rapid back-trip/intertrip of adjacent

circuit breakers, as necessary, and within KETRACO's required breaker failure fault clearance time of 300ms.

7.2.2.1.4 Auxiliary DC supplies

The auxiliary power and tripping supplies for each separate protection group shall be derived from a single DC auxiliary supply systems.

7.2.2.1.5 Protection supply and trip circuit supervision

The protection systems shall continuously supervise the DC auxiliary supplies and the integrity of all circuit breaker tripping circuits with the circuit breaker in the closed or open state. All protection relays shall incorporate comprehensive continuous self-monitoring and diagnostic facilities. All supervision relays shall provide an alarm signal into the SAS system.

7.2.2.1.6 High speed tripping relays

With immunity to operation with DC wiring capacitance discharge currents, high-speed tripping relays should be used to interface protection relay trip contacts to circuit breaker trip circuits. These are to ensure that output contacts within the protection relays will not be damaged in the event of the circuit breaker failing to interrupt its trip coil current before the protection relay contact(s) open (e.g. in the event of fault clearance by breaker fail protection). They will also form a single point of interfacing between the protection schemes and the circuit breaker. The tripping relays shall either be of the self reset type or of the latching type, with circuit breaker lockout contacts, according to protection scheme requirements.

7.2.2.1.7 Protection trip, alarm and disturbance records

The protection systems shall provide comprehensive records for trip and alarm conditions, with local indications of which element has initiated a trip or alarm and of voltage and current vector parameters at the time of trip initiation.

Voltage and current waveform disturbance recording and event-logging shall be included as part of the protection system.

7.2.2.1.8 Test facilities

The protection systems shall include comprehensive maintenance isolation and test facilities.

OHL Feeders

OHL feeders shall be provided with a single main protection and a separate back-up protection system.

The bay protection and control equipment shall be located within a dedicated relay panel, as indicated in the respective diagram.

For the communication purposes, all numerical protection devices shall be capable of connection to the Bay control unit or substation LAN.

The BCUs shall perform the check synchronization function and shall provide 3-phase voltage signals to the SAS. The appropriate busbar voltages shall be supplied to the BCU via a voltage selection scheme functions according to the monitored status of the bus disconnector switches. BCU shall also provide fault recording functions.

Logic shall be provided within the Bay Control Units and the hard wired logic scheme such that operator open and protection trip signals to the Bus Coupler and Bus Section circuit breaker are blocked when any bay is undergoing load transfer until the transfer process is complete.

The BCU shall have a main DC supply and a standby dc supply automatically connected should the main DC supply be lost. Change-over should occur within the tolerable BCU dc interruptions ride through time.

Bay control unit requirements are fully detailed in the SAS specification.

7.2.2.1.9 Main protection

The new overhead line feeder circuits between the existing substation and the new substation shall be provided with a single main protection system that comprise one set of numerical 3-Zone distance protection operating in "Blocked mode". The Main 1 distance relay shall also incorporate Directional Earth Fault protection and shall operate in blocked mode.

- Main Protection Signalling

Where the length of the OHL permits, main distance protection shall be designed for direct interfacing to a pair of optical fibres for teleprotection communication. Should there be no OPGW or separate fiber conductor in the line construction then a digital teleprotection signalling unit (Multiplexer) shall provide the necessary teleprotection communications between circuit-end relays. For direct fibre or multiplexer based communications, the distance protection should preferably be provided with an integral, two-way, high-speed, high-security intertripping channel, where energization of an intertrip send optical isolator of one relay will cause dedicated intertrip receive contacts of the remote relay to operate.

7.2.2.1.10 Auto-reclose

OHL circuits shall be equipped with a single auto-reclose relay per circuit. The auto reclose sequence shall be initiated from the main protection relays and shall preferably be integral to the BCU which provides integral check synch.

The circuit breakers are 3-phase tripping only and hence all auto-reclose sequences shall be 3-phase. The number of auto-reclose shots shall be confirmed. Typically, an auto-reclose sequence is one shot and lock-out if a second fault occurs within the reclaim time.

The auto-reclose sequence shall be blocked by distance protection time delayed impedance zones, operation of main protection Switch-onto-fault (SOTF) function, operation of busbar protection and circuit breaker failure protection.

Circuit breaker low stored energy signals shall inhibit the auto-reclose sequence until the elapse of a timer resulting in auto-reclose lockout. Should the stored energy recover before the elapse of the timer then auto-reclose sequence will continue. For 3-phase auto-reclose sequence, there is a possibility that the power system may be split and one part of the system may lose synchronism with respect to the other part. Any resulting circuit breaker auto reclose, without a check synchronism reference may result in an out of synchronism closure that damages the power system both electrically and mechanically. The severity of the damage depends on the degree of out of synchronism at the instant of closure.

For these reasons 3-phase auto-reclose shall be performed with check synchronism.

For existing substation where a central check synchronism relay is used, the availability of a signal from this scheme shall be investigated and if practical utilized. Alternatively, if the central check synchronisation scheme cannot provide the necessary signals then an auto reclose relay with an integral check synchronism feature can be provided and connected to busbar and line voltage transformers.

An intertrip receive signal shall inhibit the auto-reclose sequence until either the intertrip signal is reset or a persistent intertrip timer elapses and the auto-reclose relay goes to lockout.

The circuit breaker at the line end that recloses first shall upon detection of a permanent fault issue a persistent intertrip that prevents the remote end circuit breaker from reclosing onto the fault.

The auto-reclose relay shall be provided with a manual close inhibit feature that prevents auto-reclose for a settable period of time following manual circuit breaker closure e.g. following circuit breaker maintenance.

The auto-reclose relay shall provide circuit breaker maintenance alarm and lockout functionality.

The auto-reclose relay shall be provided with indications and alarms for:

- In/out of service
- Auto-reclose relay healthy
- Auto-reclose in progress
- Auto-reclose lockout
- Auto-reclose complete

The alarms shall be available locally on the relay and via the SAS.

7.2.2.1.11 Circuit breaker failure

For circuit breakers adjacent to the busbars, the breaker fail protection shall be integral to the busbar protection scheme and so arranged to trip adjacent circuit breaker s connected to the same busbar and intertrip the circuit remote terminal circuit breaker.

7.2.2.1.12 Back-up protection

Back-up overcurrent and earth fault protection shall be provided separate to the main protection relay.

Back-up shall also include sensitive earth fault (SEF) and broken conductor (BC) protection

functionality and shall be provided by the Bay Control Unit.

7.2.2.1.13 Trip relays

In order to permit auto-reclose functionality on OHL circuits, self resetting trip relays shall be provided for each trip coil and for each phase.

7.2.2.1.14 Fault recording

For new build substations, fault recording (waveforms and events) facilities should be integral to the numerical protection and control relays and retrievable via the substation automation and control system.

7.2.2.2 Power Transformer Protection (Primary Side)**7.2.2.3 Protection arrangements**

The bay protection and control equipment shall be located within a dedicated relay panel, as indicated in the respective diagram.

7.2.2.3.1 Bay control and monitoring

For the communication purposes, all numerical protection devices shall be capable of connection to the Bay control unit or substation LAN.

Synch check will not be required at Primary side, since the tripping logic for each transformer shall ensure that the secondary side circuit breaker is tripped whenever the Primary side circuit breaker is open. Each transformer should always be first energized from the Primary side. The secondary side circuit breaker close circuit shall be interlocked with a voltage monitoring function such that circuit breaker closure is prevented when the secondary side circuit is de-energized.

The BCUs shall perform the check synchronisation function and shall provide 3-phase voltage signals to the SAS. The appropriate busbar voltages shall be supplied to the BCU via a voltage selection scheme functions according to the monitored status of the bus disconnector switches. BCU shall also provide fault recording functions and may provide the back-up protection functions.

Logic shall be provide within the Bay Control Units and the hard wired logic scheme such that

operator open and protection trip signals to the Bus Coupler and Bus Section circuit breaker are blocked when any bay is undergoing load transfer until the transfer process is complete. For double busbar configurations with

two Bus Couplers and one or more Bus Sections, the Bus Section tripping shall not be blocked if the circuit undergoing on-load transfer and the Bus Coupler being used to provide the “parallel path” are on the same section of busbar. Where the Bus Section is included in the “parallel path” the tripping shall be inhibited.

The BCU shall have a main DC supply and a standby dc supply automatically connected should the main DC supply be lost. Change-over should occur within the tolerable BCU DC interruptions ride through time. Bay control unit requirements are fully detailed in the SACS specification.

7.2.2.3.2 Main transformer protection

The transformer and secondary side circuit is protected by the main protection transformer biased differential and separate HV and LV restricted earth fault protection. The Main protection and HV REF protection is located within the primary side protection panel and the LV REF protection located in the secondary side protection panel.

7.2.2.3.3 Back-up protection

Within the protection panels, directional overcurrent back-up protection and secondary side winding starpoint standby earth fault protection shall be provided. The directional protection shall be set to coordinate with the primary side inverse time overcurrent protection and secondary side standby earth fault protection of the parallel transformer(s). The standby earth fault protection shall be co-ordinated with the buscoupler and bus-section earth fault elements and shall trip both the primary and secondary side circuit breakers in one stage.

Back-up protection shall be integral to the BCU.

7.2.2.3.4 Transformer auxiliary protection

Protections are detailed in the specification for the transmission level.

7.2.2.3.5 Protection trip relays

The primary and secondary protection schemes for each transformer shall include latching, multi-contact, tripping/lockout relays. These relays shall be capable of being electrically reset either locally or via the SAS.

7.2.2.4 Bus Section

7.2.2.4.1 Protection arrangements

The bay protection and control equipment shall be located within a dedicated relay panel, as indicated in the respective diagram.

7.2.2.4.2 Bay control and monitoring

For the communication purposes, all numerical protection devices shall be capable of connection to the Bay control unit or substation LAN.

The BCUs shall perform the check synchronisation function and shall provide 3-phase voltage signals to the SACS. The appropriate busbar voltages shall be supplied to the BCU via a voltage selection scheme functions according to the monitored status of the bus disconnector switches. BCU shall also provide fault recording functions.

Logic shall be provide within the Bay Control Units and the hard wired logic scheme such that

operator open, and protection trip signals, to the Bus Coupler and Bus Section circuit breaker are blocked when any bay is undergoing load transfer until the transfer process is complete.

For double busbar configurations with two Bus Couplers and one or more Bus Sections, the Bus Section tripping shall not be blocked if the circuit undergoing on-load transfer and the Bus Coupler being used to provide the "parallel path" are on the same section of busbar. Where the Bus Section is included in the "parallel path" the tripping shall be inhibited.

The BCU shall have a main DC supply and a standby DC supply automatically connected should the main DC supply be lost. Change-over should occur within the tolerable BCU DC interruptions ride through time.

Bay control unit requirements are fully detailed in the SACS specification.

7.2.2.4.3 Back-up protection

Inverse-time overcurrent and earth fault protection shall be provided to safeguard against sustained overloading of a bus section circuit breaker as a result of operator error or of a power system break up.

7.2.2.5 Busbar protection (if required)

The protection arrangements are illustrated in the Protection single line diagrams.

The busbar protection scheme shall be current differential protection, of numerical design of centralised principle.

The relay shall be powered from two station DC auxiliary supplies, via dual power supply units, such that failure of one power supply unit will not result in loss of busbar protection.

There shall be a high degree of continuous self supervision, where the failure of any bay module, communications link or loss of auxiliary supply to a bay module will be alarmed and will not result in any incorrect tripping.

The bay units shall acquire the necessary current signals and they shall monitor the position of the busbar selector switch auxiliary contacts for each diameter, as necessary. They shall also provide the breaker fail protection functionality for each busbar adjacent circuit breaker.

Provision shall be made for future substation extension by ensuring the busbar protection scheme is installed with bay modules for two future "spare" diameters to ensure there will be no future problems with software versions.

The busbar protection shall include checking techniques to detect analogue input errors that might provoke an incorrect trip under load. In addition, the sensitivity of the busbar protection should be settable such that it cannot trip for any current measuring error under load conditions whilst still providing adequate sensitivity under minimum plant conditions.

Check zone functionality shall be integral to the numerical busbar protection scheme and hence a separate relay providing check zone functionality is not required

7.2.3 Substation Optical Cables and Termination

The main optical fibre cables are supplied under the overhead line contracts and are to be terminated at a termination block (TB) supplied by the overhead line contractors. The OPGW TB is to be mounted on either the line landing gantry or terminal tower and the substation Contractor will continue the FO into the substation.

Once in the substation, the main optical fibre cables are to be terminated at an optical termination block (OTB). The main OTB may be housed within a termination panel or telecommunication cubicles. The substation Contractor shall supply and install the optic fibre cable between the main OTB and the OTB located in the applicable protection panel. The optical characteristics of the substation optical fibres shall be the same as those specified in the overhead line contracts. Patch cords shall connect the protection relays to the panel OTB. A pair of spare optical fibres shall also be available in each substation optical fibre cable running from the OTB to the main protection panels and these shall be terminated at each end with the appropriate connectors.

The substation Contractor shall undertake a loss budget analysis and provide multiplexers if necessary for satisfactory transmission of signals between the substations.

7.2.4 Instrument Transformer Requirements

CTs and VTs ratio, class and accuracy limitation factor have been defined elsewhere in the substation specification. In addition, CTs and VTs are indicated on each protection single line drawing. The Contractor shall ensure that the CT and VT characteristics (VA burden or V_k) are calculated to meet at least the minimum protection and instrumentation manufacturer's requirements.

Current transformer requirements shall be determined to ensure high protection performance. The Contractor shall submit a comprehensive technical report that includes the required CT ratio and burden, the selected accuracy class and the Accuracy Limit Factor and knee point voltage calculations. The report shall confirm that CTs are designed to guarantee an excitation of the protection functions during all possible short-circuit and earth-fault conditions. For that purpose, ratio has to be selected accordingly, taking into account accuracy limits given by the measured current in relation to the rated current and by the connected burden. Furthermore, CTs shall ensure a saturation-free performance under both transient and steady state fault conditions, taking due account of system X/R ratios, system fault levels and remanent flux conditions in the CT core. Saturation of current transformers during short-circuit conditions can lead to mal-operation of protection relays and to unselective tripping. Especially distance and differential protection functions do have high requirements. In this regard it has to be considered that fault currents during transient conditions consist of a symmetrical a.c. component and a d.c. component, that rapidly saturates the core. A connected burden lower than the rated burden may help in this regard as far as the current transformer will be able to transmit higher currents without saturation. The calculation shall take into account the specific protection relay requirements. Modern protection relays do have, as an integral part, saturation detectors that reduce the time in which the relays need to be supplied with an unsaturated current. A corresponding evidence shall be based on the related manufacturer specific relay formulas. Furthermore, it has to be taken into account, that protection relays do have limits in which short circuit currents can be measured without endangering the current inputs of the protection relays. That means that having a low actual burden can also lead to secondary currents that can damage the current inputs of the relays. This has also to be verified.

The calculation shall be done for each typical core, typical in respect of the core data and the protection relay(s) connected to the core.

Typical X/R ratios of power systems shall be considered. The bus fault levels shall correspond to the respective switchgear ratings, unless specified otherwise.

Furthermore, the report shall show that selected rated burdens of CT measuring cores fit to the requirements of measuring instruments and meters. In this matter IEC definitions regarding burden limits for guaranteed accuracy class shall be considered. Additionally, it has to be considered, that the rated instrument security factor (FS) is effective at rated burden and that a connected burden lower than the rated burden results in higher amplitude of current that measuring instruments and meters need to withstand during short circuit conditions.

A burden calculation for VT windings shall show that the selected rated burdens fulfil the requirements of the protection relays, measuring instruments and meters. Furthermore, IEC definitions regarding burden limits for guaranteed accuracy class shall be considered. It shall also be considered that in case of short-circuit in the secondary circuit of the VT the tripping of the protective mini circuit breakers must be guaranteed.

Summarizing above statements, the CT and VT calculation document shall be structured accordingly in:

- General explanations describing what is calculated and how.
- Calculation per feeder/ CT(VT)/ core(winding) with
- Feeder single line diagram showing the CT cores respectively VT windings and the connected protection relays, measuring instruments and meters.
- Indication of:
 - General feeder data (short circuit current, voltage, power etc.)
 - Data of the CT core respectively VT winding
 - Data of the connected protection relays, measuring instruments and meters (burden etc.)
- Calculation of maximum possible primary current and selection of rated primary current accordingly
- Indication of the requirements of the protection relays, measuring instruments, meters etc. (a reference shall be made to the correspondent documents of the protection re-lays e.g. the chapters of the related manual)
- Calculation of the complete burden connected to the CT core respectively VT winding.
- Calculation to verify that the requirements are fulfilled.
- Conclusion
- Reference documents (e.g. relevant pages from the manuals)

The Technical Data Sheets include tentative data for CTs (ratio, rated output, accuracy limit factor) and VTs (rated output). The final data results from the calculation performed by the Contractor. Necessary changes of the data due to the calculation results do not permit the Contractor to ask for additional costs.

In case of capacitive voltage transformers (CVT) the relay system shall operate correctly and with high speed and shall have correct directional sensing in the presence of severe CVT transients produced in accordance with ANSI

standard C93.2 or IEC equivalent. The CVT transient requirement shall include the conditions of relaying accuracy with the rated burden of the CVT connected.

The voltage circuit shall be divided into separate groups for each protection relay or other equipment to be connected. All subdivisions into groups shall be carried out in the junction box nearest to the voltage transformer, where the various groups shall also be individually protected against short circuits with miniature circuit breakers.

In each relay panel incoming voltage circuits (from the junction boxes or other relay panels) shall be first wired to miniature circuit breakers, before connecting the circuits to the relays.

The miniature circuit breakers shall be provided with electromagnetic and thermal protection elements and shall have potential free contacts for blocking purpose and signalling. Auxiliary contacts for voltage blocking need to be designed for this special purpose (short tripping times).

Where voltage inputs to protection relays are required, these shall be monitored continuously. Any open phase shall be detected on high speed and shall prevent mal-operation of the affected protective relays. Unbalanced conditions in the current circuits due to defective connections should also be monitored. Auxiliary contacts of mini circuit breakers need to be designed for this purpose.

7.3 Documentation

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals.

7.3.1 Documentation with Bid

The Tender shall contain at least the following information and documents, failure of provision of the mentioned documents will lead to disqualification:

- Protection and indication single line diagrams of the substation(s);
- General arrangement drawings of the protection and indication panels;
- Manufacturing specification of the protection and indication equipment;
- Catalogues, literature and reference lists of proposed equipment;
- A comprehensive set of documentation shall be provided for all protection relays covering, as a minimum, the following topics:
 - Detailed description of protection relay including coverage of self-monitoring facilities, if applicable.
 - Range of features provided as standard.
 - Range of optional features.
 - Range of settings provided for all features, both standard and optional.
 - Details of all of the operating time characteristics for the protection relay.

- Statement of performance under reference conditions.
 - Variation of performance with departure from reference conditions.
 - Effects of interruptions to dc auxiliary power supply.
 - Current transformer requirements.
 - Voltage transformer requirements.
- Pre-energisation and commissioning;
 - Details of all necessary pre- energisation and commissioning tests shall be submitted for approval prior to the tests being performed, together with any supporting explanatory documentation such as “Installation, Operation and Maintenance manuals”. An opportunity shall be provided for KETRACO to witness site tests.
 - Type test certificates from an independent testing authority or independently witnessed;
 - A type test certificate shall be provided for each relay type, which shall confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies or users.
 - Quality Management System Manual and ISO Certificate of the equipment manufacturer.

7.3.2 Documentation after Award of Contract

All documents required for KETRACO's approval shall be submitted by the Contractor.

8. Telecommunication System

8.1 General requirements

This specification defines the minimum technical requirements to design, manufacture, and test the telecommunication system to be installed in the 132/33 kV substations. Briefly, the substations are:

- 132/33 kV Rumuruti substation, already existing, will be extended with three more 132 kV line bays ,One Transformer Bay
- 132 kV Kabarnet Substation, already existing, will be extended with One more 132 kV line bays. One Transformer Bay.

The new telecommunication systems to be provided at the substations shall be designed to transmit and receive data, voice and teleprotection signals according to this specification. The objectives of the telecommunication systems are to provide the relevant communication facilities and interfaces at the new substations and to integrate into the existing telecommunication network. All necessary hardware and software shall be provided to enable full integration to be achieved.

Complete Substation Telecommunication System to be implemented as per Grid code and KETRACO Technical specification and SCADA policy. Moreover, it should be considered remote end modification for SCADA based on existing design philosophy.

It is envisaged that the new telecommunication equipment shall be based on synchronous digital hierarchy (SDH) technology operating at STM-1/4/16 transmission level. All necessary optical boosters and pre-amplifiers shall be provided to enable satisfactory communications between substations without using intermediate repeaters or regenerators. The operating wavelength of the SDH network shall be 1310 nm or 1550 nm as appropriate. The multiplexer shall be able to be linked to the backbone telecommunication network and shall maintain redundancy with all other multiplexer in opposite sites.

The SDH network shall be designed for digital transmission using single mode optical fibres and shall conform to relevant ITU-T recommendations for the specified transmission bit rates. A minimum of 4 fibre pairs (i.e. 8 single fibres) shall be made available for use by the telecommunication system. Firewall shall also be implemented to eliminate unwanted communication and malicious attacks through SDH network.

The existing telecommunication network backbone is based on fibre optic via OPGW fitted to overhead lines. The Contractor shall be responsible for ensuring the supplied equipment is capable of interfacing with the existing telecommunication equipment. Should the bidder have any additional requirements he should state these in the Tender.

The SDH multiplexers shall be capable of being upgraded to the next hierarchy level, by exchanging appropriate modules at a later stage, to provide a higher transmission rate using the same optical fibres. The maximum transmission capacity that the proposed SDH network can achieve and whether the upgrading can be carried out whilst the system is carrying live traffic shall be stated in the offer.

The Contractor shall be fully responsible for the design of the telecommunication system and the provision of necessary items and works required for proper operation of the telecommunication system under the Contract. The telecommunication system shall provide, as a minimum, the following communication facilities:

- a. V.24/V.28 (RS232C) asynchronous data channels with speed up to 9.6 kb/s.
- b. High speed data channels (n x 64 kb/s).
- c. 2 Mb/s transport service.
- d. Voice channels.
- e. Teleprotection signalling channels.
- f. Gigabit Ethernet Interfaces 1000 Base-X/T
- g. Common LAN – 10/100 Base-T interfaces (RJ45) for connection of gateway computers of substation control system.
- g. Other non-critical operational and administrative data communication services using TCP/IP.

The Contractor shall be responsible for any modifications and re-allocations of existing channel assignment required to ensure that the telecommunication system can be developed and existing facilities are fully migrated to the new network with minimal disruption to power system operation.

A diagram showing the bidder's proposed telecommunication system and a detailed description on the functionality provided shall be submitted with the Tender.

The new telecommunication equipment shall conform to the latest editions of the International Electrotechnical Commission (IEC) Specifications, ISO Standards, IEEE Standards, and International Telecommunication Union (ITU) Specifications.

Details of the existing telecommunication system and OPGW cable can be found in Part 2G of the Bid Document.

VHF mobile radio system and network shall be provided in each new substation including a station set, at least 4 portable handsets, battery and battery charger, suitable antenna with all required accessories e.g. RG, Heliac cabling, AC & DC cabling, indication lamp and supported tower with suitable height (details as per clause No. 10 and 11).

8.2

8.3 Design and Operational Philosophy

The design philosophy of the new telecommunication system is that failure of any single component shall not cause failure of critical function. In addition, the telecommunication system shall be capable of providing a fully resilient network in which all speech, data and teleprotection signalling channels can be automatically re-routed in the event of a trunk/node failure and/or traffic congestion occurring anywhere on the network.

Cross-connection design criteria of channels shall be as follows:

- a. Transmission of teleprotection channels over physically separated multiplex equipment.
- b. Transmission of "main" and "standby/backup" channels over physically separated multiplex equipment as much as possible.

Telecommunication equipment supplied shall be equipped with dual redundant hot-standby control modules and power supply units. The equipment shall preserve configuration data during power failure and all modules shall be capable of hot swappable.

Appropriate number of 2 Mb/s tributaries on the STM-1/4/16 system will be utilised to provide voice, data and teleprotection signalling connectivity using first order multiplexing equipment. The 2 Mb/s transmission system will interconnect the following end-user facilities:

- a. High speed (64 kb/s) data channels according to ITU-T G.703.
- b. Low speed data channels (up to 9.6 kb/s asynchronous according to ITU-T V.24/V.28).
- c. Voice channels (E&M 2/4 wire).
- d. Remote subscriber channels.
- e. Gigabit Ethernet Interfaces 1000 Base-X/T
- f. Common LAN – 10/100 Base-T interfaces (RJ45) for connection of gateway computers of substation control system.

The telecommunication system shall also have provision for an engineering order wire (EOW) facility capable of providing a dedicated telephone communication system for commissioning/maintenance purposes between nodes.

Major communication equipment malfunction alarms shall be transmitted to the appropriate Control Centre via the SCADA system, to alert the system operators of the operational status of the telecommunication system. In addition, it is envisaged that remote supervision and monitoring of the new communication equipment will be via the existing telecommunication network management systems. All necessary hardware and software interfaces to enable integration with the existing telecommunication network management systems shall be provided under the Contract. Full details showing how this is achieved shall be submitted in the Tender.

8.4 Expansion and upgrade capability

The telecommunication system supplied by the Contractor shall employ open standard concept in the design and shall offer greatest flexibility for future expansion and upgrade of the system and facilities.

System expansions and upgrades carried out at a later stage shall be possible by means of minor modifications and/or by the addition of extra equipment modules to the telecommunications system. The following future upgrade options shall be possible:

- a. Single fibre operation.
- b. Dense wavelength division multiplexing (DWDM).
- c. TCP/IP Ethernet networking.
- d. Tele-Protection over Multi-Protocol Label Switching Network (MPLS-TP)

The telecommunication system shall be supplied already equipped with a minimum of 20 per cent spare capacity including interface modules for each type of communication circuit. A minimum of 50 per cent system expansion

capability shall be provided over and above the capacity/channel requirements that are needed for the new telecommunication system.

Details of system expansion and upgrade capability shall be submitted with the Tender.

8.5 Teleprotection signalling

The Contractor shall provide the necessary teleprotection signalling equipment including all necessary ancillary equipment so that teleprotection signalling commands such as blocking, permissive tripping and direct tripping can be transmitted via the new fibre optic link.

It is envisaged that at least 4 simultaneous teleprotection signalling commands shall be required per circuit. The Bidder shall include details of the proposed teleprotection signalling system in the Tender.

8.6 Telephony

For tendering purpose, the telecommunication system shall be capable of supporting:

- 3 simultaneous voice channels at each substation.

Telephone handsets shall be of modern design and equipped with push buttons for call selection and shall be suitable for desktop or wall mounted installation.

The final design and colour of the telephone handsets shall be subject to the approval of the Employer.

8.7 Power supply

A 48 Vdc power supply system shall be provided at each new substation for powering the telecommunication systems. The 48 Vdc power supply system shall consist of duplicated 100% float/boost chargers and two sets of storage battery. In the case of mains failure, the autonomy of the system shall be 10 hours. Power supply system operating in so called full float regime shall be used. The batteries and the chargers shall be sized to support the full load and 50 per cent spare capacity over and above the required loading requirements.

The 48V DC distribution shall be independent and supplied by separate main distribution panel(s) adjacent to the battery (ies) for communication equipment. Sub-circuit protection shall be in the particular panels, using MCBs. Any change-over and transfer facilities shall be located at these panels. Multiple grounding or earth return system is not permissible.

The battery capacity shall then be optimized to the minimum obtainable temperature of 10°C inside the powerhouse. Final battery capacity shall include a minimum 15% design margin in the calculated value to allow for aging and temperature effects on the battery. Aging factor shall be considered 25%.

If more than one system is specified, manual or automatic transfer facilities which will be fully interlocked to prevent loss of output voltage shall be provided. Manual or automatic transfer system shall be considered of make-before-break type.

To the automatic operations, the following requirements shall also be met with the selector switch in the 'Auto' position:

- On an automatic transfer, the breakers shall operate in such a way to prevent an interruption of power to the loads being transferred. Paralleling of supply systems will occur momentarily during this transfer. It shall not be possible to parallel the supply systems under any other circumstances.
- Individual control of each one of the supply and bus section breakers by means of their local control switches shall be blocked.
- The under voltage transfer control shall be blocked if any of the supply or bus section breakers are withdrawn from their 'connected' position.
- The automatic under voltage transfer control shall be blocked if either of the supply breakers are tripped due to an over current condition, or if there is a complete AC failure to both battery chargers.

In the manual mode, it shall not be possible to parallel supply systems. The following requirement shall also be met with the selector switch in the 'Man' position:

- Individual control of each of the supply and bus section breakers shall be possible by means of their local manual control switches. This shall apply whether the breakers are in the 'connected' or 'test' positions - The automatic under voltage transfer control shall be blocked.

The system shall continue its normal operation in case of a fault on one feeder or section of the system without affecting the DC supply to other section. The system is required to continue its normal operation with a single ground fault but an alarm shall be initiated. The system will interrupt DC supply if ground fault current increases to a predetermined level or there are two ground faults.

8.8 Interfaces with other systems/equipment

The telecommunication system shall be equipped with the necessary hardware including interconnection cabling and software to enable interfaces and full compatibility with the following systems to be made:

- a. Existing telecommunication systems.
- b. Existing telecommunication network management systems.

The Contractor shall be responsible for resolving and co-ordinating with other contractors or Authorities to ensure that the interfaces and the final installation between the telecommunication systems and other systems are fully compatible both physically and operationally. Failure to co-ordinate or delay in providing or timely requisition of the necessary interfacing information/ requirements shall be at the risk of the Contractor and the Contractor shall bear any costs which may arise as a result thereof for the provision of modification to other works which are involved with or subject to another contract.

8.9 Fibre optic communication system

8.9.1 General requirements

8.9.1.1 Introduction

The SDH system shall be designed for digital transmission using single mode optical fibres and shall conform to the ITU-T recommendations G.703, G.704, G.707, G.783 and G.957.

The multiplexing structure of the proposed SDH system shall allow existing PDH signals to be carried over the synchronous network and shall permit the extraction of individual circuits from high capacity systems without having to demultiplex the whole system. Cross connect facilities shall be provided to enable interconnections between different channels and network components.

The fibre optic communication system shall be provided with direct software control of network functions and in-service provision, and comprehensive network management and distributed bandwidth on demand facilities. In addition, remote test control and centralised alarm gathering and reporting features shall also be provided.

All electrical and electronic equipment supplied shall be properly grounded and shielded to protect the equipment and operating personnel from effects of induced currents and voltages. The equipment shall be rack mounted and be of modular design construction and be housed in approved equipment enclosures. The enclosures shall be provided with lockable doors.

The equipment shall not generate any type of electromagnetic interference at a level which could be detrimental to the performance of other equipment or which could cause annoyance or discomfort to personnel. Details of electromagnetic emission levels shall be included in the Tender. Where the performance of the equipment could be susceptible to interference, the Contractor shall state the maximum level of such interference, which will not cause equipment malfunctioning.

Built-in test and self-monitoring facilities shall be provided to enable maintenance personnel to break-in and/or make bridging measurements without degradation or interruption of service.

In order to maximise the benefit of the communication network and to facilitate the operation and maintenance of the SDH and PDH equipment, the system shall include network management capability so as to facilitate system performance monitoring, alarm and fault monitoring, system configuration, bandwidth management, dynamic allocation, automatic re-routing, prioritising of channels, testing and maintenance facilities etc.

A redundant configuration for ensuring minimum down time in case of equipment failure shall be provided by installing two physically separated SDH – multiplexers. Any failure shall produce automatic switch-over to the back-up unit and initiation of an alarm. Bidders shall provide detailed design philosophies for equipment and routing redundancy.

The fibre optic communication equipment shall be capable of providing proper performance for at least 25 years.

8.9.1.2 Loss budget calculations

The Contractor shall carry out loss budget calculations for each transmission link to ensure the SDH system meets the requirements of this Specification. The calculations shall include both a 'worst case' and a 'typical' loss budget calculation, using the respective maximum and average attenuation predicted for each component in the system.

The optical power budget calculation shall take into account of the following parameters:

- a. Mean launch power.
- b. Receiver sensitivity.
- c. System design penalties.

- d. Margin for age degradation and temperature.
- e. Connector losses.
- f. Maximum installed cable loss.

System performance calculations shall include a minimum safety margin of 3 dB.

Preliminary loss budget calculations shall be included in the Tender. Detailed calculations shall be submitted during the detail design stage for the approval of the Engineer.

8.9.1.3 Safety

The SDH and PDH equipment will be situated in high voltage electricity substations which are subject to rises in earth potential at times of system faults. Precautions shall be taken to prevent damage occurring to the equipment.

The system shall incorporate all reasonable precautions and provision for the safety shut-off of the optical source to prevent exposure to laser light during installation, maintenance and repair work. The possibility of automatic laser shut down adjustment through the network management system should be supported. Laser products shall comply with the requirements of IEC 60825 specification.

All metal parts, metal cable sheaths and equipment housings shall be bonded to earth. Details of the earthing arrangements shall be submitted to the Engineer for approval.

8.9.2 Functional requirements

8.9.2.1 General

The SDH system shall have the following features:

- a. High operational security and reliability.
- b. High quality transmission in accordance with ITU-T recommendations.
- c. Flexibility for adaptation to the desired transmission capacity.
- d. Integrated monitoring facilities.
- e. Comprehensive operation and fault diagnosis.
- f. Redundancy capability where required.
- g. Direct and easy access to the transmitted base band signal.
- h. Direct connection to multiplexing equipment employing pulse code modulation (PCM) techniques.
- i. Capability of routing TCP/IP traffic.
- j. Support Q3 interface in accordance with ITU-T G.773.

As far as practicable all fibre optic communication equipment shall self-diagnose internal fault conditions and separately alarm their occurrence. The designs shall also include diagnostic test facilities to allow step-by-step checking of the performance of the equipment.

8.9.2.2 System capacity and performance

The system shall be capable of being upgraded to the next STM hierarchy level by exchanging appropriate modules at a later stage, to provide a higher transmission rate using the same optical fibres and repeater locations, if any.

The overall mean equivalent bit error rate (BER) of the SDH system between any two end terminals shall not be worse than 10^{-9} under normal operating conditions. The typical error rate for each traffic path shall be stated. End to end error performance shall be in accordance with the requirements of ITU-T recommendation G.826.

The automatic switch-over to standby transmitter criterion shall be $BER > 10^{-9}$. Switching shall also be possible manually for maintenance purposes. The switchover shall be transparent to the data stream.

Jitter performance on STM-1/4/16 interfaces shall be in compliance with ITU-T recommendations G.813 and G.825.

The SDH system shall include provision for overcoming impairments caused by transmission delays. Details of the performance of the proposed SDH system shall be included in the Tender.

The SDH system shall preserve configuration data during power failure or management connection failure. During power or management connection failure alarm logs and performance monitoring statistics shall be preserved.

Signal synchronising facilities are required to enable the system to be implemented effectively, and facilities for connection of unused multiplexer inputs to appropriate signals as specified by the manufacturer shall be provided. In addition, details of how the Bidder intends to perform synchronisation across the fibre optic communication network shall be included in the Tender. The existing synchronization scheme applied in the system shall be followed.

8.9.2.3 Service channels

Each SDH terminal equipment shall provide at least two analogue and four digital service channels for voice communications and testing purposes between any two terminal stations exclusively for the use of installation and servicing personnel.

The 64 kb/s digital service channels shall be suitable for any data transmission requirements.

Each SDH terminal equipment shall have a handset for voice communications.

8.9.3 SDH equipment

8.9.3.1 General

The SDH equipment shall perform both multiplexing and optical line terminating functions and must be able to expansion and upgrade capability to Include MPLS TP. The aggregate ports of the SDH equipment shall be duplicated and shall be capable of operating in a '1 + 1' protected mode as part of a point to point link, or as an 'east/west' mode when used in a drop and insert chain in a ring. All features and functions of the SDH equipment shall be readily software configurable to suit operational requirements of the SDH system.

The SDH equipment shall be capable of being configured as a hub, cross connection, repeater, add/drop multiplexer or terminal multiplexer.

The SDH equipment shall be equipped with a range of plug-in tributary interfaces to support a comprehensive range of plesiochronous and synchronous tributaries including 2 Mb/s, 34 Mb/s, 140 Mb/s, and from STM-16 operation. Cross connection levels shall include 64 kb/s, VC-12, VC-3 and VC-4. Further common LAN interfaces and Gigabit Ethernet interface on tributary side shall be present.

Each SDH equipment shall comprise, but not be limited to, the following functional elements:

- a. Optical line interface.
- b. Electrical line interface.
- c. Tributary module.
- d. Switching unit.
- e. Control and alarm functions.
- f. Engineering order wire (service telephone) unit.
- g. Service data interface.
- h. Ethernet interface.

8.9.3.2 Optical line interface

The SDH equipment shall be capable of supporting the following optical interfaces:

- a. S-1.1, L1.1 and L-1.2 STM-1 interfaces in accordance with ITU-T G.957.
- b. S-4.1, L-4.1 L-4.2 and X-4.2 STM-4 interfaces in accordance with ITU-T G.957
- c. S-16.1, L16.1 and L-16.2 STM-16 interfaces in accordance with ITU-T G.957.

The optical interface shall carry out the parallel to serial conversion of traffic from the switch unit into a STM-16 2.5 Gb/s or STM-4 622 Mb/s and STM-1 155 Mb/s stream. The optical section shall convert electrical signals into an optical signal for transmission over an optical fibre and perform a reciprocal function on the receive side. Each optical line system shall be suitable for duplex operation at optical wavelength of 1550 nm over 2 optical fibres.

The electro-optic converter shall have a power output suited to the requirements of the fibre optic links and shall be suitable for transmission length of at least 180 km without the use of intermediate repeaters. All necessary optical boosters and pre-amplifiers shall be provided to suit the optical performance requirements of the fibre optic link.

The optical source shall have minimum life of at least 50 000 hours at an ambient temperature of +50°C. The transmitter shall have internal diode current and output power monitoring, which will provide status indications.

The design of the transmitter shall be in a way that under fault conditions, the launch power shall be significantly reduced to a safe level. It is preferable that the optical transmit and receive equipment are interconnected in such a way that a broken fibre will automatically switch off the optical transmitters at both ends of the section.

Transmitters which output optical power of sufficient intensity to cause hazard to health shall have mechanical interlocks to isolate the diode supply current during the installation or maintenance of the equipment. Sign warning of possible hazard shall be permanently fixed at all appropriate points.

Transmitters shall provide the continuous transmission of data timing information.

The optical receiver equipment shall have a bit error rate performance suited to the requirements of the network.

The receiver shall automatically accommodate signal level changes due to temperature effects and ageing of the system. Where necessary, receiver optical attenuators shall be provided to optimise link performance.

It shall be possible to use an optical line interface unit as a tributary module to enable STM-1/4/16 signals to be terminated when the equipment is configured as an 'Add/Drop' multiplexer.

The SDH equipment shall support FC/PC type optical connectors or similar.

8.9.3.3 Electrical line interface

The equipment shall support standard electrical tributary interfaces in accordance with ITU-T recommendation G.703. The electrical interface shall perform the same electrical functions as the optical interface unit. STM-1 electrical line signals shall be in accordance with ITU-T recommendation G.709.

It shall be possible to use an electrical interface unit as a tributary module to enable STM-1 signals to be terminated when the equipment is configured as an 'Add/Drop' multiplexer. A 10/100 Mb/s Ethernet LAN interface shall also be supported.

8.9.3.4 Tributary module

The tributary module shall perform the selective extraction/insertion of tributaries to and from the STM-1/4/16 signal whilst enabling other traffic to pass through without interruption.

The tributary module shall be capable of supporting tributary data rates of 2 Mb/s, 8 Mb/s, 34 Mb/s & 140 Mb/s.

The data from each tributary shall be mapped into virtual containers and tributary units in accordance with ITU-T recommendation G.774 which shall make up the SDH payload before being sent to the switch unit.

8.9.3.5 Switching unit

A switching unit shall be provided to allow traffic from any line interface unit to be connected to any tributary port or any other line port. In addition, it shall allow full cross connections between tributaries.

The switching unit shall provide the changeover facility from faulty units to the standby units to achieve 1+1 protection.

8.9.3.6 Control and alarms functions

Comprehensive control and alarm functions shall be included to provide performance monitoring, alarm and fault monitoring, system configuration, bandwidth management, dynamic allocation, automatic re-routing, prioritising of channels, testing and maintenance facilities etc. These functions shall interface to the telecommunication network management system to allow the control and alarm monitoring of the equipment to be carried out locally and remotely.

The equipment shall be provided with a fault location and supervisory system to monitor the status and alarms of the SDH equipment. The fault location and supervision system shall provide in-service bit error monitoring facilities.

The following alarms shall be provided on the SDH equipment as a minimum:

- a. Loss of incoming signal or loss of frame alignment.
- b. Optical transmit power low.
- c. Laser current high.
- d. Bit error rate (BER) threshold high.
- e. Optical receive level low.
- f. Multiplex input fail.
- g. Loss of clock signal.
- h. Distance alarms.
- i. Power supply fail or out of limits.

An alarm monitoring system shall be provided to monitor and display the locally derived alarms and if applicable adjacent repeater station alarms, showing the location of each alarm displayed. The system shall be capable of providing details of origin, date and time of the occurrence of alarms. It shall be possible to change alarm severity and threshold levels manually.

Alarm indications shall be clearly displayed through LEDs on the front panel of the module. It shall also be possible to remotely display some of the alarms locally at that site via voltage free contacts.

The alarm monitoring system shall form an integral part of the network management system. The alarm concept shall conform to ITU-T recommendation G.784. Test points shall be available on each unit to help in failure diagnosis.

Digital data streams shall be monitored at all levels. Equipment power supplies shall be monitored and a fuse alarm indication shall be provided for each cabinet or rack.

8.9.3.7 Engineer order wire

An engineer order wire (EOW) telephone system shall be provided at each SDH terminal site. The system shall operate on a service channel in the STM-1/4/16 -bit stream. The system shall be configured as an omnibus circuit, with a telephone handset, selective calling to reach any station along the route and an audible alert provided at each terminal.

8.9.3.8 Service data interface

Means shall be provided for accessing auxiliary channels using spare bytes in the SDH 'overhead' bit stream to enable management signals from additional equipment such as primary access multiplexers to be transmitted over the fibre optic communication system.

The number, bit rate and type interfaces available shall be stated by the Bidder.

8.9.3.9 Ethernet interface

The SDH equipment shall be capable of supporting 10/100 Mb/s BaseT interfaces complying with IEEE standard 802. Interfaces on the multiplexers tributary side shall be modular and provide up to four 10/100 Base T interfaces per –card slot.

8.9.4 Primary access multiplexing equipment

8.9.4.1 General

Primary access multiplexing equipment shall be provided as necessary and shall comply with the relevant ITU-T recommendations. The digital interface of the multiplexing equipment shall be of a time division multiplex signal conforming to the ITU-T recommendation G.703 to enable direct connection to the SDH optical multiplexing equipment.

All primary access multiplexing, de-multiplexing and signal processing and conditioning equipment shall be provided to interconnect SCADA, teleprotection and telecommunication equipment to the fibre optic communication system. It shall be the Contractors responsibility to ensure that the types and quantities of primary multiplexing equipment provided shall be capable of meeting the required number of communication channels specified, including redundancy requirements.

All equipment shall be wired for their maximum capacity. Future extension shall be possible by simple field installation of appropriate modules.

8.9.4.2 Multiplexer

The primary digital multiplexing equipment shall be capable of combining timeslots into a digital 2048 kb/s data stream conforming to the ITU-T recommendation G.703.

The multiplexing equipment shall have the following features:

- a. Sample rate for each channel shall be 8 kHz with maximum deviation of ± 50 parts per million, with 8 coding bits per sample, giving 256 quantisation levels, resulting in a 64 kb/s rate for each channel.
- b. Encoding law shall be in accordance with the requirements of ITU-T G.771.
- c. Jitter characteristics shall be equal to or better than ITU-T G.703.
- d. The 2 Mb/s interface shall be 2048 kb/s ± 50 parts per million with a HDB3 line code conforming to the ITU-T G.703.

Signal synchronising facilities are required to enable the system to be implemented effectively, and facilities for connection of unused multiplexer inputs to appropriate signals as specified by the manufacturer shall be provided. The existing synchronization scheme shall be applied.

Communications interfaces shall be capable of being made available by means of insertion of appropriate plug-in cards into the multiplexer rack to support the following user interfaces:

- a. 4-wire to 4-wire voice frequency.
- b. 2-wire to 2-wire voice frequency.
- c. 2-wire E&M signalling.
- d. 4-wire E&M signalling.
- e. 2-wire with ring down suitable for a remote subscriber telephone connection.
- f. 2-wire loop disconnect signalling.
- g. 4-wire to 4-wire voice frequency with FSK modem and channel fail detection.
- h. Data interface suitable for multirate synchronous/asynchronous data signalling.
- i. 64 kb/s data channel according to ITU-T G.703.
- j. 2 Mb/s data interface according to ITU-T G.703.
- k. Alarm collection interface.

The types and quantities of the cards for the 30 PCM channels (64 kb/s) shall be supplied so as to meet the requirements of the project.

8.9.4.3 Alarm indications

The PCM multiplexing equipment shall have extensive alarm monitoring facilities. In the event of failure, appropriate alarm indications shall be initiated. Alarm indications shall be clearly displayed through LEDs on the front panel of the module. It shall also be possible to remotely display some of the alarms locally at that site via voltage free contacts.

8.9.4.4 User interfaces

User interfaces shall be provided by the Contractor to accommodate various voice frequency (VF) and data channels requirements. The user interfaces shall allow direct connection to SCADA, teleprotection and other communication equipment.

Any special interfaces which are considered necessary for the provision of a full and complete installation of the communication system shall be included in the offer and full details shall be supplied with the Tender.

a. Telephony interface

4-wire voice frequency channel interfaces shall comprise 600 ohm balanced circuits with a bandwidth of 300 Hz to 3400 Hz. VF signal levels shall be adjustable within the range:

Input: -16 to +1 dBm

Output: -7 to +7 dBm

E & M signalling interfaces shall be provided on each 4-wire VF channel.

2-wire analogue subscriber interfaces shall permit direct connection of subscriber sets to the telephone exchange equipment. Interfaces shall comprise balanced circuits with E & M signalling and recall facilities and shall be suitable for both standard telephone instruments and telephone consoles using dual tone multi-frequency (DTMF) signalling. Telephone ringing supplies shall form part of the interface equipment.

Signalling (E & M) channel interfaces shall be suitable for a maximum signalling rate of 300 baud. The interface shall be capable of operating from an external power supply with either positive or negative polarity grounding and a maximum potential of 100 V. The E-lead shall be capable of switching currents up to 100 mA.

The external connections of both VF and E & M circuits shall be isolated from the associated board circuits. Where modems are connected to communication cables, barrier transformers shall be supplied for protection against induced over-voltages.

b. Data interface

Data interfaces of the following types shall be capable of being made available by insertion of appropriate cards into the multiplexer rack for direct connection to computer systems. The following data interfaces shall be supported as a minimum:

- a. 64 kb/s data interface according to ITU-T recommendation G.703.
- b. Multirate 0.6 to 64 kb/s data interface according to ITU-T recommendations X.21/V.11.
- c. Multirate 0 to 19.2 kb/s data interface according to ITU-T recommendations V.24/V.28.
- d. nx64 kb/s data interface according to ITU-T recommendation V.35.
- e. 2 Mb/s HDB3 coded signals on line interfaces conforming to ITU-T recommendation G.703 using 120 ohms balanced impedance, with co-directional interface synchronisation.
- f. Gigabit Ethernet Interfaces 1000 Base-X/T

- g. Common LAN – 10/100 Base-T interfaces (RJ45) for connection of gateway computers of substation control system.

Sub-multiplexing up to 8 low speed (0 to 1 200 baud) asynchronous data inputs over a single 64 kb/s communication channel shall be possible.

c. Teleprotection signalling interface

The fibre optic communication system shall be capable of facilitating the transmission of teleprotection signalling commands associated with the power transmission network. Provision shall be made by the Contractor to enable direct connection to the teleprotection equipment for transmission of remote protection signalling/tripping commands. The transmission of protection signalling commands shall preferably be utilising a complete 2Mbit/s channel according to ITU-T G.703 or transmitting N times 64 kbps on an optical fiber according to IEEE C37.94.

The protection channel interface units shall operate regular loop tests to ensure their readiness for operation. In the event of a fault being detected an alarm shall be raised and the protection command inhibited.

The maximum signal transmission time of the fibre optic communication system over any fibre optic links shall not exceed 2 milliseconds. This signal transmission time shall exclude any delay times of the teleprotection equipment.

The Contractor shall ensure that the routing and rerouting of the SDH transmission network do not compromise the operating time of the protection signalling equipment.

8.9.4.5 Cross connection equipment

Cross connection equipment shall be provided as necessary to enable interconnections between different channels and network components be made.

Cross connection functions available shall include pass through, broadcast, add/drop and loopback.

8.9.4.6 Power supply requirements

The fibre optic communication equipment shall be designed to operate from a 48 Vdc (positively earthed) supply. The equipment shall have protection against transient voltages and operate without degradation in performance for a supply voltage variation stipulated in the Technical Schedules.

All interconnection cabling from the equipment to power source and any necessary devices to protect the fibre optic communication equipment from damage in the event of overload shall be provided.

The power supply input to individual items of equipment comprising the fibre optic communication system shall be individually fused.

8.9.4.7 Optical fibre distribution frames

Optical fibre distribution frames shall be provided as necessary by the Contractor to facilitate the termination of fibres, testing and isolation of both the optical fibre cable and fibre optic terminal equipment, and to provide interface and/or cross-connect facilities between the digital multiplex equipment. Sufficient space shall be

available on the frame to allow ease of access and minimise the possibility of interference or damage to fibres carrying traffic during maintenance testing on the back-up or spare fibres.

Optical fibres shall be terminated by detachable connectors, complying with the requirements of IEC 60874, at the optical fibre distribution frame and shall be properly labelled with fibre identity, destination or source, go or return. It shall be possible to connect each optical fibre to the appropriate point on any terminating equipment. Fixed couplers shall be provided for each fibre comprising a link.

The following basic functions of the fibre distribution frame are required:

- a. Circuit re-routing/jumpering.
- b. Circuit disconnection.
- c. Patching and test connections.
- d. Bridging measurements.

Plug-in connection shall be used, and the transmit and received direction of the transmission shall be segregated. The optical fibre tail cables and connections shall be substantially protected from possibility of damage due to maintenance or installation activity.

The capacity of the fibre distribution frame shall be chosen to accommodate the maximum capacity of the fibre optic communication system plus 50 per cent spare capacity to cater for any future expansions. All fibre distribution frames shall have an earth connection provided, and shall be protected from corrosion by painting or galvanising.

8.10 Teleprotection signalling equipment

8.10.1 General requirements

The teleprotection signalling equipment shall be suitable for transmission of teleprotection commands in the high voltage networks and shall be capable of being used for blocking, permissive and direct tripping commands without any additional equipment. The teleprotection signalling equipment shall, in addition, be capable of direct transfer tripping, special switching functions and digital current comparison protection.

The teleprotection signalling equipment shall be designed and manufactured in such a way that disturbances on the transmission path shall not lead to false operation or cause undue delay in the transmission of the tripping command.

The teleprotection signalling equipment and signal transmission shall not be affected by switching operations, atmospheric conditions and other sources of interference.

The teleprotection signalling equipment shall employ state-of-the-art components together with the digital signal processing technique to provide programming facilities for flexible adaptation to various requirements of teleprotection signal transmission.

The selection of transmission time, dependability and security to suit the different operating modes shall be possible by means of programming using either a plug-in handheld terminal or programming switches on the equipment.

The teleprotection signalling equipment is required to operate over fibre optic links. It shall therefore be of a modular design so that it can be readily for direct connection to the SDH fibre optic equipment by insertion of a plug in interface module. Teleprotection signalling equipment that is an integral part of the SDH equipment without via multiplexing equipment is preferred. The type of teleprotection signalling equipment proposed shall be clearly stated in the Tender.

The equipment should be able to selectively disconnect the faulty part of the system in the event of faults in high voltage installations within the shortest possible time.

Technical descriptions detailing the teleprotection signalling equipment performance and equipment configuration shall be provided in the Tender.

The protection signalling equipment shall be capable of providing reliable performance throughout the 15-year life expectancy of the system.

The teleprotection signalling equipment shall be designed for ease of maintenance and shall include a variety of built-in alarms associated with vital operating parameters and a loop test facility.

8.10.2 Functional requirements

The teleprotection signalling equipment shall have the following features:

- a. High equipment reliability.
- b. Integral monitoring facilities.
- c. Simple operation and fault diagnosis.
- d. Direct integration to existing telecommunication systems.
- e. Wide selection of user interfaces.
- f. Easy programming for optimum setting of signal processing time, security and dependability.
- g. Permanent self-supervision.
- h. Automatic loop checking.

8.10.3 System capacity

The protection signalling system shall be designed with a minimum of 4 diverse teleprotection command channels operating in full duplex mode.

8.10.4 System performance

The protection signalling system performance shall be in accordance with the requirements of IEC 60834 specification.

8.10.5 Interfaces

The teleprotection signalling equipment shall provide suitable interfaces for the direct connection to fibre optic communication equipment.

8.10.6 Alarms indications

The teleprotection signalling equipment shall have extensive alarm and operational monitoring facilities. In the event of failure, appropriate alarm indications shall be initiated. Alarms and monitoring indication shall be clearly displayed through coloured LEDs on the front panel of the module. It shall also be possible to transmit alarms to other systems such as the existing SCADA systems via voltage free contacts with a maximum operation time of 1.5 ms.

The equipment shall be equipped with alarm circuits to detect at least the following:

- a. Error rate of guard or tripping signal codes too high.
- b. Loss of synchronisation.
- c. Alarm indication signal response.
- d. Bit error rate above the set level.
- e. Components failure.
- f. Response of an internal test routine.
- g. Receive signal low level.
- h. Loss of guard signal.

The LED alarm displays shall be capable of being reset from the equipment.

8.10.7 Power supply requirements

The teleprotection signalling equipment shall be designed to operate from a 48 Vdc (positively earthed) supply. The equipment shall have protection against transient voltages and operate without degradation in performance for a supply voltage variation stipulated in the Technical Schedules.

All interconnection cabling from the equipment to power source and any necessary devices to protect the teleprotection signalling equipment from damage in the event of overload shall be provided as part of this contract.

The power supply input to individual items of equipment comprising the teleprotection signalling equipment shall be individually fused.

8.11 48 VDC power supply system

8.11.1 Introduction

The 48 Vdc battery and charger system shall be used for powering the telecommunication equipment and shall comprise 2 x 100% rated duty Nickel-Cadmium (Ni-Cd) type battery units, 2 x 100% rated battery float/boost chargers and duplicated distribution panels.

The system shall be designed for ease of maintenance and shall include a variety of built-in alarms associated with vital operating parameters.

A preliminary single line diagram of the 48V DC system is attached in Part 2-D.

8.11.2 Functional requirements

8.11.2.1 General

The Contractor shall be responsible for the design and provision of a 48V DC system.

The chargers shall be sized to ensure that one charger alone can supply the total normal consumption of the two distribution panels. During normal operation both rectifiers shall be in operation, and they shall be able to operate in parallel.

The system shall have, as a minimum, the following features:

- a. High operational security and reliability.
- b. Alarm monitoring facilities.
- c. Simple operation and fault diagnosis.

The output of the battery and charger system shall be 48 volts (positive earth) and shall continuously supply the power requirements of the load. There shall be no power interruption to the load during mains power failure or when the mains power is restored.

8.11.2.2 System capacity and performance

The ampere capacity of the batteries shall be adequate when fully charged to maintain the stated load in normal operation within its stated voltage limits for a period of at least 10 hours:

The batteries shall normally be kept charged by a dual battery charger unit, each charger comprising a float charger with manual boost charge facilities.

The rating of each charger shall be sufficient to carry the specified maximum load including the spare capacity, whilst maintaining the battery in a fully charged condition.

The boost charger shall be rated to restore the fully discharged battery to the fully charged condition within 12 hours, without interrupting supplies to the equipment.

When the battery is connected to the charger, the psophometric noise level at the output, for loads between 0 per cent and 100 per cent, shall not exceed the equivalent of 2 mV at a frequency of 800 Hz after weighting as specified by ITU-T recommendations for any operational condition.

Automatic control of the output dc voltage is required. Variation shall not exceed 0.5 V from 20 per cent to 100 per cent full load current.

8.11.2.3 Alarm indications

The battery and charger system shall be provided with efficient built-in self-monitoring and alarm facilities. An alarm shall be activated when a fault is detected. Alarm conditions shall be displayed locally. Voltage free contacts wired to cabling terminals shall also be provided to enable remote indication of each alarm.

As a minimum the following remote signals shall be provided for connection to the Substation Control System:

- a. AC supply fail.
- b. Battery voltage high.
- c. Battery voltage low.
- d. Charger fail indication.
- e. Battery earth fault.
- f. DC supply fail.
- g. Output dc MCB Trip (Common for all MCBs).

Sufficient alarm initiation outputs shall be provided to allow each alarm of the 48 Vdc power supply system to be displayed at up to three remote locations.

8.11.3 Battery and charger equipment

8.11.3.1 Batteries

The batteries shall provide power supply for the telecommunication equipment demand and be designed to give at least 10 years life from the date of installation.

The batteries shall operate in floating service, i.e. they shall be continuously connected to load and to the charging rectifiers.

The 48 Vdc batteries shall be housed in the battery room and shall be mounted on heavy-duty epoxy coated metal racks suitably protected against corrosion and attack by the battery electrolyte. The battery shall be spaced so as to permit sufficient access to all individual cells to allow replacement of cells and/or checking cell voltages and connections. Racks shall be assembled clear of walls to permit access on all four sides of the battery bank.

Battery trays shall be factory treated with an electrolyte corrosion resistance coating.

The positive and negative terminals of each cell shall be clearly marked and permanently indicated. The positive and negative terminals of each complete battery shall be indicated by red and black markings respectively in an approved form. Each cell shall be identified by a number formed in a non-corrodible material and fixed to the cells to be visible when installed on the racks.

The Contractor, shall select the Ah capacity according to the load requirements of telecommunication and control equipment, taking into consideration the following:

- a. The 100% spare capacity.
- b. The standby time required.
- c. The service voltage required shall not drop below recommended figures (permitted voltage tolerances of the individual loads).
- d. The voltage fluctuations caused by power consumption of various loads shall be kept within permitted limits.

Cells shall be formed into a sub-assembly by mounting in groups, in robust containers. Taping together of cells will not be accepted. Stainless steel containers shall be insulated one from the other.

Cells utilizing plastic containers shall be constructed so that the plates are rigidly held so as to avoid the possibility of distortion and short-circuiting of the plates. Each cell container shall be equipped with an electrolyte level indicator and the electrolyte capacity shall be sufficient to ensure long intervals between topping-up.

The battery unit, located in a battery room, shall be connected to the distribution board and battery charger by halogen free insulated copper cables. A fuse box, located outside the battery room, shall be provided for the battery. The positive and negative fuses shall be arranged in pairs and shall be fully segregated from each other by an insulating barrier. The fuses shall be of the high breaking capacity type in accordance with IEC 60269.

The Contractor shall submit a calculation of battery capacity.

8.11.3.2 Battery chargers

The batteries shall normally be kept fully charged by a dual battery charger unit. Each battery charger shall be capable of simultaneously supplying the full load and trickle charging the batteries. Under normal condition, each battery charger shall support half the load. In the event of a failure of one of the battery chargers, the healthy charger shall automatically take-over the full load current without supply interruption. Manual change-over of chargers shall also be possible.

The battery charger shall be of the solid state static thyristor or switch-mode rectifier type suitable for dc power supply and charging of the associated storage battery. The rated output and current of rectifier shall correspond to the requirements of system load and battery charging. The operation of the rectifier shall be fully automatic.

The output voltage shall be maintained constant and just sufficiently above the open circuit voltage of battery to keep the battery in a fully charged condition, independent of load variations or variations of ac input voltage within the specified limits. Provisions shall be made to adjust the charging voltage for a fully charged battery with an accuracy of at least 1%, and to move the setting point within a range of $\pm 10\%$.

The rectifiers shall be fed from the LVAC main switchgear. Double wound transformers shall be provided at the input side of rectifier to prevent galvanic connection between the dc and ac system.

The charging rectifier shall normally operate in the float charge mode. It shall be possible to select the charger to 'Boost charge' mode. When selected to 'Boost charge' mode, the battery condition shall be monitored and on achieving a fully charged condition, the rectifier shall automatically regulate the charging current and change over to the 'Trickle charge mode'. In addition to Boost and Float Charge modes, the charger shall also be equipped with manual equalizing mode for initial conditioning and periodical maintenance of batteries. Irrespective of the mode of operation the load voltage will be maintained to nominal level by the automatic introduction of suitable dropping diodes.

When an ac supply failure occurs which lasts for more than five minutes, the rectifier shall automatically select the 'Boost charge' mode immediately on restoration of the ac supply.

Each mode shall be signalled on the front of the rectifier cubicle. Manual or automatic switchover from one mode to the other shall be possible. No break in voltage shall occur during such switchover.

Rectifier ratings in all modes of operation shall be adequately adjustable to deliver the optimum charging rate recommended by the battery manufacturer while also supplying the normal steady state loads. The Contractor shall submit a calculation of rectifier load.

The rectifiers shall be equipped with automatic current limiting devices to make them short-circuit proof. Current limitation shall be 100% of rated output current. Each rectifier shall be designed to carry 110% of rated output current for an indefinite time.

All fuses shall be equipped with a flag, enabling an easily visible detection of any blown fuse. Battery fuse shall be equipped with signalling contact.

The charging rectifiers shall be of approved construction and shall be equipped with all necessary fuses, protective devices, indicating instruments, switches, lamps, etc. and shall be suitable for automatic and manual control. All voltmeter instruments shall be connected via fuses to the busbars, feeders, batteries, etc.

The mains supply voltages available to the chargers will be 415 Vac, 50 Hz three phase.

Internal cooling of the charger shall be by natural ventilation. If forced ventilation is unavoidable then 100 per cent redundant fans shall be provided.

The output dc voltage control range shall be adjustable and the range of voltage shall be stated in the Tender.

The dual battery charger unit shall be housed in the LVAC room or in the telecommunication room. Final location to be decided and agreed by the Engineer.

8.11.3.3Control and instrumentation

The battery and charger system shall have a local control panel to show the status of the key parameters and mode of operation of the system. A mimic diagram shall be mounted on the front panel and shall clearly display the main circuit in relation to the various switching equipment.

Each of the two rectifier cubicles shall contain at least the following indications/meters:

- a. AC input voltmeter
- b. Ammeters for AC input current
- c. DC output voltmeter.
- d. Ammeters for charger current output & battery current.
- e. LED indications for:
 - Charger on.
 - Float mode.
 - Boost mode.
 - Under voltage.
 - Over voltage.
 - Current limit.
 - Charger fail.
- f. Circuit breakers for rectifiers shall be electrically operated with provision to be controlled:
 - Individually, from the board.
 - Remotely.

8.11.3.4 Construction

The cubicles shall be completely self-supporting, made of a required number of standardized, prefabricated, vertical sections bolted together to form indoor metal clad, dust-proof rigid unit, degree of protection IP51. The cubicles shall be free standing, equipped with bottom frames suitable for bolting to the floor. Sheet steel thickness shall not be less than 2 mm. The switchboard and charger cubicles shall be vermin and termite proof.

Hinged doors shall be provided to provide easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks and shall be flush fitting and sealed with a gasket made of rubber or other approved material to prevent the ingress of dust. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.

The cubicle shall be designed for cable entry from the bottom rear and equipped with glands suitable for all incoming and outgoing cables. Adequate working clearance shall be maintained inside the cubicles.

The main switchgear and distribution board shall be provided with a copper earth bus of the size not less than 100 mm² and in cases where two or more cubicles are installed adjacent to each other this earth bar shall be continuous.

A light suitably positioned to ensure even illumination of the entire panel shall be provided inside each cubicle as well as 1-phase, 10 A, socket-outlet of the same type as other outlets in the installation.

8.11.3.5 48V DC distribution board

The 48 Vdc distribution boards shall supply power to telecommunications equipment. The board shall be composed of standard cubicle of approved construction.

The busbars shall be made of copper painted with suitable paint while all connection points shall be tin-plated. The busbars shall be supported by insulators having high mechanical and electrical strength, sufficient creepage distance and shall be able to withstand all short-circuit conditions without damage. To ensure maximum safety to personnel, the busbars shall be completely insulated at the front.

The busbar shall be supervised by an under voltage relay to be set at 80% of rated voltage with time delay between 0-5 seconds.

Switching of the outgoing feeders shall be effected by two pole, manually operated miniature circuit breakers.

The miniature circuit breakers shall be equipped with an adjustable, temperature compensated thermal overload and an adjustable magnetic instantaneous over current release for automatic tripping. The short circuit rating shall be adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit.

Auxiliary contacts shall be provided on each circuit breaker for signalling circuits.

The Contractor shall submit a calculation of selectivity between all protective devices in a circuit for all 48 Vdc feeders to the Engineer for approval. Time delayed releases shall be used wherever necessary in order to provide proper selectivity between circuit breakers of a circuit. Resetting shall also be provided.

The above-mentioned protective devices shall withstand the specified short currents. Auxiliary contacts shall be provided on each circuit breaker for signalling circuits.

8.12 Documentation

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals.

8.12.1 Documentation with Bid

The Bid shall contain at least the following information and documents, failure of provision of the mentioned documents will lead to disqualification:

1. Type test certificates
2. Technical bulletin of the equipment to be used
3. Front views of cubicles if applicable with arrangement of offered equipment
4. List of references for the different equipment
5. List of applicable quality assurance, environmental, EMI, SWC and electrical standards
6. Quality Management System Manual and ISO Certificate of the equipment manufacturer.

7. Proposed training courses/ sessions

8.12.2 Documentation after Award of Contract

All documents required for KETRACO's approval shall be submitted by the Contractor.

8.13 IP PABX and Telephone Equipment

8.13.1 General Information

This part of the Specifications covers the design, manufacture, factory testing, transport, delivery, erection, unloading and storage at site, commissioning and handing over in satisfactory operating condition of IP-PABX equipment.

The IP telephony equipment shall be designed and arranged in full compliance with all applicable Sections, Articles and Drawings of these Specifications as below.

8.13.1.1 International Telecommunication Unit

- ITU-T Recommendations of Q-Series
- ITU-T Recommendations of V-Series
- ITU-T Recommendations of G-Series

8.13.1.2 Internet Society (ISOC)

- RFC 3261 - SIP
- RFC 3265 - SIP Extension: Specific Event Notification
- RFC 3515 - SIP Update: SIP Refer Method
- RFC 3665 - SIP Basic Call Flow Examples
- RFC 3851 - SIP Update: Symmetric Response Routing
- RFC 3853 - SIP Update: Usage of AES instead of 3DES
- RFC 4320 - SIP Update: Issues with the SIP Non-INVITE Transaction
- RFC 4916 - Connected Identity in the Session Initiation Protocol

Supplementary standards are the international standards ISO, the German standards DIN and VDE, the European standards EN (CENELEC), the British standards BS, the American standards (ANSI, IEEE and ASTM) or specific national standards in the above mentioned sequence, if there are no relevant IEC-standards existing or if there is no sufficient information available in the IEC-standards and/or if explicitly asked for in these Tender Documents.

The Bidder shall submit with his offer a list of similar IP based telephony systems already delivered by the manufacturer proposed. In addition, the Bidder shall submit with his offer valid certificates proving that the proposed manufacturers are certified by ISO 9001. Manufacturers not having sufficient experience in manufacturing and testing of similar equipment like those as specified and/or not being certified by ISO 9001 will not be accepted.

Contractors are held responsible to carry out the erection and pre-commissioning work for all IP telephony equipment under supervision of the IP telephony system manufacturer according to the manufacturer's instruction.

Each item which is obviously necessary for proper function and completion of the work, whether especially specified in the Tender Documents or not, is to be included in the Tender and Contract price.

Furthermore, the equipment shall comply with the stipulations of the following Articles.

8.13.2 Common Requirements

Within the frame of the assignment a new IP-PABX system shall be provided for installation in each new substation. The IP-PABX to be installed shall be capable to deal with an overall amount of 300 utility internal remote subscribers (substations and offices). For substation internal telephony a total amount of 25 subscribers shall be considered. The total amount of subscribers managed by the IP-PABX shall be extendable in case of need.

The design shall be based on site and service conditions as specified elsewhere.

Neutral points shall be brought out by suitable means and shall be grounded as required.

The required equipment shall have been already working successfully in telecommunication network operated by power utilities. Therefore, it shall be suitable for operation in harsh environment with electromagnetic interference and shall provide a high reliability and security.

8.13.2.1 Transmission Media

The IP telephony equipment shall use the following transmission media:

- The local area network (LAN) within the substation
- FO infrastructure for the connection to remote locations / substations
- 2 wire twisted pair cable for the connection to the public switched telephone network (PSTN)

8.13.2.2 Hardware Requirements

The IP-PABX system shall consist at least of the following basic elements:

- The IP telephony exchange server
- The IP Gateway
- The subscriber handsets (IP Telephones)
- The necessary cabling and accessories

8.13.2.3 IP telephony exchange server

The IP telephony exchange server shall be located in the telecommunication room of the control building along with other communication equipment. The final location shall be approved by KETRACO.

The exchange shall be of modular construction with provision for expansion. Printed circuit cards shall be supported by insulating guides, terminated on multi-contact connectors and properly secured to the frame. Means shall be provided to extract cards easily for maintenance and installation (hot swap). Interconnection between cards shall be made by use of multi-conductor cables terminated by compatible connectors. All hardware components shall be treated against corrosion and fungus caused by humidity or moisture. Exchange enclosure shall cover the entire equipment and protect it against dust and insects. Means shall be taken to prevent overheating and moisture in equipment. Where necessary, a small heating element and thermostat shall be provided.

It shall be possible to enable or disable any shelf, plug-in unit, including common equipment where spares are provided, without affecting other parts of the system. It shall be possible to remove or insert any peripheral circuit pack without degrading service to any other part of the system. It must not be necessary to remove any components in order to access and / or test other components or connectors. The circuit packs shall be clearly labelled and visible from the front as to the functions of the card. Furthermore, it shall be possible to read serial numbers, if used, without removing the cards. A 10 years guarantee must be given to assure availability of spare parts and assistance in case of maintenance.

Enclosure shall allow access to interior from the front or back by means of doors or removable panels.

Along with exchange, a multiterminal distributor shall be supplied where all lines (trunks + extension) will terminate. Multiconductors interconnection cables (5 meters length minimum) will be fitted at one end to the exchange by means of a plug-in connector and at the other end to the distributor terminals. The distributor shall come in a suitable junction box to protect against dust and insects. Provision shall be taken to avoid moisture and fungus. All external cables in the exchange enclosure shall enter through bottom plate.

The IP exchange shall be powered from the 48V source of the power supply.

8.13.2.4 The VoIP Gateway

The VoIP gateway shall be a standard industrial gateway which has been successfully in service in at least 5 different locations during the last 3 years. The major task is the conversion of IP packages into DSS1-protocol and vice versa.

The gateway shall be able to handle common VoIP protocols as for instance SIP, H.323, and/or MGCP and MeGaCo as well as ISDN protocol.

8.13.2.5 VoIP handsets

The VoIP handsets shall be provided for desk and wall mounting, equipped with signalling push buttons and function push buttons for automatic call back, automatic redialling, call forwarding and speed calling. There shall be provision for eleven (15) indoor handsets.

One (2) standard wall type telephone sets shall be installed in outdoor areas. The telephones shall be designed to withstand mechanical stress, a corrosive atmosphere and extreme moisture. In hazardous areas the casing shall be pressure-tight and of integrated cast iron. Alternatively, standard outdoor wall phones may be used when there is a possibility to connect them through the VoIP gateway to the call server.

8.13.2.6 Cables and Accessories

The cables shall be Cat-5 and therefore fulfil the requirements stated in EIA/TIA-568. Sockets, connectors and terminations have to fit the requested standards to avoid quality loss.

Additionally, a patch field shall be installed in the respective 19-inch cabinet where all extensions shall be cabled to. From there patch cords shall connect to the router installed in the same location.

8.13.2.7 Software Requirements

The IP telephony equipment shall fulfil the following software-based requirements:

The IP PABX equipment shall be able to be integrated into an existing network structure and to be interfaced with 3rd party equipment without any need of customisation.

Alarm monitoring shall be possible from the rack itself, the outside of the cabinet and the network management system.

The equipment shall be using common standard protocols (e.g. SIP, H.323, H.248, MGCP etc.) for the VoIP as well as for the PSTN side.

The numbering plan of the IP PABX shall be in compliance with the existing dialling plan.

Call priority: can be assigned to certain extensions or Network Tie Lines as a fixed attribute. Calls originated by these extensions or on these lines will always have priority over routine calls. Alternatively, extensions may be given a Service Class which allows them to obtain Priority on a call-by-call basis when needed. During the application of priority, priority intrusion is used to intrude upon an established call when congestion is encountered upon initiating a call to another extension. The function may be inhibited either manually or automatically.

Hot-line Extension: This type of extension shall have the facility to automatically call a pre-designated number by only lifting the handset.

Call Diversion on Busy: Calls to an extension are diverted to a predefined directory number when the extension is busy.

Call Diversion on No Answer: Calls to the extension are diverted to a predefined Directory Number (DN) when the call is not answered within a specified period of time (default duration of ten seconds).

Call Transfer: Allows an extension user on any two party call to Hold the existing call, originate a call to a third party and then transfer the call to a third party. The station user can then consult privately with the third party before completing the transfer, or can return to the original caller.

Call Forward: All incoming calls to a station user can be automatically forwarded to another pre-selected destination within or outside the PABX to which the station user is connected.

Call Waiting: Alerts the station user busy with an established call of additional calls waiting to be transferred to the station user.

Ring Again: Allows a station user, on encountering a busy connection, to be alerted when a called party or trunk route becomes free. The system will then automatically redial the desired destination.

Call Pick-up: Enables the definition/ programming of specific call pick-up groups whereby a station can pick up an incoming call for another station his call pick up group by lifting his handset and dialling a pre-designating call pick up code. In case of the dispatcher console, the lifting of handset will not be required and the code will be dialled while on-hook.

Conference: Allows a station user to establish a conference without the attendant console's assistance. Conferences may be inside or outside the local PABX to which the station user is connected.

On-hook Dialling: This feature enables a user to originate a call without lifting the handset.

Privacy: When a station user is engaged in a two party conversation, no other party can enter the conversation.

Authorisation Code: For the purpose of overriding the access restrictions, a specific two to three-digit pre-programmed code is dialled by a designated station, to enable him to gain free access to the network. Dial tone is returned to the station user after dialling the code and he is able to call the destination without restriction.

Night Service: This feature allows the routing of all incoming calls to a pre-programmed night number, outside normal working hours. It shall be possible to set and adjust the exact night service hours by programming of the system and it shall not be possible for a station user or night service number to alter/ modify these parameters.

8.13.2.8 Scope of Supply

As a general rule, the supplier is liable to include all material for full operation of IP telephony equipment including:

IP-PABX for substation internal / external telephony incl. the described amount of indoor and outdoor telephone sets.

Cabinets: all accessories for proper installation and connection with transmission equipment (i.e. SDH/PDH equipment etc.) incl. cabling and installation material.

Software and interface for PC programming and setting.

Documentation as hard and softcopy.

8.13.3 System Design

The supply shall comprise the system design leading to a firm guaranty by the supplier of the operation of the system. Essentially, without limiting the scope of work, the services shall include:

- a) Gathering of site data

- b) Site survey including remote site inspection (if necessary).
- c) System design to establish network topology, equipment location and characteristics.
- d) The system design Report shall be submitted to KETRACO's approval not later than two months after contract signature.
It shall be written in English and include Supplier's recommendations for each site and all relevant information leading to these recommendations such as maps, topology, contingency analysis, attenuation, error rate analysis, equipment losses and gains, etc.
- e) IP PABX component layout and wiring diagram showing dimension of frame, modular rack, position of each card or component, wiring between components and outgoing cable to distributor. These drawings shall include outline dimensions of
- f) Software user manual with a detailed description of each feature, and step-by-step instructions for programming of the IP PABX.
- g) Detailed description of operation and maintenance software including troubleshooting guide showing procedure to locate and detect failure.
- h) Proposal of adaptation of the existing numbering plan to the new equipment.

8.13.3.1 Modular extendibility

The system shall be extendable on the basis of "n" card positions for analogue or digital peripheral circuit cards per rack. Extendibility shall also be provided by additional cabinets with racks for further I/O cards.

8.13.3.2 Flexibility

The system and customer data shall be software parameter driven and controlled via a telephone set, the operator position or from a PC application program. User friendly programming tool shall be available to generate HW/SW configuration.

8.13.3.3 Maintenance

Cards shall be exchangeable without a major disturbance of telephone traffic. Input/output of maintenance data shall be performed via ITU-T language.

8.13.3.4 System Assurance

System maintenance standard test routines shall be available for: fault detection, localisation, isolation and reporting.

8.13.3.5 Analogue Subscriber Interfaces

Analogue line cards shall be available with DTMF / decadic dialling.

8.13.3.6 Digital Line Interface

Following digital line interfaces shall be available:

Ethernet interface for the connection of the IP handsets

Data transmission speed up shall be a minimum of 64 kbit/s synchronous and 19.2 kbit/s asynchronous

8.13.3.7 Caller Number Identification

The PABX equipment shall incorporate the capability of transferring the caller number identification throughout the network to enable the appearance of this information (on a per call basis) on the dispatcher consoles at the Load Despatch Centre. The display of this information shall facilitate the efficient working of the dispatcher as it shall alert the dispatcher about the originating and terminating station and calling or called directory number.

8.13.4 Factory Acceptance Test

Before the installation of the equipment a Factory Acceptance Test (FAT) shall be carried out during which all components of the IP telephony equipment shall be tested.

The test shall be prepared to set up a complete fibre optic link (test system at end A, transmission media, test equipment at end B), simulating a lossy conductor with attenuation in between end A and end B.

The tests shall include, but not be limited to, the testing of the different interfaces (G.703, X.21, V.24 etc. with BER test) as well as each possible set-up and signal to be transmitted. Also the functionality of indication lamps and alarms shall be tested.

8.13.5 Field Installation

The field installation shall consist of:

- a) Provide liaison equipment to coordinate the works
- b) Unpack equipment, verify content against shop bill of material and condition
- c) IP PABX and remote handset installation
- d) Interconnect equipment
- e) Connection to fibre optic cable
- f) Carry out functional test

9. Substation Control System

General

This section details the supply (hardware and software), data engineering, erection, testing and commissioning of the systems for control and monitoring of the new Substations and interfaces to other associated substations. A new Substation Control/Automation System (SCS/SAS) shall be installed at each substation. In the event of having hard wired mimic control board at existing substation, this shall be updated accordingly. The required modification of SCS in the associated SS shall also be included to carry out renaming and updating the SLD and to integrate the extension to the central SCADA/EMS system at the National Control Center (NCC) and Regional Control Center (RCC) and National System Control Center (NSCC). KPLC operates the electricity network from the NCC.

Details of the equipment to be controlled and monitored at each substation site are indicated in the individual substation sections of this technical specification.

The diameters control cubicles shall be arranged in Control Rooms. The houses shall be installed in-between the diameters with each house accommodating the control cubicles for two adjoining bays. The substation control building shall house the cubicle with the common bay control unit for auxiliary and building services, the superior substation automation system with Human Machine Interfaces, gateways to national and regional control center, GPS and the telecommunication equipment. The bay control units shall be connected via fibre optic cables to the superior automation system.

9.1 Scope of Works

The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KETRACO's personnel and warranty of the works.

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

9.1.1 Substation Works

The scope of work consists of:

- Works at new and existing substation(s) incorporating high voltage switchyards, transformer connections, protection, control, SCS and related civil works.
- The design, engineering, supply, delivery, installation and testing of SCADA and EMS database modifications at the NCC, NSCC and the RCC, for the control and monitoring of the new and existing substations.

The drawings referred to below are to aid the description of the SCS functionality and requirements. Tenderers may submit alternate configurations that provide the same functionality and other requirements such as availability and performance.

9.1.2 Modifications at the NCC/RCC

The following works are required at the NCC/RCC:

1. Update of NCC databases to incorporate new substations and modified existing substations and data received from the RCC
2. Reconfiguration of NCC/RCC applications, as necessary, to utilise the updated database data
3. Update of the Geographic Map
4. Update of NCC/RCC Operator displays to incorporate new / modified line diagrams.
5. Update of NCC/RCC Mimic board to incorporate new / modified circuits
6. End to end testing of new controls, indications, analogue and alarms from the substation to both the NCC/RCC.

9.2 Scope of Work for SCS

9.2.1 Overview

The proposed distributed control systems for the above work shall offer at least the following functionality: -

- Full operational control, reporting, alarm and indication facilities for the substation from the NCC/RCC (Supervisory level).
- Full operational control, alarm and indication facilities for the substation from Human Machine interface (HMI) workstations in the substation control room (Substation Level).
- Operational control of each circuit/bay using the bay control unit LCD display (Bay level).
- Control of each item of plant from the Local Control Cubicle (LCC) (Local Level)
- The control facilities from each control point are to be interlocked (hardwired and software) to prevent operation of any device simultaneously from more than one control point.
- At least one fully operational control point shall remain available in the event of a single equipment or communications failure.
- Complete facilities must exist for the proper lockout and maintenance tagging of circuits and plant items to ensure the safety of personnel and the security of the system
- The new control systems shall use IEC 61850 communication protocols and be readily interfaced with third part devices operating on IEC 61850 or other open protocols. The Tenderer shall describe such interfaces and provide an experience list of devices with which the offered control system has previously been interfaced.

Protocol converters are required in case of mismatch between SAS protocol and protocol required by NCC and RCC.

9.2.2 New & Existing Substation Scope of Work

For each substation the contractor shall provide the following:

- Provision of all hardware and software necessary to control and monitor the entire substation both locally and remotely from the NCC and RCC.
- Complete Substation Control System (SCS) for New Substation and Extension and Interfacing of SCS for Existing Substation.
- Incorporate new substation and Extended bays of Existing Substation into the SCADA/EMS System at the NCC/RCC .

9.3 SCS Specification

9.3.1 Introduction

The following sections describe the distributed control system requirements for new substations SCS.

This specification describes standard terms and equipment typically associated with SCS. Alternate configurations may be considered so long as the overall functionality and redundancy required by this specification is maintained or improved.

9.3.2 Overview

A computer based SCS shall be provided for monitoring and control. The SCS shall be designed to provide the following four control levels:

1. Supervisory Control (NCC/RCC)
2. Station level through a HMI
3. Bay level, using a Bay Control Unit (BCU) with LCD mimic
4. Local, directly from the Local Control Cubicle (LCC).

The entire substation shall be monitored and controlled from Substation Control Room through two independent substation computers and associated HMI(s), while individual circuit bays shall be monitored and controlled from processor based Bay Control Units (BCU) located in a separate BCU suite of panels. The SCS shall typically include:

Station Level:

- 2 independent Gateways (Main and Hot-standby) for external communications to the NCC/RCC.
- 2 independent Station computers (Main and Hot-standby)
- 2 independent Operator Workstation(s)/HMI, and the complete workplace (desk, chair). The design of the desk and chair shall be subject to employer's approval.

- 1 independent Engineering Workstation/HMI, and the complete workplace (desk, chair). The design of the desk and chair shall be subject to employer's approval.
- Event printer.
- Operator log printer
- Hard copy colour printer.
- Common bay control unit, for monitoring AC/DC system supply and all other equipment on S/S level (telemetry, telecommunication, HVAC, fire protection etc.) The fire protection signal shall be communicated to NCC/RCC.
- Satellite clock, complete with GPS Receiver, Antenna and necessary time synchronization ports.
- Interface for laptop computer for maintenance, information transfer and emergency HMI
- UPS system for SCS as specified under LV Service Equipment. (This shall as well supply the online monitoring devices for reactor bank and auto transformer and fire protection panel.)
- Communication network equipment [station (system) LAN, Field Communication Network, Various optical couplers, etc.].

Bay Level:

- Bay control units (BCU) for each individual circuit/bay with a LCD mimic and user interface for control and monitoring of the circuit/bay
- Interface for protection devices that cannot directly interface with the substation LAN
- Interface for laptop computer for maintenance, information transfer and emergency HMI

9.4 System Functions

SCS shall include the following functions:

- Control of all switching devices *
- Real time indication of status, alarms and devices
- Display of measured values, high/low limit checking.
- Indication of real and historical values
- Data Archiving
- Disturbance Monitoring and analysis
- Trend display facilities
- Protection device information

- Remote access to SCS from the NCC using TCP/IP link
- Remote communications
- Indication of automatic tap changer relay status
- Manual local and remote setting of tap changer relay
- Check sync control
- Interlocking of primary plant
- Substation Monitoring System functions (Parameter of digital protection relays – protection setting, service values, trip values, etc.)
- Time synchronisation.
- Operator action monitoring (in case of any inappropriate action taken, a mal-operation message is displayed)
- Self-check & diagnostic: These functions are essential for system operation Safety and easy maintenance.
- Manual data setting (can be performed by the operator) using the following functions:
 - Device status setting
 - Analogue data setting
 - Control inhibit setting
 - Alarm inhibit setting
 - Maintenance tag setting
 - High/Low limit setting
 - Protection relay parameter setting, etc.
- Bay Control from bay control units (BCU) using LCD mimic
- Bay indications, alarms and events from bay control units (BCU) using LCD mimic

Also, all required signals related to the control, status indications and monitoring of the switchgear, power transformers, LV AC/DC switchgears and other relevant equipment shall be provided to the SCS.

* It shall be possible to independently select individual Switch bay Control point (e.g. NCC/RCC/SCS/BCU/LCC) irrespective of overall substation control authorisation.

9.4.1 Data Scope

The data scope required for SCS will be determined at design phase in accordance with actually contracted equipment. 10% spare capacity, for each type of I/O module and system function shall be added after the finalisation of the lists of Alarms/Signals.

Typical alarms/signals are presented below but the Contractor shall include all alarms, indications and measurements of each item of plant and the SCS system. These alarms may then be grouped according to KETRACO's requirements for signals to the NCC/RCC. The final signals list shall be submitted by the Contractor for review and approval by KETRACO.

Fire protection signal and fault locator signal shall be communicated to NCC/RCC.

All bay control units shall have direct analogue inputs for secondary CT and VT measurements. Power system measurements including real and reactive power shall be an internal calculation within the bay control unit. The MW and MVar values shall be displayed on each bay and busbars on the overview screen.

Signal lists shall be worked out per substation. The lists shall include the signals of the complete substation including all other works as e.g. building facilities, auxiliary supply. The signal lists shall include as minimum the following columns:

- Signal text including designation of the equipment
- Originator of the signal including designation
- DI/DO designation or internally generated signal
- Status Text (e.g. OPEN, CLOSED)
- Alarm Hierarchy (EVENT, ALARM Priority 1 etc.)
- IEC 61850 Reference
- Transmission to NCC/RCC
- Signal address for NCC/RCC

9.4.1.1 Transformer Bays

Control functions shall comprise:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Station wide interlocking between BCUs

Measuring functions shall comprise:

- Amps
- Volts and Frequency
- MW

- MVAR
- Transformer oil and winding temperature

Position indication and alarms shall comprise at least, final list of signals to be agreed during design stage:

- CB open indication
- CB closed indication
- Tap changer position
- Maintenance earth switches close indication
- Maintenance earth switches open indication
- Diameter/Bus Disconnecter open indication *
- Diameter/Bus Disconnecter close indication *
- Circuit Disconnecter open indication *
- Circuit Disconnecter close indication *
- Local/Remote Control Selection indication
- CB Drive fail indication
- CB fault indication
- Protection operated
- Transformer Buchholz alarm
- Transformer Buchholz trip
- Transformer Oil High Temperature alarm
- Transformer Oil High temperature trip
- Transformer Winding High Temperature alarm
- Transformer Winding High Temperature trip
- Pressure relief valve operated
- Oil level low
- Cooling fans on
- Cooling System Faulty
- OLTC Buchholz alarm
- OLTC Buchholz trip
- OLTC Pressure relief valve operated
- OLTC Oil Low Level alarm
- All status and alarms from the Tap changer/AVC relay
- Trip circuit faulty

- VT fail/Out of service
- AC Aux. Supply failure
- DC supply failure
- All other relevant alarms such as biased differential protection – trip, restricted earth fault trip for HV and LV, standby earth fault, over current trip, SF₆ alarms etc.

Note: All relevant alarms for Earthing Transformers shall also be included.

* Disconnecter status signals as per the substation primary arrangement.

9.4.1.2 OHL Bays

Control functions shall comprise at least, final list of signals to be agreed during design stage:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Station wide interlocking between BCUs.

Measuring functions shall comprise:

- Amps
- Volts and Frequency
- MW
- MVar

Position indications and alarms shall comprise:

- CB open indication
- CB close indication
- Maintenance earth switches close indication
- Maintenance earth switches open indication
- Diameter/Bus Disconnecter open indication *
- Diameter/Bus Disconnecter close indication *
- Line Disconnecter open indication
- Line Disconnecter close indication
- Line earth switch close indication
- Line earth switch open indication

- Status local/remote control selection indication
- CB fault indication
- CB drive fail indication
- Protection operated
- VT fail/Out of service
- Trip circuit faulty
- Inter-trip send and receive
- AC aux. Supply failure
- DC supply failure and
- All other relevant alarms such as Line Differential Protection Trip, Distance Protection Trip, O/C Protection Trip, SF₆ alarms etc.

Note: * Disconnecter status signals as per the substation primary arrangement.

9.4.1.3 Mid Diameter (If applicable)

Control functions shall comprise at least, final list of signals to be agreed during design stage:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Station wide interlocking between BCUs.

Measuring functions shall comprise:

- Amps
- Volts
- MW
- MVAr

Position indications and alarms shall comprise:

- CB open indication
- CB close indication
- Maintenance earth switches close indication
- Maintenance earth switches open indication
- Diameter Disconnecter open indication *

- Diameter Disconnecter close indication *
- Status local/remote control selection indication
- CB fault indication
- CB drive fail indication
- Circuit Breaker Failure Protection operated
- Trip circuit faulty
- AC aux. Supply failure
- DC supply failure and
- All other relevant alarms such as SF₆ alarms etc.

Note: * Disconnecter status signals as per the substation primary arrangement.

9.4.1.4 Bus Section Bay (if applicable)

Control functions shall comprise at least, final list of signals to be agreed during design stage:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Station wide interlocking between BCUs.

Measuring functions shall comprise:

- Amps
- Volts
- MW
- MVar

Position indications and alarms shall comprise at least, final list of signals to be agreed during design stage:

- CB open indication
- CB close indication
- Maintenance earth switches close indication
- Maintenance earth switches open indication
- Bus Disconnecter open indication
- Bus Disconnecter close indication

- Status local/remote control selection indication
- CB fault indication
- CB drive fail indication
- Protection operated
- VT fail/Out of service
- Trip circuit faulty
- Inter-trip send and receive
- AC aux. Supply failure
- DC supply failure and
- All other relevant alarms such as Cable Protection, O/C Trip, SF₆ alarms etc.

9.4.1.5 Bus Coupler Bay (if applicable)

Control functions shall comprise at least, final list of signals to be agreed during design stage:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Station wide interlocking between BCUs.

Measuring functions shall comprise:

- Amps
- Volts
- MW
- MVar

Position indications and alarms shall comprise:

- CB open indication
- CB close indication
- Maintenance earth switches close indication
- Maintenance earth switches open indication
- Bus Disconnecter open indication
- Bus Disconnecter close indication
- Status local/remote control selection indication

- CB fault indication
- CB drive fail indication
- Protection operated
- VT fail/Out of service
- Trip circuit faulty
- Inter-trip send and receive
- AC aux. Supply failure
- DC supply failure and
- All other relevant alarms such as O/C Trip, SF₆ alarms etc.

9.4.1.6 Common alarms

All relevant alarms including, but not limited to, the following

- 400kV & 220kV Busbar protection
- LVAC Switchgear
- 110 V DC switchgear
- 48V DC switchgear
- Batteries, chargers (110V & 48V)
- Telecom/Telemetry
- UPS
- GPS Clock
- Fire Protection System
- HVAC system
- Substation Security

9.5 Equipment Requirements

9.5.1.1 General

The control system shall be designed for easy modification of hardware and software and for easy extension of the substation either from the substation HMI or each of the control centres. Maintenance, modification or extension of components shall not require a shutdown of the whole SCS. The control equipment shall comply with the latest revisions of the IEC publications, except where otherwise stated.

There shall be no single point of failure of the SCS at the substation level that will cause a loss of control and monitoring functionality of the substation. The bidder shall state how this is achieved.

Failure of any component of the SCS at bay control level shall not result in more than one feeder / circuit being out of control by the system. The bidder shall state how this is achieved.

The main process information shall be distributed to databases in different bay terminals. The system shall include the concept of a Distributed Data Base approach for safety reasons.

Special attention shall be paid to the issue of cyber security. The SCS shall provide security capabilities as intrusion protection and protection against virus attacks. The security capabilities shall be described in detail in the bid documentation.

“Operational Technology Cyber Security”, “Telecom & SCADA Cyber Security requirement for new substation projects”, and also “SCADA System Security management policy” for substation shall be provided based on the KETRACO regulations. Any required coordination with adjacent Substations or dispatching Centers shall be considered. (if any)

9.5.1.2 Environmental Requirements

The bidder shall ensure that all equipment is fit for purpose and housed appropriately for the substation environment. The following requirements reflect the fact that the Bay Control Units are typically based on numerical protection relay devices.

The station level equipment (station computer, gateway, LAN) shall so far as possible also meet the following requirements but may be housed in a IP50, force cooled cubicle. Failure of the cooling fan shall not result in system failure. Any deviation from the specifications shall be highlighted.

The operator's desk and HMI, typically housing a desktop computer, shall be suitably designed to reduce the effects of dust.

Bay Control Unit's shall comply with the following environmental requirements: -

- Atmospheric Environment
- Mechanical Environment
- Electrical Environment
- Electromagnetic Compatibility

which are defined within the General Protection Specification.

9.5.1.3 SCS Architecture

The architecture of the SCS shall be such that it provides the same overall division of operational responsibility as exists between the NCC and RCC. To this end, it is envisaged that each gateway shall have two communication channels. One for connection to the NCC and one for connection to the RCC as follows;

Gateway 1: Communication Port 1 – NCC Main
 Communication Port 2 – RCC Back-up

Gateway 2: Communication Port 1 – RCC Main
 Communication Port 2 – NCC Back-up

Enforcement of the division of operational responsibility at the substation and bay levels shall be through the configuration of 'permissions' within the SCS. It should be considered that architecture for 400kv substations shall consider based on PRP protocol.

Load shedding is initiated by the NCC and requires the tripping of selected feeder circuits at multiple substations. It shall be possible to send the trip commands directly to the substations from the NCC.

9.6 Substation Level Equipment

9.6.1 General

The design of all SCS hardware shall be such as to ensure satisfactory operation in an electrically hostile environment typical of high voltage electrical installations. In order to prevent incorrect functioning or damage to the equipment when subjected to interference arising from power system switching, fault currents and lightning, all SCS input and output circuits and power supply circuits shall be provided with isolation and/or immunity to electrical interference. The bidder shall state how this is achieved and the international standards to which the SCS has been tested.

There shall be no single point of failure on the Substation level equipment that will cause a loss of SCS functionality.

The Substation level equipment shall typically consist of the following:

- Substation computers
- Communication gateways
- Substation Local Area Network(s)
- Human Machine interface
- System Clock
- Printers
- Audible Alarm
- External Data storage system

Alternate configurations of hardware shall be considered so long as the functional and separation requirements are met.

9.6.2 Substation Computer

The substation computer coordinates the operation of the SCS. The functionality shall include:

- agent Logging

- SCS Management software

The substation master control shall be capable of automatic restart in the event of power failure without loss of functionality or local database. It shall be readily possible to update the substation computer software to alter or extend the SCS functionality. The bidder shall state how this is achieved.

9.6.3 Communications Gateway

The SCS shall be able to communicate with the NCC and RCC on separate communication channels using a variety of open protocols. The gateway shall be connected to the communication equipment. IEC 60870-5-104 communication protocol shall be used for data transmission to the NCC and RCC on the main and alternate routes. The selection of main or alternative route will be made by the respective control centre master station and the gateways shall respond via whichever route it receives communication from the master station. In the event of route failure, fallover to the alternate route will be managed by the respective master station.

The NCC shall be capable of remote access to the SCS over a TCP/IP link. This link shall be used for downloading of fault waveforms, sequence of events records and similar data. The bidder shall state the functionality available through such a link. Down loading of information to or from the SCS to the NCC shall not have any impact on SCS performance including alarm response times.

9.6.4 Substation Local Area Network

Local substation communications shall use an optical fibre LAN to connect the components of the SCS using IEC 61850 protocol. The LAN may be of star-coupler configuration or a fibre ring configuration. No single point of failure of the substation LAN shall result in any loss of substation control functionality. It should be considered that architecture for 400kV substations shall consider based on PRP protocol.

9.6.5 Operator Workstation

The Operator workstations / HMIs shall consist of high performance computer and monitor with computer desk. It shall be fully integrated into the SCS on the substation LAN. The proposed HMI shall be based on the latest PC technology available on the market at the time of offering. The operator desk and chair shall be of high quality construction, appropriate to continuous use by the operator.

9.6.6 Printers

Three high performance printers shall be provided, each capable of connection to the substation LAN.

- 2 off Matrix Printer Logger (or equivalent for use with fan fold paper), one for events and one for operator log.
- 1 off Colour Printer to print screen shots or other information

9.6.7 Satellite Clock

The Satellite GPS Clock shall be provided for time synchronization and event time tagging with resolution of at least 1 ms. The GPS Clock requirements are as following:

- GPS C/A code receiver
- TCXO-HQ Timebase
- Single board computer with Linux operating system/Windows, supporting the following protocols:
 - NTP/SNTP v4, Time protocol (RFC 868),
 - Daytime protocol (RFC 867),
 - SNMP v1,2,3, SNMP Traps, SSH v2,
 - IP v4, IP v6, DHCP client, HTTP(S),
 - Email, FTP, Telnet, Syslog
- Power supply: 100-240 VAC(or different DC variants)
- Metal 19" modular chassis, 1U/84HP, slimline (483 mm wide x 43 mm high x 285 mm deep)1 x RS232 front panel interface , 9pin D-Sub male connector for initial setup and configuration
- 1 x USB (Rev. 1.1) front panel interface to:
 - install firmware upgrades
 - backup and restore configuration files
 - copy security keys
 - lock/unlock front panel keys
- 3 x Bicolor LEDs: Ref. time (e.g. GPS),
- Time Synchronization Service (NTP) and Network-Link status
- 1 x Red alarm LED (configurable)
- 1 x LC Display, 40 character x 2 rows
- 2 x LAN interface, RJ45 connector, status LEDs for link, activity, speed (10/100 Mbit)
- 2 x RS232 interface, independent, 9pin D-Sub female connector, with following data formats:
 - Standard-Telegram, SAT,
 - NMEA0183 (RMC),
 - Uni Erlangen (NTP), COMPUTIME,
 - SYSPLEX-1, SPA, RACAL
- 1 x Pulse Per Second (PPS), TTL into 50 ohm, pulse duration 200 msec, active high, female BNC connector
- 1 x Standard Frequency 10 MHz, TTL into 50 ohm, female BNC connector
- 1 x Alarm relay output, change-over contact, 3pin DFK connector

9.6.8 Audible Alarm

One common sounder shall be provided to give at least two distinct audible alarms in case of alarms/faults or events. The sounder shall be configurable according to the event type and to the control status of the SCS (Local/Remote). An auto-silencing scheme shall be provided for the alarm and the sounder shall be controlled by distinctly labelled "Audible alarm ON/OFF" control switch. The complete unit shall be mounted in suitable relay/control panel.

9.6.9 Common Bay Unit

The Common Bay Unit (CBU) shall be provided for monitoring of the common services (AC/DC system supply) and all other equipment on the S/S level (telemetry, telecommunication, HVAC, fire protection etc.). The CBU shall be located in the Control/Relay Room.

9.6.10 CCTV

Integrated Closed Circuit Television (CCTV) System to be provided for the substation buildings and outdoor area, including:

- Control room
- Warehouse
- Telecom collocation room
- Generator room
- Storage yard
- Switchyard area
- Gates and corridors
- Guard house
- Boundary wall (chain-link fence) and site area

The Contractor is responsible for the integration of all necessary controls, indication and alarms as KETRACO requirements.

The contractor shall provide and install minimum ten (10) CCTV cameras along as follows:

1. Minimum Six (6) 360 degrees CCTV PTZ cameras
2. Minimum Four (4) fixed angle CCTV Entrance camera for viewing the entrance.

The location of the different cameras shall be defined during detailed design stage. The CCTV system shall be installed both at the switchyard and within the main Control building. The CCTV system shall have the possibility for remote access at KETRACO Headquarters and at the National and Regional Control Centers.

Two (2) 24" LED monitor shall be mounted in the central control room for viewing live and recording footages of the CCTV cameras.

One (1) PC with a 22" LED Display shall be mounted in the guardhouse for viewing live of both CCTV cameras.

The PTZ camera should be such that it can be controlled with a joystick from the control room.

The network video recorder and switches shall be located inside the Control room secured in a 9u cabinet and shall have a 2 extra channel license to allow expansion of cameras at the facility. Depending on the storage requirement, the minimum storage capacity it will house is 2 TB.

They shall be IP based with several ports for future integration to a central system.

The source of supply shall be from a UPS based system.

The cameras shall have the following specifications:

- **IP Dome cameras – Internal and External**

- i. Be a vandal resistant IP/Network Mini-dome camera.
- ii. Be designed to provide support for H.264 and MPEG-4 video, and support resolutions up to 1280x960 pixels using a 1.3MP CCD sensor with Wide Dynamic Range (WDR) Capabilities.
- iii. Be designed to provide two individually configured simultaneous video streams to total 30/25 frames per second in all resolutions up to 1280x960 pixels in H.264 or MPEG4 in any combination.
- iv. Have a Vari-focal electronically controlled zoom lens that can be set and adjusted via the NVMS software.
- v. Operate on an open source; Linux-based platform, and including a built-in web server.
- vi. Make use of a modular design allowing for interchangeable parts (bubble, housing, electronic assembly, etc) enabling the unit to be serviced, maintained, or upgraded to new technologies without removal of the physical housing.
- vii. Be equipped with a built-in mechanical IR cut filter to provide IR sensitivity for Day/Night functionality.
- viii. Built in PoE
- ix. Supports both IPv4 and IPv6
- x. Digital PTZ
- xi. IP66, IP67 and NEMA 4X ratings

- **Analytics PTZ camera**

Video Motion Detection (VMD) and Non-Motion Detection (NMD) which includes multiple trip-wire detection rules, multiple video detection zones, unattended object and illegally parked vehicle detection.

The NVMS Analytics camera shall support as minimum:

- i. Video Analytics for people and car counting
- ii. Video Analytics Behaviour recognition including tailgating detection, loitering, detection and grouping detection (group can be defined to be up to five people)
- iii. Video Analytics for Crowd detection package (crowd is defined by percentage of area covered)
- iv. Video Analytics Object removal detection
- v. Video Analytics PTZ Camera Control - PTZ camera control for object tracking
- i. Video Analytics VMD Detection over PTZ Camera Pre-sets

- **180 Degree cameras**

- vi. 2 x 2MP CMOS sensors
- vii. 1600 x 1200-pixel array for each sensor
- viii. 1/2" optical format
- ix. Sensitivity 0.2 Lux at F1.2

- x. Dynamic range 61Db
- xi. Maximum SNR 50 dB
- xii. Moonlight mode – Extended exposure
- xiii. Compression H264, MJPEG, 21 quality levels
- xiv. 22fps 1600 x 1200
- xv. Capable of PoE

Technical Specifications

Specification	Requirements	Proposal
Audio	Audio/Video Output	
Zoom	Optical Zoom: 35 X Digital Zoom: 10 X	
Video	Video Compression: MPEG 4/H.264 Part 10 Max Video Resolution: 704 x 480 / NTSC Light Sensitivity: 1 Lux Frames Per Second: Up to 30 Video Source: Embedded CCD/CMOS/PIXIM Image Sensor: 1/4 inch colour CCD image sensor Shutter Speed: 1/60 ~ 1/120,000 second NTSC Automatic Electronic Shutter (AES) Automatic Gain Control (AGC) Automatic White Balancing (AWB) Flip Image Mirror Image Colour Images at daytime and b/w at night Min. Illumination (day) Colour (day) 0.1 lux f1.4 Min. Illumination (night) B/W (night) 0 lux f1.4	
Software	Drivers Recording Software Installation Utilities	
Event Operations	Motion Detection FTP Snapshots Email Snapshots Schedule Snapshots Event Snapshots	
Dimensions	Length: 155.0 mm Width: 155.0 mm Height: 125.0 mm Weight: Net 4000g All measurements are +/-25% margin	
Protocols	Protocols: TCP/IP, HTTP, SMTP, FTP, Telnet, NTP, DNS, DDNS, UPnP, DHCP,	

Safety	Certifications: CE, FCC in addition to referenced standards must be intrinsically safe	
Lens	Auto Iris Lens Type: 35 x Optical Zoom Lens	
Environment	Temperature: 0 to 50° C Humidity: 90% Outdoor: Hazardous and Potentially explosive	
Pan/Tilt	Pan Tilt Pan Range: 180° at minimum, up to 360° Tilt Range: 90° at minimum Auto Panning Auto Patrol	
Power	Consumption: Maximum 12W Output:12V DC, 1.5A Input:100 ~ 240V AC, 50/60 Hz, 0.4 A	
Security	Access Restrictions Number of Simultaneous Logged-in Users:10	
System	Compatible Operating System: Windows 7, Windows Vista Compatible Browsers: MS Internet Explorer, Google Chrome, Mozilla Firefox Viewing Protocols: Active.	
Infra-red imaging	Thermal imagery to enable night viewing	
Storage	2TB	
Warranty	1 Year	

9.7 Bay Level Equipment

9.7.1 Bay Control Unit

Bay level control, status monitoring, interlocking, synch check, instrumentation and fault recording functions shall be achieved at all voltage levels through the deployment of a Bay Control Unit (BCU). The BCU deployment shall be based on the requirements of the substation primary plant arrangement and shall have at least one BCU per switch-bay. For Breaker and ½ switchgear arrangements, including variants, BCUs shall be assigned one per CB, however, alternative proposals will be considered.

A BCU shall provide a serial communications interface for any numerical protection relays that cannot be interfaced directly to the substation LAN. Information from such protection relays shall be available to the SCS.

Requirements for the BCU that are secondary functions of protection devices such as fault waveform capture may be removed from the BCU requirements so long as the data is fully accessible through the BCU / Substation LAN to the SCS. Such features must be clearly listed and detailed by the bidder.

The BCUs from a hardware and software point of view shall be independent of each other and shall enable operation of the bay even if a fault occurs at the station level equipment or local communication network.

The BCU local control shall incorporate a LCD mimic on which it shall be possible to view the BCU setup parameters, bay plant status and measurements such as current, voltage and power. If a bay protection device housed in the same cubicle as the BCU is fitted with a LCD display, measurements and alarms associated with the bay protection device may be presented on its own LCD display.

The BCU shall be equipped with a serial port for connecting a laptop computer by which it shall be possible to undertake local control at bay level even if the station level processor is not available for any reason.

Each BCU shall be supplied with standard Application software, including as a minimum the following functions:

- Apparatus control
- Interlocking
- Measurement presentation
- Events time tagging module
- Synchronizing module etc.

The main requirements for protection functions are described in Protection and Control Specification.

The control output of the BCU shall be used to control various power system devices such as circuit breaker trip/close coils. They shall use a select and check-before-execute command sequence between the BCU and the NCC/RCC Master Station. The sequence shall include, as a minimum, the following functional capabilities:

1. The Master Station shall transmit a control selection message addressing the proper SCS and control point within the BCU, and indicate the control action desired.
2. The SCS shall initialise its control logic, reassemble the control selection message received in (a) above, and transmit the reassembled message back to the Master Station.
3. The information in the message sent to the master station shall be generated by the SCS point-selection logic and indicate the point and control function selected.

The 'check back' message shall not be a simple repeat of the message received in the transmission from the Master Station but shall be a reconstruction of the message as interpreted by the SCS from the received message. The master station will verify the returned message with the message sent in (a) and, if valid, shall issue an execute control message to the SCS.

The SCS shall only operate the control point selected in the BCU after the check-before-execute sequence above has been performed without error or interruption by any other messages. The SCS shall reset its control logic upon any error in the sequence or if the execute message is not received within a user defined preset time after the initial command message is received at the SCS.

The design of the command circuit shall ensure that no single hardware failure of the module can result in an incorrect operation of any command output.

An on-board watchdog circuit shall be provided to monitor correct software operation of the control module in the BCU. Should a watchdog time-out occur, then all outputs shall be inhibited and an alarm generated.

9.8 Operator Interface

9.8.1 Overview

This section defines the facilities that shall be available at the SCS operator interface to allow the operator to monitor the status of plant items and perform control operations securely and efficiently. The operator interface shall be a computer terminal / workstation typically described as a Human Machine Interface (HMI).

The main functions of the HMI are to:

- View plant status information and to acknowledge alarms.
- Perform primary and secondary plant switching and other control operations, associated to the substation, securely and efficiently
- View sequence of event logs, alarm logs and access protection relay information

The facilities available at the HMI shall include those needed to allow it to function as a substation control point (SCP), acting as a backup control point, in the event of a failure of either the NCC or RCC.

9.8.2 Basic Requirements

The SCS HMI shall comprise of a number of linked displays that provide the following:

- Substation Overview
- Individual Busbar Groups
- Detailed views of the individual circuits
- Automatic tap change control (ATCC) relay overview
- Common Facilities
- Communication Status
- Alarm List
- Event List
- Trend displays (real-time and historical)
- Report displays
- Input Suppression Status
- Protection Relay configuration
- Power disturbance analysis
- SCS System status

The substation line diagrams shall be completely user configurable, the final representation shall be agreed in the design phase with KETRACO. Point and click links shall be provided at the top of all user screens to allow the operator to navigate to selected screens quickly (Alarms, events, Substation Overview, ATCC, etc.).

The main operator interface to the HMI for line diagram navigation, control selection and alarm acknowledgement, etc., shall be through a multi-button pointing device such as a mouse or tracker-ball. A keyboard shall be used for password entry, applying notes to plant and similar functions. The SCS functionality available to the operator shall be password controlled to at least 3 levels, system view, system control, system modification.

9.8.3 Substation Overview

The substation overview display shall provide the Operator with the electrical topology of the substation and will display the current status of plant items including maintenance tags. Depending on the size of the substation and to aid the clarity of presentation the overview may be split between two or more screens.

The AC/DC system single line diagrams indicating the actual equipment status shall be represented on the station HMI. It shall be possible to operate the incomer ACBs and bus coupler ACB of the 415VAC board from the station HMI.

The following plant items should be displayed on the Overview screen.

- Busbars
- Circuit breakers
- Diameter/Busbar Disconnectors
- Line disconnectors
- Bus section disconnectors
- Transformers
- Shunt Reactors
- Capacitor banks
- Other AVC equipment
- Control Point

Colour shall be used to identify different voltage levels. Circuit, circuit breaker and busbar names shall be displayed on the overview screen. Real time frequency and busbar voltages shall also be displayed.

Dynamic busbar colouring shall be configured for different status of the busbar i.e. live, dead and earthed.

The switchgear equipment symbols to be used on the HMI shall be subject to KETRACO's approval.

The upper and lower colour alarm limits for all bay measurements for voltages and frequency shall be implemented. These limits shall be provided by KETRACO.

Selection between the hierarchical operating levels shall be via software i.e. selection between NCC/STATION level for the SCS system.

9.8.4 Individual Busbar Groups

The individual busbar group screen shall provide a single screen view of each voltage level in the substation. The following plant items should be displayed on the individual busbar groups.

- Busbars
- Circuit breakers
- Diameter/Busbar Disconnectors
- Line disconnectors
- Bus section disconnectors
- Transformers
- Earth switches
- Shunt Reactors
- Capacitor banks
- Other AVC equipment
- Control Point

The alignment of the plant on the individual busbar group screen shall match that of the overview screen. The detailed screen shall include the following information:

- Name of substation
- Name of circuit
- Name of plant
- Plant status
- Plant Measurements
 - o Amps
 - o Volts
 - o Active and Reactive Power, including direction of flow
 - o Frequency

9.8.5 Detailed View

Detailed views of each circuit shall be available by selecting the circuit from the overview screen or Individual Busbar Groups. Control of the plant shall only be available from the detailed view. The following plant items, where present on a circuit, shall be represented on the detailed views.

- Busbars
- Circuit breakers
- Busbar disconnectors
- Line disconnectors
- Bus section disconnectors
- Transformers
- Earth Switches
- Shunt Reactors
- Capacitor banks
- Other AVC equipment

The alignment of the plant on the detailed screen shall match that of the overview screen. The detailed screen shall include the following information:

- Name of substation
- Name of circuit
- Name of plant
- Plant status
- Load shedding Group (33kV Feeders)
- Plant Measurements
 - o Amps
 - o Volts
 - o Active and Reactive Power, including direction of flow
 - o Frequency
- Transformer Measurements
 - o Actual Voltage
 - o ATCC function In/Out
- Control Point

Where a transformer has an ATCC function there shall be a link between the detailed circuit screen and the ATCC Overview screen.

9.9 ATCC Overview

The ATCC view shall detail all the plant associated with the ATCC functions, provide control selection of target voltage and display the following information:

- Actual Voltage
- Target Voltage
- Tap Position
- Amps
- ATCC Function In/Out
- Target Voltage Selection
- Control mode (Master/Follower)

A separate ATCC Overview screen shall be provided for each ATCC voltage level.

9.9.1 Amps / Power Summary

The Amps/Power summary screen shall detail all the circuit power flows, magnitude and direction, in tabular format, and provide a zero summation check.

9.9.2 Common Facilities

The Common Facilities screen shall provide substation control of all common site systems such as local/remote control, alarm klaxon and floodlights.

9.9.3 Plant Representation

The representation of the plant (static and dynamic) shall be finalised during the design stage. The bidder shall provide sample screen layouts using international symbols for the plant.

The single line diagrams shall have the following colours for each voltage level (to BS 381C:1996), final representation will be fixed during design stage:

- | | |
|-----------|-----------------------|
| ○ 400kV | To be associated |
| ○ 220kV | Light Violet (No 797) |
| ○ 132kV | Black |
| ○ 66kV | Green (No. 221) |
| ○ 33kV | Red (No. 537) |
| ○ 0.415kV | Blue (No. 166) |
| ○ Earth | Black |

For bidding purposes, dynamic plant shall be represented as follows:

- Closed Busbar: Colour according to voltage level

- Open: White
- Discrepancy: Orange flashing
- Running: White flashing

Running shall be indicated for a pre-defined time. Once time out has happened the plant shall be considered as a discrepancy.

9.9.4 Hand Dressed Plant

The HMI shall have the facility to hand dress Plant which is not monitored through the SCS. This facility shall only be available through the detailed screen and shall be reflected in the overview screen where appropriate.

9.10 Maintenance Tagging

The HMI shall have the facility of tagging selected plant items as being out for maintenance. This shall restrict the control of the plant item and provide a text box for explanation to other operators. All items of plant with a tagged message shall be highlighted as such on all screen displays.

- Red Tag Prevent closing and opening operation
- Yellow Tag Prevent closing operation only
- Green Tag Prevent opening operation only
- White Tag Will not prevent operation but tag information shall be read by the operator prior to operation

9.10.1 Alarm and Event Screen

The HMI shall present both an Event screen and an Alarm Screen. Indication of new or unacknowledged alarms shall be presented to the operator on all screens. All alarms shall appear on the event screen. Each item on the event / alarm screen shall be time tagged. Items on the alarm screen shall be displayed in one of the following three groups:

- Unacknowledged Alarms, Inverse Red Text
- Acknowledged Alarms, Red Text
- Cleared Alarms, Green Text

9.10.2 Trend displays

Trend displays shall allow the operator to view real time and historical trends. The requirements of this feature will be developed during the design phase.

9.10.3 Report displays

Report displays shall allow the operator to generate pre-defined reports. The requirements of this feature will be developed during the design phase.

9.10.4 Control from Substation

The following steps shall be required for the control of any item of plant through the SCS HMI:

- Operator enters password through HMI
- System verifies password and unlocks appropriate level of authorisation
- The Operator selects the circuit to be operated from the Overview screen
- The Operator selects the plant item to be controlled from the detailed view
- The Operator selects the required action such as Open / Close / Raise / Lower etc.
- The SCS executes the control request

Messages shall be displayed on screen during the control steps to allow the Operator to monitor the control progress and cancel the operation at any point. The control operation shall have a time out facility to return the system to a safe state should the time be exceeded.

9.11 Database Management System

Each SCS shall be provided with a database management system. The database management system shall present the information via a user interface such that any individual database is transparent to the user. The database management system shall provide a means of verifying the database in order to check consistency and completeness of the database. The SCS database shall be fully tested prior to uploading on the SCS or NCC/RCC to ensure errors are reduced to a minimum.

The database modifications shall all be documented. The contents of a database shall not be lost if the power supply fails. After a power failure, the SCS shall start and load its database automatically. The SCS shall allow the user to configure the database on site or from the NCC or RCC, respective to the associated SCS operational responsibilities. The NCC/RCC database shall be kept updated with the current configuration data for each SCS. Bidders shall state how this is achieved.

9.12 Configuration and Maintenance

The SCS shall perform continuous self-diagnostics to monitor its own operational capability. Any detected fault or abnormality which could affect the SCS performance or operational capability shall be indicated to the respective control centre, NCC or RCC, and locally at the HMI.

A laptop computer based configuration and maintenance facility shall be provided along with all database and software interfaces required for the maintenance and configuration of the SCS, e.g. SCS diagnostics, database compiler, software listings, SCS configuration listings, etc.

The laptop computer shall have diagnostics for the BCU processor(s), memory, I/O ports, and any other functional areas of the BCU. The laptop computer shall also be used to monitor and test the BCUs operation and communication interfaces and shall be capable of emulating both the SCS and the NCC/RCC.

9.13 Performance Requirements

9.13.1 Overview

The performance of the SCS shall be based on a standard circuit which consists of at least the following controllable items, indications and measurements:

Controls:

- 7 primary plant items, including 1 circuit breaker with synchronising.
- 4 secondary plant items and associated indication.

Automatic tap change control:

- 1 Transformer for every 5 circuit breakers, with each transformer having a minimum of 21 tap positions.

Analogues:

- 6 analogues

Single point status:

- at least 50 points

The standard circuit shall meet the following performance requirements where:

1. Normal Activity for a standard circuit is defined as:
 - One primary plant alarm every 30s
 - One control action every 60s
 - Different display request every 60s
 - 20% of analogues require processing every 1s
2. High Activity for a standard circuit is defined as:
 - One primary plant alarm every 2s
 - One control action every 15s
 - Different display request every 30s
 - 40% of analogues require processing every 1s

9.13.2 System Loading and Utilisation

Description	Normal Activity	High Activity
Utilisation of any processor	30%	70%
Utilisation of any memory device	30%	70%
Utilisation of any communication device of network bus	40%	80%

9.13.3 Response Times

Description	Normal Activity	High Activity
Display appearance	< 1s	< 2s
Presentation of binary changes	< 1s	< 2s
Presentation of analogue changes	< 2s	< 4s
From order to process output	< 1s	< 2s
From order to update of display	< 2s	< 3s

9.14 Inspection and Testing

9.14.1 General

9.14.1.1 Test Principles

The principle of testing shall be that, at stages throughout the work, formal tests shall be performed and recorded against written test specifications to provide a high level of confidence to both the Contractor and KETRACO that the Works meet the specified requirements such that subsequent stages of the Works may proceed.

The testing philosophy for the SCS shall ensure that the System hardware and software equipment functionality is thoroughly exercised and validated at the Contractor's premises before delivery and commissioning. The test methodology shall complement the design methodology and the two shall be developed in parallel.

This document does not constitute a Test Specification or Test Procedure for any part of the system but rather it sets out the stages at which tests are required and the subjects, locations and purpose of the testing at each stage.

The Contractor shall be responsible for specifying, conducting and recording all tests and the test documentation for all tests shall be written by the Contractor and submitted to KETRACO for approval in accord with the requirements for document submission. The degree to which KETRACO intervenes in the testing process will depend upon the level of confidence built up during the project.

Inspection of incoming goods and components, and subassembly testing, shall be undertaken by the Contractor in accordance with the procedures set out in the Contractor's own Quality Plan and are not described here.

This Specification covers the higher levels of complexity, namely:

- Type testing
- Subsystem testing
- System testing.

Type testing is required to verify that the equipment meets with the specified environmental conditions. For purpose built equipment such as BCU, station computer, terminals and connectors test certification shall be provided or tests shall be carried out to verify compliance with the required standards. However, for proprietary equipment such as printers, VDUs and keyboards, it shall suffice to provide test certification that shows the equipment is suitable for the intended environment.

'Subsystems' are defined as single items or small groups of closely related equipment (including software) such as printers, workstations, operator consoles, etc., that may be installed as an organisational entity.

The 'System' is defined as the interconnection of all Subsystems and any other equipment that will eventually comprise all of the equipment supplied under this Contract (with the exception of spares) along with the communications and network media and interface equipment supplied by others.

9.14.1.2Responsibilities

The Contractor's responsibilities shall include but not be limited to requirements to:

- Produce written test plans, schedules, procedures, method statements, test record sheets and procedures for fault reporting, for all tests.
- Submit all test documentation associated with any subsystem or system test for approval by KETRACO within the required time scales.
- Ensure that all test documentation associated with any testing has been approved by KETRACO prior to the commencement of the corresponding testing.
- Provide the equipment, test equipment, test software, personnel and facilities to conduct the testing.
- Successfully carry out internal acceptance testing using the approved test procedures and correct any errors found in either the test procedures or the subsystem/system being tested prior to the commencement of the witnessed acceptance tests.
- Provide facilities for KETRACO and/or their Representatives to witness any Factory tests.
- Produce permanent records of all test progress and results in a formal systematic manner.
- Carry out all remedial work and re-testing necessary for the equipment to pass the tests.

Each of the above responsibilities shall be discharged to the satisfaction of KETRACO, but approval by KETRACO shall not imply any diminution of the Contractor's responsibilities. It is expressly the responsibility of the Contractor to satisfy himself that items 'supplied by others' are in a satisfactory condition for the Contractor's tests to be conducted.

9.14.1.3 Test Equipment and Facilities

The Contractor shall provide all equipment and services required for testing, including, but not limited to:

- Laboratory test instruments
- Special test equipment, emulators, simulators and test software, to permit full testing of System functions and performance
- Other items of the System, specified elsewhere as being part of the Contractor's supply, even if not part of the Subsystem under test
- Consumables required to prepare for and perform the tests.

All test instruments shall be subject to routine inspection, testing and calibration by the Contractor. All test instruments shall be subject to approval by KETRACO and, if required by KETRACO, shall be calibrated at the expense of the Contractor by an approved standards laboratory.

All test software shall be subject to formal quality assurance requirements stipulated elsewhere in the Specification.

9.14.1.4 Testing Stages

Inspection of incoming goods and components, and subassembly tests, shall be performed in accordance with the Contractor's Quality Plan. The formal stages of testing to be performed fall into the following three categories:

- | | |
|-----------------------------------|---|
| a) Type Tests | Equipment shall pass these tests in order to be accepted for use under this Contract |
| b) Factory Acceptance Tests (FAT) | Systems shall pass these tests before they may be shipped to site |
| c) Site Acceptance Tests (SAT) | Systems shall pass these tests before they may be put into operation and before they are Taken Over |

The acceptance testing includes the elements of testing outlined in **Table -1** and **Table -2**.

Table -1 Factory Acceptance Tests

Testing Stage	Purpose	Results
Internal Acceptance Testing	Tests to be performed by the Contractor prior to witnessed testing as a 'dress rehearsal' for all test procedures and to ensure there are no faults pre-existing at the commencement of the witnessed tests.	The test results shall be sent to KETRACO for review to them to assess the readiness of the System for witnessed testing.
Subsystem Factory Acceptance Testing	<p>To prove the design of a Subsystem prior to the Subsystem being used in the System FAT.</p> <p>In the case of subsystems or auxiliary equipment, not required to be tested as part of an integrated System FAT (e.g. UPS); to prove the subsystem/equipment before despatch to site.</p>	<p>Subsystem tests shall be completed to the satisfaction of KETRACO before the System FAT can commence.</p> <p>Subsystem tests shall be completed to the satisfaction of KETRACO before despatch to site.</p>
System FAT	To prove that the complete System being supplied under the Contract performs in accordance with the Contract requirements.	Tests shall be completed to the satisfaction of KETRACO before despatch to site.

Table -2 Site Acceptance Tests

Testing Stage	Purpose	Comments
Installation Tests	To ensure that the installed subsystem/system is functioning as specified after installation.	Tests shall be completed to the satisfaction of KETRACO.
Point-to-point Testing	To verify correct correlation and operation between Master Station Database and plant.	Tests shall be completed to the satisfaction of KETRACO.
Subsystem Acceptance	To check the operation of a Subsystem in the field.	Tests shall be completed to the satisfaction of KETRACO.
System Acceptance	To check that the totality of the equipment and functionality supplied under the Contract performs in accordance with the Contract requirements and interacts correctly with equipment supplied by others and interfacing to the Works.	Tests shall be completed to the satisfaction of KETRACO.

Table -2 Site Acceptance Tests

Testing Stage	Purpose	Comments
System Performance	To verify the performance of the System.	Tests shall be completed to the satisfaction of KETRACO.
Tests on completion	To ensure the Subsystem or System are ready to be put into operational use	Tests shall be completed to the satisfaction of KETRACO.

9.14.1.5 Notice & Witnessing of Tests

The Contractor shall provide, as part of the Programme of Work documentation, a master plan showing the scheduled dates of testing and shall provide updates to this plan, when any changes are known, at least six weeks in advance of the tests.

The Contractor shall advise KETRACO in writing of the actual date of commencement of every test covered by Clause 9.14.1.4 (c), at least 15 working days before the commencement. Notice of Factory Acceptance Tests shall be given as defined in the general part of this specification.

KETRACO shall have the right to witness any tests whether conducted at the Contractor's premises or elsewhere. Records of every test, whether witnessed or not, shall be taken by the Contractor and copies sent to KETRACO within three weeks of completion of the tests.

9.14.1.6 Test Procedures and Result Sheets

The Contractor shall prepare test procedures and result sheets for all tests. The Contractor shall also prepare a cross reference listing that clearly shows function by function and clause by clause, where the test for each of the respective function/requirement Functional Design Specification have been included in the tests.

Separate test procedures and result sheets shall be provided for factory and site acceptance tests. All test procedures and result sheets will be subject to review and approval by KETRACO.

Test result sheets will be retained as part of the permanent QA record for the SCS.

9.14.1.7 Contractor's Prior Tests

The Contractor shall successfully complete a prior run of all tests, using the test procedures and result sheets described above before the commencement of the formal tests.

Any revisions to the test documents found necessary as a result of the prior tests shall be made before the commencement of formal tests.

Test results from the prior tests shall be made available to KETRACO on request, to indicate the readiness of the equipment for tests to commence.

9.14.1.8 Conduct of the Tests

The Contractor shall conduct the tests in accordance with the approved test procedures, and shall enter the results in the result sheets.

For each test, KETRACO will determine whether the test has passed or failed. In general, the test will be considered to have failed if either:

- The result of the test is not in accordance with the expected result described in the test procedure,
- or
- The result of the test is in accordance with the expected result described in the test procedure, but some other unexpected or unexplained event occurred which KETRACO considers to be a fault.

Full use shall be made during the tests of operator manuals and other documentation provided by the Contractor, to provide a series of tests of their accuracy.

9.14.1.9 Failures

The Contractor shall correct all faults found during testing, and shall arrange for the test to be repeated. The test shall only be repeated when the fault has been remedied and the equipment demonstrated to function correctly.

Where remedial measures involve significant modifications that might, in KETRACO's opinion, affect the validity of earlier tests then the Contractor shall repeat the earlier tests and obtain satisfactory results before repeating the test in which the fault was first identified.

KETRACO shall have the right to order the repeat or abandonment of any test in the event that results demonstrate that the equipment is significantly non-compliant with the Contract requirements.

KETRACO shall have the right to suspend any test in the event that errors or failures have become unacceptable. KETRACO shall also have the right to suspend any test in the event of a fault being detected by the Contractor but not reported to KETRACO within 24 hours. In this event, the suspension shall remain in effect until reporting has been brought up to date to the satisfaction of KETRACO.

9.14.1.10 Fault Categories

KETRACO will allocate a category to each fault, which shall determine the future conduct of test. Test categories shall be as defined in **Table -3**.

9.14.1.11 Repeat Tests

The Contractor shall correct and re-test every fault detected during the tests.

Time spent by KETRACO and/or KETRACO's representatives witnessing re-tests, or waiting at the Contractor's premises or the test site while corrections are made prior to re-test, shall be charged to the Contractor at the standard hourly rate for the personnel concerned. All other costs incurred by KETRACO and/or KETRACO's

representatives as a result of such re-tests, including accommodation, subsistence and travel charges, will be charged to the Contractor at cost.

If KETRACO and/or KETRACO's representatives is required to return to the Contractor's premises or the test site to witness such re-tests then time spent by the personnel concerned in travelling to the site of and witnessing such re-tests, and all charges incurred by them in so doing, will be charged to the Contractor.

9.14.1.12 Fault Log

The Contractor shall maintain a fault log throughout each series of tests. Every fault detected during the tests will be entered in the log, together with the actions taken to clear and re-test the fault.

The fault log will be retained as part of the permanent QA record for the SCADA/EMS System.

9.14.1.13 Hardware Failure Reports

For each hardware failure that occurs at any stage of testing, the Contractor shall investigate the failure and prepare a report on its cause(s) and design implications. The report shall clearly show:

- The most likely cause of the failure
- An analysis of any stress that may have been caused to other components of the equipment being tested as a result of the failure
- Whether the failure is a result of any component operating outside its design range
- Whether any design changes should be made to avoid further failures.

All such reports will be retained as part of the permanent QA record for the SCADA/EMS System.

9.14.1.14 Software Failure Reports

For each software failure that occurs, once the software has been approved for inclusion into the system and is subject to configuration control, the Contractor shall generate a software failure report. The report shall clearly show:

- The observed symptoms
- The likely cause
- The fault category (from Table below)
- The report shall also clearly show the following information that shall be entered when the failure has been investigated:
 - The actual cause of the failure

- The corrective action taken
- All software modules affected

All such reports will be retained as part of the permanent QA record for the SCADA/EMS system.

Table -3 Fault Categories	
Category	Definition
0	An item recorded as a fault during testing, and subsequently considered to be a normal acceptable occurrence. Testing may continue.
1	Minor fault. An event not affecting the functionality being tested in that session; testing may continue.
2	Repeatable fault not affecting the functionality being tested in the session. Testing may continue at the discretion of KETRACO.
3	Repeatable fault affecting the functionality being tested in the session. The fault must be rectified before retest of the affected test sessions or sessions. Testing may proceed on other sessions if permitted by KETRACO.
4	Major fault affecting the functionality being tested in the session. The fault must be rectified before recommencing testing.
5	Non-repeatable fault affecting functionality being tested in the session. The action taken will depend on the severity of the fault. Discussion is needed to establish the most appropriate course of action.
6	Documentation error or deficiency. The error will usually be amended during the test and the test will continue. The documentation shall be corrected before the tests are considered complete.
7	Deficiency in the ability of the test or test equipment to demonstrate the function being tested in the session. Discussion is needed to establish the most appropriate action.
8	Other fault not covered above, but requiring explanation and, in some cases, correction.

9.14.1.15 Type Tests

Full details of type tests performed on equipment identical to that being offered shall be submitted with the offer, accompanied by a proposed schedule of tests to be performed for each item of equipment. If the submitted type test results are satisfactory then the type tests specified may, at the discretion of KETRACO, be waived.

In general, type test results shall show that the equipment being proposed for this Contract will perform in accordance with its design specification in the environments to which it will be subject in its application under this Contract. The environmental factors include climatic (temperature, humidity, wind, rain, etc.), electromagnetic (radiated and conducted), mechanical (transport vibration, handling knocks, operational ruggedness, earthquake stresses) and chemical (salt laden atmosphere).

Where appropriate, the type tests shall also demonstrate that the equipment does not exceed accepted standards in terms of its impact on the environment (e.g. noise, harmonic emissions into the mains, etc.).

9.14.1.16 Factory Acceptance Tests

Subsystem FAT

A Subsystem Factory Acceptance Test shall include the inspection, hardware test and software test of any clearly identifiable Subsystem, prior to use as a component in a System test. The test shall prove that the Subsystem meets its particular physical, functional and performance specification. All corresponding inspection, and component and subassembly test documentation shall be complete and available for inspection prior to the commencement of a subsystem FAT. The tests shall be carried out at the Contractor's premises.

System FAT

The System FAT shall combine all Subsystems and shall include other equipment that shall represent, emulate or simulate those parts of the "System" to be eventually provided. The System FAT shall commence only if all associated subsystems have successfully completed their individual FATs to the satisfaction of KETRACO. The Contractor shall have completed his own internal system integration tests prior to commencement of the System FAT.

The System shall be inspected to ensure that all interfaces mate correctly and that the System is complete. The System shall then be tested as a whole to prove that it meets the Specification in all aspects of function, performance, capacity, maintainability and operability.

It is required that the results of the test shall demonstrate System reliability and availability consistent with the values specified and those guaranteed by the Contractor. The test shall be carried out at the Contractor's premises. Upon satisfactory completion of the test, the System will be ready for delivery to site.

The FAT shall not commence until all documentation associated with the FAT including Test Plan, Cross-reference Document, Test Specifications, Test Procedures and Test Record Sheets have achieved Category I approval. The System equipment will not be allowed on site until the FAT has been successfully completed and the corresponding test records have been reviewed by KETRACO.

Partial shipment may take place, by agreement with KETRACO, of equipment that has been successfully factory tested (and the corresponding test records have been reviewed by KETRACO) and is not required to form part of the System FAT.

General FAT Requirements

It is the responsibility of the Contractor to produce the Test Documentation for the FATs to the satisfaction of KETRACO. Coverage shall include, but not be limited to, the following:

- **Order of Tests** Tests shall be conducted to prove the integrated functioning of the system as a whole and shall include (but not be limited to) the following:
 - a. Hardware inspection
 - b. Hardware functionality including firmware and operating system level software tests on CPU, disks, I/O interfaces etc. (The extent of this testing will be dependent on the extent and nature of the subsystem tests)

- c. Integrated system tests to prove the functionality of all applications software in the context of the complete integrated system, equipment and software configuration
 - d. System performance tests to demonstrate that the integrated system can achieve the guaranteed levels of response and to determine the limits of the response envelope
 - e. System performance in the face of various contingencies
 - f. Soak test to give an indication of system reliability, stability and robustness.
- **Inspection** Prior to commencement of the tests, the equipment shall be inspected to ensure:
 - a. Correct standards of workmanship and quality
 - b. Correct identification labels, cabling, tagging, housing and mounting etc.
 - c. Adequate accessibility
 - d. Compliance with the Specification and reviewed drawings (including compliance with fire safety and materials requirements)
 - e. Verification of model numbers, quantities of items etc.
- **Test Conditions** The conditions of the tests shall be no less rigorous than:
 - a. All subsystem components shall have been successfully inspected and tested, as necessary, and all corresponding documentation shall be complete and available for inspection.
 - b. All necessary maintenance and adjustments shall be carried out before commencement of the test so that the tests can continue uninterrupted by routine operations.
 - c. The equipment shall be complete at the start of the tests and no interchange of modules or equipment shall be allowed.
 - d. All parts subject to wear, such as electromechanical peripherals, may be omitted from the tests if agreed by KETRACO. The printing and recording equipment needed for conducting the test shall be run throughout the test.
 - e. Each subsystem and/or each module shall be tested cyclically at least once per hour whilst all other parts are functioning normally.
 - f. No repairs or adjustments shall be carried out during the test period unless agreed by both parties.
 - g. The test shall run for at least 200 hours continuously. It need not be permanently manned throughout this period provided that a comprehensive log of operations tested and faults occurring is printed.
 - h. Where there is redundancy in the equipment the test period shall be divided equally between the redundant parts. All modules must remain powered up for the duration of the test.
 - i. Test equipment and test software shall be provided to load the equipment to a greater extent than the worst case predicted for the complete system. Online loading and all functions shall be tested under these worst case conditions. Sufficient hardware (e.g. remote terminals) and/or simulation devices shall be provided by the Contractor to ensure that the Design System Loading conditions can be achieved and System performance demonstrated to the satisfaction of KETRACO.

- j. The tests shall be carried out at the prevailing ambient conditions of temperature and humidity, no special conditioning is required.
- **Computer Equipment** The Contractor shall provide all the software necessary to carry out the tests. Tests shall include:
 - a. CPU tests
 - b. RAM write/read tests
 - c. Disc write/read tests
 - d. Data highway loading tests
 - e. Peripheral tests
 - f. Workstation equipment test.

Tests shall exercise communication ports and shall overload ports so that queuing of messages occurs. The tests shall use a simulated network, or where practical, a real network.

- **Communications** Tests shall include, where appropriate:
 - a. Data integrity in the presence of noise
 - b. Loss of Link procedures
 - c. Demonstrate that communication systems do not interfere with each other (e.g. cross-talk) or with other systems
 - d. Demonstration of network management functions
 - e. Programming, control and configuration of the network.
 - f. The tests shall use a simulated network or, where practical, a real network.

- **Soak Test**

Each subsystem soak test shall be carried out over a period of time sufficient to fully prove the correct functioning of the equipment comprising the subsystem. The initial System soak test shall have a minimum duration of 100 hours. The time shall be calculated as the number of hours continuously connected and running. All errors or problems shall be printed out. Messages shall also be output periodically indicating continuing successful operation. The equipment shall perform successfully without errors or failures that are inconsistent with the reliability and availability criteria of the System design.

- **Functional Tests**

During the functional tests, every function specified for the system in the Functional Design Specification shall be thoroughly tested. Both positive and negative tests shall be carried out.

Before commencement of the functional tests, all software for which source code is supplied under the Contract shall be reassembled and/or recompiled from source. The resulting object code shall be re-linked and used for the tests.

Similarly, all configurable databases, screen displays and reports shall be regenerated from source. All of these activities shall use compilers, assemblers, linkers and generation/startup utilities identical to any of those supplied under the Contract.

- **Performance Tests**

The performance tests shall demonstrate that the performance and response times of the equipment are in accordance with the specified requirements.

- **Unstructured Tests**

In addition to the structured tests described above, all factory acceptance tests shall include a 48-hour period of unstructured testing, during which KETRACO and/or KETRACO shall be at liberty to instruct the Contractor to carry out such additional tests as may be required to test the reliability and robustness of the system.

9.14.1.17 Site Acceptance Testing

After equipment has been erected and connected up on site, the Contractor shall carry out to the satisfaction of KETRACO such tests as may be required to prove compliance with the Specification, independent of any factory tests.

In support of the Site testing activities, the Contractor shall prepare an overall test plan that covers all testing to be carried out on Site. The test plan shall indicate test precedence and dependencies and should be co-ordinated with the Contractor's general programme of work. It shall conform to the relevant requirements for test documentation. The test plan will be subject to the approval of KETRACO and should be closely co-ordinated with KETRACO in terms of the availability of plant for testing and the timely provision of the associated permits to work.

KETRACO shall have the right to waive some tests and require additional tests to be carried out if findings on Site indicate additional or alternative tests are required to properly demonstrate that the works comply with the requirements of the Contract.

The general requirements for testing and factory testing set out in preceding clauses of this section are applicable to Site testing.

Subsystem SAT

A Subsystem SAT shall be conducted to prove that the Subsystem has not been damaged during packaging, delivery and installation on site. The test shall prove that the Subsystem is operating correctly and interfaces correctly to equipment and services on that site. On completion of the test, the Subsystem shall be ready for use in the System SAT.

The scheduling of Subsystem SATs shall be subject to coordination with the installation and testing schedules of equipment of other suppliers, to which the Subsystem is designed to interface.

System SAT

The System SAT shall be conducted on all the interconnected equipment forming the Contractor's scope of supply, together with equipment of other suppliers to which the System is designed to interface.

The System SAT shall be conducted after all the various elements of the System have been installed in the field and have all successfully completed their individual Subsystem SATs. The System SAT shall be performed with equipment in the locations in which they will eventually operate.

This test shall demonstrate that the overall design of the System meets the functional and performance requirements of the Specification in the field, using the actual communications network and including equipment supplied by others, to which the System is designed to interface.

The Contractor shall satisfy himself by testing and other necessary means that the physical communication links between terminations supplied by others meets the Contractor's requirements. Any deficiencies in such equipment shall be reported fully in writing by the Contractor to KETRACO upon their discovery, to allow prompt remedial action to be instigated. The correction of deficiencies in such equipment shall not be the responsibility of the Contractor, provided that the deficiencies have not resulted from inadequate definition and specification of requirements on the part of the Contractor.

General SAT Requirements

It must be emphasised that all testing that requires an interface to operational equipment must only be carried out after prior agreement with KETRACO and adequate advance notice shall be given to KETRACO by the Contractor of their intent to conduct testing involving operational equipment.

The end to end testing shall require coordination between the two individual Contractors. Each Contractor shall provide a detailed commissioning plan for the end to end testing for review and approval by KETRACO. This shall be followed by joint meetings by both Contractors and KETRACO to finalize the responsibilities of each EPC Contractor.

It is the responsibility of the Contractor to produce the Test Documentation for the SATs to the satisfaction of KETRACO. They shall meet the appropriate requirements for the Factory Acceptance Test specified in General FAT Requirements. In addition, the following requirements shall be met:

- **Commissioning**

It shall be the Contractor's responsibility, within the scope of definite work, to fully commission the System in such a manner as to enable trained operators to use the System.

In the event of necessitated shutdowns at key installations within the grid to facilitate the commissioning of the substation, the duration for such an activity shall be depended on the availability and reliability of the grid as advised by the National Control Center (NCC) currently managed by KPLC.

The Contractor shall submit for review/approval by KETRACO the CVs/Resumes of the commissioning personnel. The employer reserves the right to request for changes in composition of the commissioning team as deems appropriate.

The commissioning tests shall be carried out by the Contractor taking into consideration KETRACO's standard practice for substation commissioning. The Contractor shall submit for review/approval the substation pre-commissioning and commissioning test plans and methodology for KETRACO's approval. Detailed consultative meeting shall be held between Contractor, KETRACO and employer's representative shall be held to discuss and agree on the testing and commissioning methodology and protocols.

The Contractor shall budget for a commissioning duration of two months per substation.

For the final end to end testing and commissioning of the substations, the Contractor shall be bound by the requirements and constraints of Kenyan National grid as advised by the National Control Center NCC managed by KPLC

In the end to end testing between the new substation and existing substation shall be planned for every Sunday of the week depending on the grid system constraints as advised by NCC

- **Duration and Downtime**

Each Subsystem SAT and the System SAT shall be carried out over a period of time sufficient to fully prove the correct functioning of the equipment. All errors or problems shall be printed out. Messages shall also be output periodically indicating continuing successful operation. The equipment shall perform successfully without errors or failures that are inconsistent with the reliability and availability criteria of the System design.

- **Testing to Plant**

Initial setting to work and all subsequent 'live' tests will be directed by KETRACO, and carried out jointly by KETRACO and the Contractor. Tests shall be subject to KETRACO's standard safety procedures, and all operational switching will be carried out by KETRACO according to a programme that will be prepared and agreed in advance between KETRACO and the Contractor.

9.14.1.18 Specific Site Test Requirements

Installation Tests

Following despatch from the factory and arrival at site, the Contractor shall ensure that the location for the system or subsystem is fully prepared to proceed with installation. Of completion of installation the Contractor shall set the equipment working and carry out the necessary tests and diagnostic to verify that the system or subsystem is functioning according to the requirements. When completed the results of the diagnostic and verification tests shall be submitted to KETRACO. Following this and subject to the tests being approved, the Installation Tests shall be conducted by the Contractor. On successful completion of these tests the EMS/SCADA system/subsystem shall be made available for the point to point testing and verification of the database.

Point To Point Testing

Site acceptance test procedures for the new SCS equipment shall ensure that the SCS database and displays are correctly mapped onto the BCU input output connections to the plant. The process of testing this mapping may take up to 1 month to complete. Therefore, the Contractor shall establish, to the satisfaction of KETRACO, quality procedures that ensure the validity of the results of previous testing are systematically reviewed following subsequent changes in the database, displays and or the system code. These procedures should identify when previous test results may no longer be valid due to subsequent changes on the system. If test results are invalidated by subsequent actions, then re-testing will be necessary. The scope of the re-testing shall be agreed with KETRACO on a case by case basis.

Readiness to Commence Tests On Completion

When KETRACO is satisfied that the Site acceptance testing has shown that the works as a whole comply with the specification and that:

- a. All test documentation and records are complete in order and signed off by the Contractor's test engineers;
- b. The spare parts and test equipment are complete, in working order and available for use;
- c. The initial issue of technical documentation and copies of marked as built drawings have been provided;
- d. Training has been completed as required by the Contract;
- e. And the arrangements for support during the warranty period have been agreed;

The Contractor may apply to commence the Tests On Completion.

System Acceptance

The System will be accepted by KETRACO if both:

- The System and all items of equipment have successfully completed all the specified tests
- All failures, problems and reservations noted during the tests have been corrected to the satisfaction of KETRACO.

If either of these conditions has not been complied with, then the necessary corrective action shall be agreed between the Contractor and KETRACO.

9.14.2 Spare Parts

In order to assist in the ordering of spare parts, the bidder is required to recommend a spares holding to cover the first five (5) years, following the end of the Defects Liability Period, and to provide a cost breakdown. The Contractor shall not have access to spares held by KETRACO during the Defects Liability Period.

The maintenance philosophy which will be adopted will generally be for fault-finding to card level and module replacement, with the faulty modules being either scrapped, if damaged beyond repair, or returned to the

Contractor for repair, as appropriate. The Contractor shall operate a module repair and replacement scheme, details of which shall be provided with the Tender, including turnaround times.

The bidder shall base the list of recommended spare parts on the above maintenance philosophy. This list shall be submitted as an optional price and shall include a cost breakdown. Prices for the supply of spares shall include all associated charges and shall remain valid for orders placed within the term of the Defects Liability Period. KETRACO shall be at liberty to order quantities of spare parts at variance with those listed by the bidder. The prices shall remain valid for any such variation of quantities, unless stated otherwise in the Tender.

The cost of spare parts shall not be used to calculate the cost of any variations to the Contract.

The spare parts recommended shall be identical functionally, electrically and mechanically, to the corresponding parts in the equipment supplied under the Contract and shall be suitably packed and clearly marked, ready for reception at KETRACO's stores. Any special handling instructions shall be clearly marked on the packages.

The Contractor shall supply equipment lists of the recommended spare parts which include the names and addresses of the individual manufacturers of the listed items.

The recommended spares holding shall be quoted on a unit basis, as an option, for selection by KETRACO at any time up until the end of the Defects Liability Period.

The availability of spare parts to KETRACO, at a reasonable cost, shall be guaranteed by the Contractor as follows:

The Contractor shall maintain an adequate stock of spare parts for a minimum period of ten years (or until the end of the equipment's specified life) after the product has been removed from quantity production, declared obsolete or officially removed from sale

Where a component, which is not under the Contractor's control, has become unavailable, it is the responsibility of the Contractor to offer a compatible alternative at reasonable cost

Design improvements or changes made to a product during its production run shall be carefully assessed such that component interchangeability shall not be affected.

This requirement shall apply to equipment manufactured by the Contractor and also to equipment purchased from other suppliers.

9.14.3 Documentation with Tender

The Tender shall contain at least the following information and documents:

- 1) General arrangement drawings of the SCS;
- 2) Overall structure of the SCS;
- 3) Detailed description of the SCS;
- 4) Manufacturing specification of the SCS;

- 5) Catalogues, literature and reference lists of proposed equipment;
- 6) Type test certificates from an independent testing authority or independently witnessed;

Quality Management System Manual and ISO Certificate of the equipment manufacturer.

10.LV Service Equipment

10.1 General Requirements

This Specification provides for the design, manufacture, factory testing, delivery and commissioning of the complete LV (AC and DC) service equipment and includes all auxiliary equipment necessary for complete installation.

All materials and equipment shall be provided as required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

The LV service equipment shall comply with this Specification and the latest revisions of the respective IEC publications.

The 415/240 V AC, three phase, five wire (3~, N, PE) solidly earthed supply system shall comprise two 11/0.415kV earthing/ auxiliary transformers supplied from the transformer tertiary winding.

Each incoming supply connected to the LVAC switchgear defined in this specification is to provide a highly reliable and safe auxiliary power supply within the substation. The switchboard shall provide feeds to substation equipment as defined by the single line diagrams and additional spare feeds for future diameters' requirements. The LVAC arrangements are illustrated in the single line schematic diagrams in the tender drawings (Part 2-D).

The auxiliary transformers shall constitute the main auxiliary LVAC supply.

The 110V DC supply system shall comprise 2 x 100% rated duty, Nickel-Cadmium (Ni-Cd) type battery units, 2 x 100% rated battery float/boost chargers and a DC distribution switchboard configured to provide duplicated supplies as defined by the single line diagrams and additional spare feeds for future diameters' requirements. The 110V DC arrangements are illustrated in the single line schematic diagrams in the tender drawings (Part 2-D).

The 415V AC uninterruptible power supply (UPS) system shall be supplied and installed to feed:

- Substation control system equipment whose power supply is not available with 110V DC
- Fire protection panel
- Online monitoring systems

The UPS shall comprise dual independently operating units, arranged to share the load, incorporating static switches, manual bypass switch and a distribution switchboard.

10.2 Scope of Works

The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KETRACO's personnel and warranty of the works.

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

Typically, each new build substation Low Voltage Services will include:

1 415/240 LVAC Switchgear:

1 – Main distribution board to be installed in the substation control building with two sections, fully metal enclosed design, draw-out type, comprising two incoming cubicles, one bus-section cubicle, one Emergency Diesel Generator/temporary commissioning supply cubicle, and separate cubicles with the required number of outgoing feeders equipped with MCCBs, including spares, completely wired and tested, complete with all other devices and accessories including automatic changeover scheme.

X – Sub distribution boards to be installed in the substation control building as specified/required by KETRACO, fully metal enclosed design, incoming feeders equipped with MCCBs, with the required number of outgoing feeders, including spares, completely wired and tested, complete with all other devices and accessories including automatic changeover scheme, if redundant incoming feeders present.

1 – Sub distribution board to be installed in the Control Room (if any), fully metal enclosed design, redundant incoming feeders equipped with MCCBs, with the required number of outgoing feeders, including spares, completely wired and tested, complete with all other devices and accessories including automatic changeover scheme.

2 110V DC System for Substation power supplies comprising:

2 - Nickel-Cadmium (Ni-Cd) Batteries 110V DC, minimum Ah (10h) rated as stipulated in the Technical Data Sheets, to be installed in the substation control building

2 - Battery Chargers 415V AC/110V DC, minimum 250 A rated, thyristor controlled, suitable for parallel operation with each other sharing the load, complete with all the accessories, to be installed in the substation control building

1 - 110V DC Switchboard with two sections, fully metal enclosed design, draw-out type, comprising two incomers and one bus-section equipped with MCCBs of the required rating, with the required number of outgoing feeders, including spares, completely wired and tested and complete with all the devices and accessories, including automatic changeover scheme, to be installed in the substation control building

1 – Sub distribution board to be installed in the Control Room, fully metal enclosed design, redundant incoming feeders equipped with MCCBs, with the required number of outgoing feeders, including spares, completely wired and tested, complete with all other devices and accessories including automatic changeover scheme.

3 UPS 110V DC/415V AC, appropriately sized (6000 VA minimum) consisting of dual independently operation units complete with all accessories. The Contractor shall provide sizing calculations for the UPS loading. The UPS supply shall power the fire protection panel within the control building as well as the reactor bank and auto transformer online monitoring devices.

- 4 **48V DC system** consists of DC distribution board, batteries (Nickel Cadmium type) and chargers as per tender SLDs & KETRACO Standard Specification. DC system shall be designed based on future requirement and shall be sized for the final number of bays including all non-equipped spare bays.

The tender drawings provided as the conceptual design and the Contractor is responsible to provide detail design together with required calculations. The following items shall be considered:

Space provision and facility for future extensions shall be considered.

All the modifications at existing Substations (/remote end Substations) shall be considered.

Relay panels which shall house all main1, main2 & CB protection relays together with connection and all accessories. It shall be emphasized that protection relays specifications at both ends should be matched and in accordance with KETRACO Protection policy and standards. However, any required modification on remote end Relay & Control panels (including supply, installation, and modification of relays, control equipment & circuits, and etc.), in case of necessity, falls into Contractor's scope of work and responsibilities.

Bus bar protection panels including protection relays (low Impedance Bus-bar protection schemes), auxiliary relays, etc. as required together with connection and all accessories.

Configuration and quantity of protection panels shall be finalized during detail design stage subject to the approval of Client/Consultant.

Protection system shall be supplied and implemented as per tender drawings & KETRACO Standard Specifications.

Relay setting calculations to be implemented for all protection relays. Relay setting calculation for local and all remote ends shall be carried out including relay configuration changes.

Protection, control and metering, for all equipment to be provided as indicated in single line diagram.

Contractor shall check and review the interlocking scheme at remote ends and carry out modifications based on operational requirement.

Metering equipment shall be in line with per Metering and Data Exchange Code, Grid Code and KETRACO standards (Main and Check Tariff Metering) on Overhead Line Feeders. Meter pulses are to be made available to Master SCADA through SCS/RTU control system. Proposed meters shall be of class 0.2s and be equipped with Ethernet ports.

Online Condition Monitoring (OLCM) shall be considered as per Transformers and 400kV CBs Standard Specifications.

OLTC and RTCC shall be considered as per Standard Specification.

LV power, control, lighting, Earthing, instrumentation, telecommunication cables for complete project under the scope of this project including cable supporting system and accessories as per KETRACO Standard Specification.

LV Cable and Accessories within substation and related services to be implemented, including but not limited to:

- Interconnection between Earthing/Auxiliary transformer and 415VAC main distribution board including cable supporting system from EAT transformers.
- Connection between 415VAC main distribution board and Sub-Distribution Board.
- Interconnection between 415VAC busses.
- All other LV power, control, lighting, Earthing, instrumentation and telecommunication cables including cable supporting system and accessories.

Note: Tentative cable routes shall be as per equipment layout. However final lengths and sizes shall be estimated by the Contractor. Contractor shall also carry out adequacy checks for the selected cable sizes as per tender SLDs.

10.3 Equipment Requirements

10.3.1 LVAC Service Equipment

10.3.1.1 General Design Requirements

The LV AC switchgear shall be designed as an indoor switchgear installation and shall be of metal-clad design with fully insulated busbars. The free-standing switchgear shall be mounted directly above the cable trench and shall have both front and rear access for maintenance. The switchgear shall be purpose built to meet the requirements of the Specification.

The switchgear shall be supplied from either substation earthing transformers or auxiliary transformers by cables. The switchboard shall be equipped with outgoing 3-phase, four wire, 415/240 V circuits to cater for station services. The nominal rating of all outgoing feeders shall be selected according to the respective load.

The AC switchgear shall be of a single busbar arrangement. The main fully insulated busbars shall be divided into two independent sections with a bus section circuit breaker. The incoming feeder circuit breakers and the bus section circuit breaker shall be provided with automatic, high-speed changeover facilities and also, shall be interlocked such that only two of three circuit breakers can be closed at one time. Auto changeover facility shall be provided in case one out of two breakers opens/trips.

All electrical components shall be incorporated into the withdrawable portion and shall be capable of complete withdrawal without removing any termination.

The incoming circuit breaker shall be interlocked with the earthing switches of the respective 11 kV transformer circuits. Incoming circuit breakers shall also be interlocked with the EDG/Commissioning temporary supply circuit breaker to prevent parallel operation.

In the event of outage of the air-conditioning system in the LV Services room, the switchgear installation shall remain operational at full load, and at the ambient temperature of 50°C. Switchgear shall be provided with humidity controlled anti-condensation heaters with isolation facilities.

The complete switchgear shall be capable of carrying rated load current without a temperature rise of any part exceeding 65°C. Parts that may be touched by operating personnel shall not exceed a temperature of 70°C.

10.3.1.2 Switchgear

The switchgear shall consist of cubicles and shall be erected in a single row. The switchboard shall be provided with lifting lugs. The height of the switchgear shall not exceed 2250 mm and operating handles of all equipment shall be within the reach of a person standing at ground level.

The switchgear shall comply with IEC 61439-2 and other relevant IEC Standards and local standards if not otherwise stated. The switchgear shall be of draw-out design. The switchgear shall be designed to comply with the degree of protection of IP51 and shall be vermin and termite proof.

The switchboards shall be type-tested including arc fault containment (IEC 61641, criteria 1 to 7 to be fulfilled).

The fully insulated busbars shall be located in the rear upper part of the cubicle. The connections from the busbars to the equipment contacts shall be isolated from the incoming or outgoing connections.

The cross sectional area of the busbars may be graded according to the current rating, but shall remain capable of the short time current rating stated in the Schedules. All busbars and connections shall be made of copper and encapsulated.

All separately mounted metallic parts that are not normally energised shall be earthed. To this end they shall be equipped individually with terminals for the connection of the earth conductor. The switchboard shall be provided with an earth bar incorporating terminals for the connection of earth conductors, directly connected to the earthing system at both ends. All metallic parts that are to be earthed for safety reasons shall be connected to this bar in the factory and form part of the wiring system. The cross section of this earth wiring shall be adequate for the short-circuit current.

Hinged doors shall be provided at the rear for easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks, and duplicate keys to an approved change system and shall be flush fitting and sealed with a gasket of rubber or other approved material to prevent the ingress of dust. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.

Each cubicle shall be equipped with a cable compartment, isolated against other compartments of the cubicle, and glands suitable for all incoming and outgoing cables. The cubicle shall be designed for cable entry from the bottom rear. Armoured cables shall be equipped with armour clamps for connection to the earth bar.

It must be possible to work within each cubicle with the equipment withdrawn whilst the incoming contacts are energized. The minimum requirements for protection shall be:

- Insulating barriers installed between phases within the cubicle
- Automatically operated metallic shutters provided to cover busbar and feeder spouts

On the front of the switchgear cubicle of each incoming feeder a coloured mimic diagram shall be provided, with the necessary switch position indicators, symbols and signal lamps.

All equipment installed on the front panel of the cubicle shall be flush mounted.

Each incoming feeder unit, including the emergency diesel generator/commissioning supply incomer, shall be fitted with an indicating voltmeter with selector switch and one ammeter with a selector switch. Each busbar section shall be fitted with an indicating voltmeter.

Outgoing feeders of 250A or more and feeders to rectifiers shall also be fitted with an ammeter.

The indicating instruments shall be connected to earthed cases and shall comply with IEC 60051.

Cast-resin insulated, corona-free current transformers shall be provided for protection and measurement as per single line diagram. The current transformers shall be of the single or three pole, multi-ratio type for indoor installation and shall comply in all respects with the requirements of IEC IEC 61869-1. The current transformers shall be mounted at the withdrawable units or in case of incoming feeders current transformers shall be mounted in the circuit breaker compartments. The current transformers must withstand the dynamic and thermal short circuit stress resulting from system faults.

Earthing transformer LV side restrictive earth fault protection shall be provided. On the incoming circuits, overcurrent and earth fault protection as well as for overvoltage / undervoltage protection shall be provided. LV side restrictive earth fault protection shall trip both the LV incomer and main transformer circuit breakers.

Each outgoing circuit from the switchgear shall be controlled and protected by moulded case circuit breakers of a design type that provides a means to readily remove it from the installation and their short circuit rating being adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit.

Switchgear provision shall be made for an Emergency Diesel Generator connection that additionally provides a temporary diesel generator supply for construction and commissioning purposes. The connection shall be arranged to ensure that the Emergency Diesel Generator cannot be connected in parallel with incoming supplies from the earthing / auxiliary transformers. The connection point for the diesel generator shall be positioned to permit a convenient and speedy connection, preferably close to the substation entrance.

All cubicles shall be supplied complete, including protection, instrumentation, all internal wiring, terminal blocks, etc.

Suitably rated LV surge arresters shall be installed to protect the system against overvoltage impulses. The surge arresters shall be equipped with remote signalling contact, the alarm to be transmitted to the substations control system.

Proof of selectivity for the feeders with regard to the grading shall be provided and the Contractor shall submit the respective calculations for approval.

10.3.1.3 Circuit Breakers

The circuit breakers shall be of the air break type in accordance with IEC 60947, be modularly sized, of draw out design and suitably rated to handle the relevant capacities at their installation location.

Circuit breakers shall be fitted with 110V DC electric motor wound spring operated mechanisms. Means shall be provided for hand-charging the operation springs.

Circuit breakers shall have a test position, in which their main contacts are separated (with automatic metallic shutters closed), but the mechanism stays fully operational and the auxiliary contacts are still connected. The draw out operation from the service to the test position shall only be possible with the circuit breaker in its off position. In addition, it shall not be possible to put back a closed circuit breaker into its service position. The circuit breaker compartments shall be provided with an adequate number of auxiliary contacts signalling the circuit breaker position.

The main contacts shall be generously dimensioned and shall be silver-plated or equivalent, and arcing contacts shall be fitted. Direct acting overcurrent release shall be provided for protection against short-circuit currents, and shall be adjustable to a multiple of the normal current. These devices must ensure selectivity with the fuses and/or circuit breakers below. The circuit breakers shall further protect the transformers against overload.

An adequate number of auxiliary contacts shall be available for each circuit breaker. A trip alarm contact shall be provided for signalling any involuntary tripping of the circuit breaker. All contacts shall be easily convertible from close to open and vice versa. All contacts shall be wired onto the cubicles terminal blocks.

The circuit breaker shall be supplied with an appropriately rated integral protection (control) module that shall provide Long time, Short time, Instantaneous (LSI) and Ground (G) protection functions. Separate neutral protection is not required.

The circuit breaker shall be completed with the following:

- Manual charging lever for the closing spring
- Manual On green push button (to be placed behind sliding covers which serve to pre-vent unintentional actuation)
- Manual Off red push button (to be placed behind sliding covers which serve to prevent unintentional actuation)
- Handling truck

The circuit breaker shall have following flag indicators.

- On/ Off indicator
- Spring charged/ uncharged
- Position indicator for fully inserted, test, isolated position

Each circuit breaker shall be equipped with two tripping coils.

10.3.1.4 Miniature and Moulded Case Circuit Breakers

Each outgoing feeder shall be controlled and protected by a withdrawable moulded case circuit breaker.

All MCCB's shall be of instantaneous type and shall be designed and constructed to have short circuit breaking capacity as required. The rated service short-circuit breaking capacity shall fulfil the values of the prospective short-circuit current at the location. This guarantees, that the shut down time, after a breaking of short-circuit current, is as short as possible, due to the fact that the circuit breaker keeps to be serviceable.

The MCCB's shall be designed to provide positive trip-free operation on abnormal overloads and short-circuit, with quick break contacts for both manual and automatic operation. Adequate protection for the stationary and movable contacts shall be provided with effective and rapid arc interrupting devices, in particular limiting the value of the specific let-through energy I^2t and the current peak. All MCCB's shall be fitted with thermos-magnetic trip unit, opening the breaker automatically in case of abnormal overload or short-circuit. The thresholds for the thermal device (bimetal) and the magnetic device shall be adjustable. The MCCB's shall have an operating lever for manual operation. The position of the operating lever shall correspond definitely with that of the power contacts (positive operation), thereby guaranteeing safe and reliable signals, in compliance with the prescriptions of the relevant IEC standards. The operating lever shall indicate:

- MCCB closed
- MCCB open
- MCCB open due to protection trip

The circuit-breaker operating mechanism shall have free release regardless of the pressure on the lever and the speed of the operation. Protection tripping automatically opens the power contacts. To close them again, the operating mechanism shall have to be reset by pushing the operating lever from the intermediate position into the lowest open position.

The MCCB's shall have double insulation between the live power parts and the front parts of the apparatus. Each electrical accessory shall be completely segregated from the power circuit, thereby preventing any risk of contact with live parts, and, in particular, the operating mechanism shall be completely insulated in relation to the powered circuits.

It shall not be possible to open the board door when the circuit breaker is in 'CLOSED' position.

The MCCB's shall be delivered with padlocking facility to prevent the lever closing operation.

The MCCB's shall be provided with under voltage release wherever necessary according to the supplied consumer.

All Mini Circuit Breakers (MCBs) shall be of high performance, rapid interrupting, current limiting type designed and type tested. They shall be of type B characteristic for all general lighting and small power circuits, and of type C characteristic for circuits supplying pumps, air-conditioning units, street lighting etc. The category of duty shall be selected adequately, the necessity of back-up protection to be considered thoroughly.

The MCBs shall be of single or three pole type, depending on the consumer to be supplied. The MCBs shall be equipped with auxiliary trip contacts as required for signalling. The MCBs shall be equipped with real contact position indication, directly connected to the moving contact. Padlocking facilities shall be provided and included in the delivery.

Each distribution board shall provide MCBs as spare for future, completely wired in respect to connection to busbar and auxiliary contact remote signalling. In each distribution board 20 % spare MCBs of each installed type (type in regard to characteristic and rated current) shall be furnished, but minimum three spare MCBs of each type.

In addition to the overcurrent and short circuit protection afforded by MCBs every circuit supply-ing socket outlets, water heater, water cooler, cooker unit, wet area and etc. shall be equipped with a Residual Current Circuit Breaker (RCCBs) to provide protection against shock and earth leakages. The sensitivity of these units shall be 30 mA.

10.3.2 110V DC Service Equipment

10.3.2.1 General Design Requirements

The 110V DC service equipment shall be designed, supplied and installed to provide high availability, reliable and safe supply for control, protection, alarm and indication devices, tripping and closing circuits, emergency power and emergency lighting.

The 110 V battery system shall comprise 2 x 100% rated duty Nickel-Cadmium (Ni-Cd) type battery units having minimum capacity of 400Ah and 2 x 100% rated duty float/boost charger units having minimum capacity of 100A. These shall be arranged such that under normal conditions both float chargers are operating to supply the specified DC load via two busbars operated independently and at the same time each automatically float charging its associated battery to keep it fully charged within the specified voltage limit for the correct operation of equipment.

It shall be possible to switch either charger out of service leaving the remaining charger and batteries to carry the full DC load requirement and at the same time provide the full battery float charge requirements. It shall not be possible to switch off more than one charger at one time.

It shall also be possible to switch either battery out of service leaving the remaining chargers and batteries to carry the full DC load requirement and at the same time provide the full battery float charge requirements. In this case the normally independent DC supply busbars shall be coupled through a bus section switch.

The system shall be such that either battery may be connected to the chargers through changeover contactors, which shall be mounted in the DC Switchboard.

Under boost charge conditions the charger shall be capable of supplying the full boost charge requirement, taking care not to exceed the maximum permissible battery voltage. Only one battery unit (100% of total battery capacity) shall be on boost charge at any one time and means shall be provided to automatically limit the voltage applied to the loads connected to the DC bus during the boost charge period to a value no greater than the float charge value.

In case of loss of AC supply during boost charging, the charger shall return automatically to the float charge position upon restoration of AC supply and the battery automatically reconnect to the DC busbar. The charger shall continue to operate in float charge mode unless manually re-selected to boost charge.

The second 100% charger shall continue to operate normally in float charge mode with the second battery and continue to supply its own DC load requirement.

Selection of the boost charge shall be by manual means. Each charger shall be rated to be capable of boost recharging each battery from the discharge condition to 100% of fully charged capacity in a time not exceeding 8 hours. The control of the boost charge condition shall be such that the charging rate is reduced as the battery approaches full charge to avoid excessive gassing.

When selected to "Boost charge" mode, the battery condition shall be monitored and on achieving a fully charged condition, the rectifier shall automatically regulate the charging current and change over to the float charge mode. The maximum period of boost charging shall be controlled automatically by a preset timing switch which will return the charger to float mode.

The 110-volt battery system shall be centre point earthed through a limiting resistance to limit earth fault D.C. current to maximum 10 mA. A suitable D.C. centre zero milli-ammeter shall be provided for the detection and clearing of 110 volts D.C. faults. A suitable battery earth fault scheme shall be provided, which shall be capable of detecting, in the event of an earth fault, whether the positive or negative pole is earthed. Earth-fault alarm shall be initiated locally and remotely via the SCS.

10.3.2.2 110 V Battery Units

The battery units shall be Nickel-Cadmium (Ni-Cd) type with capacity minimum 400Ah. The batteries shall comply with IEC 60623 and other relevant Standards if not otherwise stated.

The battery shall be mounted on heavy-duty epoxy coated metal racks suitably protected against corrosion and attack by the battery electrolyte. The battery shall be spaced so as to permit sufficient access to all individual cells to allow replacement of cells and/or checking cell voltages and connections. Racks shall be assembled clear of walls to permit access on all four sides of the battery bank.

Battery trays shall be factory treated with an electrolyte corrosion resistance coating.

The cell container shall be made for non-flame propagating "transparent" shock resistant and leak-proof plastics.

Positive and negative terminals of each cell shall be clearly and permanently indicated. Intercell connections shall be silver plated. Each terminal connector shall be stamped with the associated battery numbers.

The float voltage of the battery shall be the optimum required. It shall not exceed the maximum voltage rating of the equipment being supplied.

The discharge capacity of the battery shall be sufficient to supply loads during a discharge time of 10 hours and maintain at least 90% rated voltage. The battery shall be capable of supplying normal standing load for the full discharge period at the minimum stated ambient temperature, emergency lighting load for a period of three hours and also be capable of sequentially closing and simultaneous tripping the most distant group of circuit breakers when the battery is at the end of its discharge period. (The 'most-distant group' is defined as that group of circuit breakers which may be tripped simultaneously by a single protection operation and which has the highest impedance in the dc supply system). Furthermore, random load at the most critical time of the duty cycle shall be verified.

The capacities of batteries selected shall be justified by calculation using the principles laid down in IEEE 1115 - Recommended Practice for Sizing Nickel-Cadmium batteries for stationary Applications. The minimum ambient temperature relevant for the calculation of the normal standing load must be 0°C. The battery capacity shall include a design margin of 1.3 to accommodate any future substation expansion and an aging factor of 1.25. The calculation shall consider the voltage drop between battery and consumer. The consumer currents shall be calculated during the complete discharge time using the final discharge voltage. For the calculation of the consumer load the final configuration of the substation shall be considered.

At the end of the rated discharge period the voltage available at the terminals of the equipment being controlled shall not be less than the minimum operating voltage of the equipment being supplied.

Protective relays that need non-standard DC voltages shall be supplied with DC/DC converters.

The battery units shall be located in a battery room and shall be connected to the distribution board and battery charger by halogen free insulated copper cables. A fuse box, located in the battery room, shall be provided for each battery. The positive and negative fuses for each battery shall be arranged in pairs and shall be fully segregated from each other by an insulating barrier. The fuses shall be of the high breaking capacity type in accordance with IEC 60269 and shall have auxiliary contacts for remote supervision.

Sufficient electrolyte shall be provided to permit the first filling of each cell and 5% spare electrolyte in solid form shall be provided for topping up during commissioning and another 5% spare electrolyte in solid form shall be delivered to KETRACO Stores.

After first filling of the battery cells the contractor shall carry out the initial charging. Everything needed for this shall be in the responsibility of the contractor. Furthermore, it is in the contractor's responsibility that the batteries remain charged.

The following information shall be indelibly marked on outside of each cell of the batteries:

- Manufacturers name and trade mark
- Country and year of manufacture
- Ah capacity
- Upper and lower electrolyte level

One set of tools comprising two syringe hydrometers, one voltmeter, ten cell-bridging connectors, one electrolyte-pouring funnels, two electrolyte thermometers, battery instruction card for wall mounting, electrolyte airtight containers, labels, other items necessary for the erection and correct functioning and maintenance of the battery shall be provided with the battery.

10.3.2.3 Battery Charging Equipment

The battery chargers shall be thyristor- controlled devices and shall operate fully automatically have minimum capacity of 100A for 110V DC system.

The battery charger output voltage shall be maintained constant and just sufficiently above the open circuit voltage of the battery to keep the battery in a fully charged condition, independent of load variations or variation of the AC input voltage.

Drop of the battery charger output voltage on float charge position shall be such that the failure of a single cell shall not lead to cascading of the bank on excessive charging.

The DC output of each charger unit shall remain within ± 2 per cent under any of the following conditions:

- System frequency ± 5 per cent;

- Rated voltage input ± 10 per cent;
- Output between 5 - 100 per cent of rated output.

The chargers shall be equipped with an automatic current limiting device to make them short-circuit proof. Current limitation shall be at 110% of rated output current. Each charger shall be designed to carry 110% of rated output current for an indefinite time.

The charger shall be equipped with fuses, protective devices, indication instruments, switches, lamps and other necessary equipment.

Rectifier stacks shall comply with the requirements of IEC 60119 and IEC 60146 as appropriate.

Rectifier transformers shall be of the air-cooled type, rated in accordance with the requirements of the Schedules and comply with BS EN 61558 as appropriate. They shall be capable of withstanding the "let through" energy of the fuse controlling the AC supply to the transformer.

The rectifiers shall be fed from the LVAC switchgear.

Rectifier transformer shall be double wound to prevent galvanic connection between the DC and LVAC systems.

10.3.2.4 Switchboard and Charger Cubicles

The DC switchboard and charger cubicles shall be designed for indoor mounting and shall be of fully metal enclosed design. The free-standing switchboard and charger cubicles shall be mounted directly above the cable trench and shall have both front and rear access for maintenance. Battery charger cubicles shall be of single tier construction and a separate DC distribution panel shall be incorporated.

The switchboard shall consist of cubicle(s) and shall be erected in a single row. Each charger shall be arranged in a metallic cubicle that shall match the switchboard cubicles in height and other dimensions. The height of the cubicles shall not exceed 2250 mm and operating handles of all equipment shall be within the reach of a person standing at ground level.

The switchboard shall comply with IEC 61439-2 and other relevant IEC Standards if not otherwise stated. The switchboard shall be of draw out design.

The switchboard and charger cubicles shall be designed with a degree of protection IP51 and shall be vermin and termite proof.

Hinged doors shall be provided to provide easy access to equipment contained within the cubicle. The hinged doors shall be of the lift-off type, secured with integral handles provided with locks and shall be flush fitting and sealed with a gasket made of rubber or other approved material to prevent the ingress of dust. Cubicles and doors shall be structurally stiff and braced to withstand twisting without distortion.

The cubicle shall be designed for cable entry from the bottom rear and equipped with glands suitable for all incoming and outgoing cables. Adequate working clearance shall be maintained inside the cubicles.

The main DC switchboard shall be designed with a single busbar system containing two sections with a moulded case circuit breaker (MCCB), similar to the MCCBs used on the LVDC incomer circuits, in between and each section shall be supervised by undervoltage, overvoltage and earth fault relays. The main busbar shall be installed in the rear upper part of the distribution panel and shall be fed by battery/charger units.

The incoming circuits to the main busbars shall be controlled and protected by two-pole type MCCBs suitable for use on battery backed 110V DC circuits.

Outgoing circuits shall be controlled and protected by DC miniature circuit breakers, their short circuit rating being adequate to protect each circuit against the effects of a fault at the outgoing terminal of the unit. Sufficient number of two pole MCBs for outgoing circuits including spare unused feeders shall be provided.

Coloured mimic diagrams shall be provided on the front of the DC equipment cubicles with the necessary switch position indicators, device symbols and alarm lamps. The colour and format of the mimic shall be approved by KETRACO

For individual cubicles the necessary instruments, control switches and switch operating devices shall be installed on the front panel.

Ammeters shall be provided to indicate battery output current. Voltmeters shall be provided for measuring battery and charger volts. Voltmeter shall be connected via miniature circuit breakers to the busbar. The indicating instruments shall be provided with connections from the back side and in accordance with IEC 60051.

The following local alarms shall be provided by means of indicator lamps, together with facility for remote indication and audible alarm:

- AC Supply Fail;
- Battery - High Voltage;
- Battery - Low Voltage;
- Charger Fail Indication;
- Battery Earth Fault;
- DC Supply Fail.
- Float Charger On;
- Boost Charger On;
- Output DC MCB Trip (Common)

Means shall be provided to provide separate initiations to remote systems for each alarm generated in the 110 V DC power supply system.

In the event of outage of the air-conditioning system in the LVAC/DC room the switchgear installation shall remain operational at full load and at the ambient temperature of 50°C. Switchgear cubicles shall be provided with humidity controlled anti-condensation heaters with isolation facilities.

Cubicle wiring and terminals shall be in accordance with the General Technical Requirements.

10.3.2.5 Miniature and Moulded Case Circuit Breakers

All MCCB's shall be of instantaneous type and shall be designed and constructed to have short circuit breaking capacity as required. The rated service short-circuit breaking capacity shall fulfil the values of the prospective short-circuit current at the location. This guarantees, that the shut down time, after a breaking of short-circuit current, is as short as possible, due to the fact that the circuit breaker keeps to be serviceable.

The MCCB's shall be designed to provide positive trip-free operation on abnormal overloads and short-circuit, with quick break contacts for both manual and automatic operation. Adequate protection for the stationary and movable contacts shall be provided with effective and rapid arc interrupting devices, in particular limiting the value of the specific let-through energy I^2t and the current peak. All MCCB's shall be fitted with thermo magnetic trip unit, opening the breaker automatically in case of abnormal overload or short-circuit. The thresholds for the thermal device (bimetal) and the magnetic device shall be adjustable. The MCCB's shall have an operating lever for manual operation. The position of the operating lever shall correspond definitely with that of the power contacts (positive operation), thereby guaranteeing safe and reliable signals, in compliance with the prescriptions of the relevant IEC standards. The operating lever shall indicate:

- MCCB closed
- MCCB open
- MCCB open due to protection trip

The circuit-breaker operating mechanism shall have free release regardless of the pressure on the lever and the speed of the operation. Protection tripping automatically opens the power contacts. To close them again, the operating mechanism shall have to be reset by pushing the operating lever from the intermediate position into the lowest open position.

The MCCB's shall have double insulation between the live power parts and the front parts of the apparatus. Each electrical accessory shall be completely segregated from the power circuit, thereby preventing any risk of contact with live parts, and, in particular, the operating mechanism shall be completely insulated in relation to the powered circuits.

It shall not be possible to open the board door when the circuit breaker is in 'CLOSED' position.

The MCCB's shall be delivered with padlocking facility to prevent the lever closing operation.

All Mini Circuit Breakers (MCBs) shall be of high performance, rapid interrupting, current limiting type designed and type tested. The category of duty shall be selected adequately, the necessity of back-up protection to be considered thoroughly.

The MCBs shall be of two pole type. The MCBs shall be equipped with auxiliary trip contacts as required for signalling. The MCBs shall be equipped with real contact position indication, directly connected to the moving contact. Padlocking facilities shall be provided and included in the delivery.

Each switchboard shall provide MCBs as spare for future, completely wired in respect to connection to busbar and auxiliary contact remote signalling. In each switchboard 20 % spare MCBs of each installed type (type in regard to characteristic and rated current) shall be furnished, but minimum three spare MCBs of each type.

10.3.3 415 V AC Uninterruptible Power Supply

10.3.3.1 General Design Requirements

The uninterruptible power supply (UPS) system shall supply continuously regulated AC power as required for substation operation. The UPS shall also power the online monitoring system for the reactor bank and autotransformer and fire protection panel. The UPS system shall consist of dual independently operating units working as sharing the load method with all necessary control, static switches, manual bypass switch, etc. necessary for the reliable operation of UPS system under all operating conditions of the substation.

The UPS system shall comprise but not be limited to the following major items:

- two thyristor controlled 110V DC/415 V AC inverters;
- two static interrupters and transfer switches;
- one 415/415V three phase isolating by-pass transformer;
- two manual by-pass switches;
- one UPS distribution board with control devices.

The output power shall be designed to meet the uninterruptible consumer demands and shall be in no case less than 6000 VA for a 10hr autonomy period (to be confirmed by calculation).

The UPS shall be suitable for continuous operation, and function satisfactorily with a combination of variations of the incoming supply voltage of $\pm 10\%$ of nominal and frequency of $\pm 5\%$ of nominal.

The UPS system shall be fed from 110 V DC switchboard by two suitable rated MCCB connected to the separate bus sections.

Multiplication relays with three contacts for each alarm of the UPS system to be provided.

The enclosure of UPS shall be of similar construction and height, as the cubicles of LV AC and DC systems. The UPS cubicle shall be located in the LVAC & DC room, as well. The cubicle shall be suitable for installation on false floor or above floor openings.

The system shall be isolated from the earth.

10.3.3.2 Inverters

Two inverters with static switches shall be supplied and installed to provide the 415 V three phase, 4 wire, 50 Hz, power supply. The output of the invertors shall be continuously synchronized to the input of the static switch.

The inverters shall furnish a constant output voltage to a varying AC load with a varying DC input voltage.

The inverters shall have load switches for the input circuits, as well as contactors, locally/manually and automatically operated, for the output circuits, located upstream the static switches.

The inverters shall have overload and short circuit protection. All internal circuits of the inverters shall be protected by HRC fuses or current limiting circuit breakers.

The electronic control modules printed circuit boards shall be equipped only with solid state equipment. Their regulation shall meet output voltage requirements under all load conditions. It shall be specified whether the transformers used are off the shelf equipment and easily replaceable. The UPS output shall be Y-connected. Control sensors shall be included for detecting and signalling inverter failures (including internal faults). The specifications outlined below are applicable for the conditions of 0-100% load changes, 0.5 lag to 1.0 power factors, and 0-50 °C temperature range.

Inverter voltage input	110V DC $\pm 10\%$
Inverter voltage output	415V, 50 Hz, 4 wire (solidly earthed at the neutral end)
Voltage adjustment	$\pm 5\%$
Frequency adjustment	± 2 Hz
Overload rating	150% of rated output for 1 minute 125% of rated output for 15 minutes

The inverter shall have natural ventilation.

10.3.3.3 Static Transfer Switches

A static transfer switch shall be provided to bypass the critical load from the inverters directly to the main power source (415/415V 3 phase bypass transformer), and vice versa, without interrupting or degrading computer operations. This operation shall occur in the event that the inverted system fails or an overload beyond the capabilities of the inverters develops either by load faults or inrush currents. The static transfer switch shall consist of static interrupters located on the output of each inverter and a static switch on the bypass transformer.

The static switch shall be capable to feed the output loads and shall be rated 30% above the nominal inverter rating.

Internal failures in an inverter unit shall cause the static interrupter to trip with minimum damage to the inverter and isolate only the inverter which failed. Failure of two inverters or overload conditions discussed above shall remove the inverters and bypass to the main supply. Necessary voltage, frequency and automatic synchronizing devices for synchronization of the inverter outputs with the main supply shall be provided.

10.3.3.4 Manual By-pass Switches

This switch shall allow the load to be supplied from the AC distribution board, during periods when the UPS is being installed or repaired. The switch transfer shall be "make-before-break" to assure loads power continuity.

10.3.3.5 Isolating By-pass Transformer

This transformer shall be 415/415V, three phase, 50 Hz and shall be oversized in order to accommodate overloading and to meet the performance required in the transient and short-circuit states, it shall be of the dry type with electrostatic screen.

Its regulation shall meet output voltage requirements under all load conditions (0% to 100% load at 0.8 power factor).

10.3.3.6 UPS Output Protection (Including Outgoing Lines)

The Contractor shall install the protection devices he deems necessary to protect the UPS from overloads and short-circuits at its output. The devices must not activate as a result of transient caused by connecting in a load drawing a heavy current.

10.3.4 Diesel Generator

10.3.4.1 General

A fully rated emergency diesel generating set complete with all accessories shall be provided. The emergency diesel generating set shall be of well-proven design configured to enable the safe shutdown of the plant and maintain essential supplies in the event of loss of DNO supplies.

10.3.4.2 Foundations and supports

The foundations together with any steelwork, foundation bolts, tubes or other equipment necessary shall be supplied in accordance with the relevant requirements specified elsewhere in this document.

The diesel generating sets shall be mounted on fabricated steel channel sub-frames of the skid type through anti-vibration mountings of an approved type.

All supports for intake air filtration equipment and exhaust silencers, daily service oil tanks and any other equipment shall be supplied. Silencer and exhaust pipe supports shall be of the anti-vibration type. Equipment such as the control panels and any other item likely to be affected shall be protected from vibrations transmitted through the floor.

10.3.4.3 Fuel and fuel systems

The engines shall be suitable for operating on the specified distillate fuel. A complete distillate fuel oil system including valves, piping, daily storage tanks and fuel meters shall be provided for the emergency generating plant. The daily service tank for the diesel generator shall be free standing. The tank, which shall be large enough to supply the generator with fuel for a continuous running period of 10 hours, shall be complete with all mountings including a contents gauge. High and low level alarm switches shall be provided together with all fuel piping between the daily service tank and engine. Sight glasses, filters and fire shut off valves for the unit shall be included. Direct motor driven self-priming gear type booster pumps shall be provided (if required) to guarantee the maximum required fuel flow under all circumstances. The capacity to be determined by the engine manufacturer. Replenishment of the daily service tank shall normally be from the distillate fuel oil purge pumps with alternative connection facilities provided for road tanker. A fill point cabinet shall be provided. The cabinet shall be of mild steel construction with a lockable door and shall include a contents gauge, a flanged valve, cap

and chain. Fuel shall be provided as part of the contract as soon as the set is installed to enable the diesel generator to provide power during commissioning. Drawings showing the extent of oil fuel pipework included in the Contract shall be submitted with the Bid.

10.3.4.4 Engine

The engine shall comply with ISO 3046 and shall be medium speed, of the multi-cylinder, in line or vee arrangement, water cooled, cold starting type, fitted with renewable cylinder liners. Forced lubrication oil systems shall be incorporated and shall include filters with replaceable elements. Suitable oil pressure switches shall be provided to give warning of low oil pressure and to trip the associated unit if the pressure falls to a dangerously low level. Lubricating oil coolers complete with all necessary pipework suitable for operating from the engine cooling water system shall be provided as necessary. An integral fuel system shall be provided for the diesel engine consisting of injectors, metering pumps and duplex filtration equipment which shall be of the replaceable element type, complete with changeover device and pressure difference indicator. A flywheel shall be provided between the engine and the generator. A proximity sensor shall be mounted close to the circumference of the flywheel starter ring and used to measure the speed of rotation of the engine. The Contractor shall state in the Schedules whether turbo-charged or naturally aspirated engines are to be supplied. The Contractor shall include for the provision of a steel drip tray on the diesel generator room floor in front of each unit.

10.3.4.5 Engine governing

Details of the governing equipment shall be stated in the Schedules. The governing equipment supplied shall comply with ISO 3046. It is anticipated that the load will be stepped onto the diesel generator. A delay of a few seconds will be allowed between application of loads. On return of the mains supply it is anticipated that the load will be removed from the diesel generator at a similar rate. All electric motors will be direct on line started

10.3.4.6 Cooling equipment

The diesel generator unit supplied shall have an air cooled radiator and engine driven fans arranged to discharge cooling air from within the diesel generator room to the outside of the building. The diesel generator unit shall be complete with a suitable canvas or sheet metal duct to connect the radiator outlet to the cooling air discharge louver which shall be supplied and fixed to the wall of the building. The Contractor shall provide anti draught flap louvers at each discharge connection to prevent the ingress of wind. The diesel generator room air intake louver shall open automatically on diesel generator start-up and shall close on shut down. Engine driven fans shall provide the necessary air flow. Water shall be circulated through the radiators and engine jackets by engine driven pumps. The water circulating systems shall have a thermostatic control to ensure the water attains operating temperature as quickly as possible. Thermostatically controlled electrical heaters shall be installed in the engine jackets to maintain the water temperature at a minimum of 10°C under standby conditions. High water temperature alarm, and low water level detection equipment complete with relays shall be fitted to the generator unit, and the engine shall be arranged to automatically shut down should the water temperature reach a dangerous level or cooling water level be unsatisfactory. Suitable drain points for the attachment of a hose connection shall be provided on diesel generator unit cooling system.

10.3.4.7 Starting equipment

The diesel generator shall be provided with an emergency starting air receiver sized to provide ample storage to allow at least 12 consecutive starts without re-pressurizing between starts. The air receivers shall be constructed in accordance with the ASME code for unfired pressure vessels, or equivalent. Three (3) compressors arranged

in parallel shall be provided for the diesel generator units. These compressors shall be low capacity, high discharge pressure, reciprocating multi-stage machines. Two compressors shall be motor driven and the third (back up) compressor shall be driven by a battery start diesel engine with provision for manual cranking. The maximum air pressure for the starting air system shall be 30 bars. Each compressor shall be capable of charging one receiver in one hour or less. The two motor driven compressors shall be controlled by an automatic start/ stop controller which starts the compressor on a preset low receiver pressure and stops the compressor when the air pressure reaches the desired maximum level. Alarm indication of low pressure shall be provided in the Central Control Room.

10.3.4.8 Intake air system

The diesel generator shall be provided with the following air filtration equipment. A 100 per cent capacity self-cleaning inertial type separator a. A 100 per cent capacity self-cleaning automatically rotated, viscous impingement filter. The above equipment shall be mounted as high as possible above the ground with provision to ensure the equipment can be serviced easily. The turbo-charger provided with the unit will ensure scavenging air as well as fresh air for combustion. The turbo-chargers shall be preferably driven by engine accessory gear. Sound attenuators, which properly reduce the turbo-charger noise within the specified limits, shall be provided.

10.3.4.9 Exhaust system

The exhaust manifold from the engine shall be taken outside the building and connected to the stack. The diesel engines shall be provided with exhaust silencers mounted outside the building capable of meeting the specified noise levels. Exhaust piping as well as the silencer shall be stainless steel. Exhaust manifolds, stack and silencer shall be insulated with mineral wool and provided with aluminium cladding. The Contractor shall be responsible for the design, furnishing the materials and installation of all supporting steel, rigid duct supports, sliding supports, expansion joints and insulation needed in conjunction with the exhaust system.

10.3.4.10 Oil/water drain pump

A drain pump shall be provided complete with all accessories, piping, valves, controls etc to drain oily water from the sump pit below the diesel generator.

10.3.4.11 Barring device

A barring device shall be provided to rotate the engine shaft for engine adjustment and repair purposes. The engine manufacturer shall determine whether the device is power or manually operated. An interlock shall be provided to prevent the starting of the diesel while the barring device is engaged.

10.3.4.12 Operation of the generating plant

The set shall be complete with auxiliary equipment required to operate the set locally as well as from the SCS via its associated control console in the Substation Control Room. The emergency generator set shall be connected to the LVAC switchboard as shown on single line diagram in Part 2-D. During emergency conditions the generator breaker may be manually or automatically closed either locally or remotely. Controls shall be provided to synchronize (manually or automatically) and load each generator. The generators shall be capable of being started, synchronized to the system without dependence upon the substation ac auxiliary supplies and accepting load within 10 seconds after receiving start signal. With initiation of stop signal the unit shall shut down in an orderly manner. Operation of the generator protective devices shall trip a lockout relay which in turn shall open the generator circuit breaker and cause a set shut down. Failure of starting sequence shall automatically shut down

and make insensitive any further start signals until the fault has been corrected. Active and reactive load sharing with other machines and load control, speed, voltage and VAR control shall be provided.

10.3.4.13 Generator

The diesel generating set shall be complete with a direct driven generator together with automatic voltage control equipment (AVR). The AVR shall be of well-established design selected in conjunction with the other features of the diesel generating sets offered, to ensure trouble free operation. The AVR shall use three phase voltage sensing to minimize the effect of the waveform distortion caused by load. The generator shall be air cooled type and meet the requirements of IEC 60034-1 and IEC 60034-22. Insulation shall be to Class 155(F) or Class 180(H) with winding temperature rises to Class 130(B) or Class 155(F) levels respectively. A solid coupling shall connect the generator rotor to the flywheel.

10.3.4.14 Generating set protection

The generating set shall be provided with equipment which shall protect the generator set from damage due to fault conditions. All relays or similar equipment for over speed, oil pressure, cooling water level and high cooling water temperature, directly associated with the prime mover shall be mounted on the generating set engine and associated with a suitable trip relay. Protection equipment shall be provided and arranged to trip the associated circuit breaker, suppress the excitation and shut down the diesel engine and control system if faults should occur. The minimum requirement for the protection of the diesel generator shall be:

- a. Differential
- b. Overcurrent
- c. Restricted earth fault
- d. Reverse power
- e. Overvoltage
- f. Diode failure.

10.3.4.15 Generator control panel

The control panel shall be of the automatic standby type a fabricated steel cubicle, set mounted or freestanding, to form a pre-wired package. Generator control shall be PLC operated to SCS. Visual indication of alarm conditions and system status shall be provided on the control panel through the use of LEDs. Each of the conditions shall be linked to the Substation Control Room. The control panel shall incorporate repeat starting protection. Three repeat starting attempts shall be made. The engine shall be automatically cranked for a 10 second period with a 10 second rest period between each attempt. All adjustable timers shall be factory set to a nominal value, along with all adjustable sensing systems. The adjustable sensing systems shall be factory set to a nominal value. The control panel shall include a selector switch, the positions shall be:

- Test off load - Exercise mains failure detection
- Normal/automatic - Alert status monitoring auxiliary system
- Off position - Set will not start/set will stop

When on normal/automatic the system shall sense a transient, a permanent fall, or a complete failure of the supply voltage on one or more phases. Depending on the pre-programmed time delay settings, a start command signal shall initiate the automatic starting sequence. Once the generator frequency and voltage have attained the correct level, the standby contactor shall close. If the auxiliary system supply returns during the start sequence, the system shall abort starting and return to normal. In the event of a further start of the auxiliary system supply during the shut-down sequence, the plant shall automatically resume supply of the load. On complete shut-down the system shall automatically reset itself in readiness for further failures. The diesel generator auxiliary system shall be self-supporting to allow diesel generator start in the absence of external power.

10.4 Inspection and Tests

10.4.1 General

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

All tests on material and equipment shall be made in accordance with IEC Standards if not otherwise specified.

The following lists of tests do not restrict KETRACO's right to call for further tests if he considers these necessary.

High temperature operation tests shall be performed at the maximum ambient temperature of 50°C.

10.4.2 Workshop Test

10.4.2.1 Type Test

Type test shall be performed on each type and rating of the specified equipment with the purpose of proving its properties, according to the IEC standard. An internationally recognized laboratory shall certify the type test reports. The Contractor shall submit certified copies of type test reports covering the proposed equipment.

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

- Type Tests conducted at an internationally recognized laboratory acceptable to the Employer.
- Type Tests conducted at the manufacturer's laboratory and witnessed by representatives from an internationally recognized laboratory acceptable to the Employer.

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

The following type tests shall be performed in addition to the tests mentioned in the standard:

- Testing of breaking and making capacity of circuit breaker and fuses (breaking capacity);
- Testing of current-time characteristics of protective releases on circuit breakers and of fuses, verification of selectivity of different elements.

- Temperature rise test(s).

LVAC and DC distribution boards shall be arc tested according to IEC 61641, criteria 1 to 7.

10.4.2.2 Routine Tests

Routine tests shall be performed on each piece of equipment to be supplied for the purpose of revealing faults in material or construction. They shall not impair the properties and reliability of any part being tested or reduce its lifetime.

The following routine tests shall be performed:

- Visual checking of all the equipment to verify conformity with the specifications;
- Power frequency withstand voltage test for all LVAC equipment with 2500 V, 1 min. and for all DC equipment with 1500 V, 1 min.
- Electrical test of charging rectifier to check the automatic current limitation, trickle and boost charging, ripple and manual control.
- Operational test.

10.4.3 Site Tests

On arrival at the site and during and after completion of erection all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment.

The following tests shall be performed:

10.4.3.1 Batteries

Verification of proper and complete erection of the batteries;

Checking of intercell connections;

First filling with electrolyte and initial charging;

Checking of electrolyte level and density;

Checking of voltage of each cell after the charging;

Measuring of the insulation resistance to earth;

Charge and discharge tests.

10.4.3.2 Chargers

Verification of proper and complete erection of chargers;

Verification of proper AC supply voltage, all connections;

Measuring of insulation resistance to earth;

Checking of operation of chargers in each mode;

Checking of control, signalling and tripping circuits;

Load voltage - characteristics.

10.4.3.3 LVAC and DC Switchgear

Verification of proper and complete erection;

Checking of all connections;

Checking of labelling of the cubicles, fuses, circuit breakers, etc.;

Measuring of insulation resistance;

Operation checking of different elements such as contactors, relays, circuit breakers, signalling devices, etc.

Commissioning tests shall be done according to a programme agreed with KETRACO.

10.4.4 Documentation with Tender

The Tender shall contain at least the following information and documents:

- 1) Single line diagrams of the LV Services;
- 2) General arrangement, construction and overall dimension drawings of the LV Service Equipment including front and section views;
- 3) Manufacturing specification of the LV Service Equipment;
- 4) Catalogues, literature and reference lists of proposed equipment;
- 5) Type test certificates from an independent testing authority or independently witnessed;
- 6) Quality Management System Manual and ISO Certificate of the equipment manufacturer.

11.Tariff Metering

11.1Substation Works

The following specification applies to all new substations.

11.2General Requirements

The metering system must provide accurate, reliable and secure measurement of electric energy and make available this information to all commercial parties.

Both Main and Check energy meters shall be provided and must be installed and commissioned to agreed procedures and standards. These shall be of class 0.2s.

The meters and the metering system must be designed such that it can be integrated into the substation control system (SCS) or a separate metering system with facilities to provide secure local and remote (National Control Centre or Regional Control Centre) interrogation of the metered data.

The energy meters shall appropriately be programmed to provide the following information:

(a) Stored in the meter (for local and remote reading)

- (i) Maximum Active Power (P)
- (ii) Maximum Active Power, Date
- (iii) Maximum Active Power, Time
- (iv) Maximum Reactive Power (Q)
- (v) Maximum Reactive Power, Date
- (vi) Maximum Reactive Power, Time
- (vii) Maximum Apparent Power (S)
- (viii) Maximum Apparent Power, Date
- (ix) Maximum Apparent Power, Time
- (x) Active Energy (Total in the month, frozen at end of the month)

(b) Transmitted to the National System Control Centre SCADA reports database

(at each bus bar and/or line bay/ transformer incomer bay)

- (i) Active Power, MW (Import and export values)
- (ii) Reactive Power, Mvar (Import and export values)
- (iii) Current, A
- (iv) Voltage, kV
- (v) Active Energy, MWh
- (vi) Voltage Angle, degrees

The Energy metering values described in (b) above shall be available at the substation SCADA system and the National system control.

The energy meter shall be able to communicate on IEC 61850 and have remote access capability for interrogation.

The meters must have the functionality to be accessed by the various monitoring equipment at both the substations and the NCC and RCC.

The programming codes shall match with Kenya's grid practice. The existing meters would be re-programmed appropriately, if needed.

11.2.1 Measurement Transformers

The measurement transformers shall be located at the commercial interface between power systems.

Measurement transformers may be of the combined CT/VT type or separate CTs and VTs. The transformers shall be dedicated to tariff metering purposes; usage for other purposes is subject to approval.

The CT cores shall have accuracy class 0.2s and the VT core accuracy class 0.2.

For transmission systems separate CT cores and separate VT secondary windings shall be provided for each Main and Check metering systems.

11.2.2 Required Smart Meters

Accurate smart meters, with the ability for remote reading, should be installed at

- i. the point of injection of reactive power compensator
- ii. both ends of all transmission lines and
- iii. the low voltage side of all transmission transformers.

11.3 Marshalling and Cabling

11.3.1 General

A Marshalling box shall provide a common connection point for CT and VT cables from phase measuring transformers and the metering cubicle. The marshalling box shall also provide suitable environmental protection for the internal equipment.

11.3.2 Cabling

Separate multi-core cables shall be provided for VT and CT signals from the measuring transformers to the marshalling box. In order to minimise coupling between signals, separate multi-core cables are required for VT and CT signals from the marshalling box to the metering panel(s) and shall avoid being ran adjacent to power cables.

The VT and CT cabling shall be dedicated to tariff metering and not be shared for any other purpose.

The cables for both VT and CT signals shall have a minimum 2.5mm² and 4mm² conductor. For cabling runs in excess of 300m, the conductor size must be increased in order to reduce the connected cable burden and keep within the rated CT burden.

The metering voltage measuring and auxiliary (where relevant) supplies shall use separate cores from the marshalling box to the metering cubicle. These measuring and auxiliary supplies may be combined from the measuring transformer to the marshalling box.

For each CT circuit 6 cores shall be provided i.e. 2 per phase providing a go and return arrangement.

11.3.3 Marshalling Box

The marshalling box shall provide the following:

- Be lockable to prevent unauthorised access.
- Suitable terminations for CT, VT, meter auxiliary supply (if relevant), earthing links and alarm circuits that permit testing and isolation and shorting (where relevant) of circuits without disturbance to the integrity of wiring connection.
- VT winding neutrals shall be earthed via a removable link to create the neutral star-point.
- CT secondary earth applied via removable links.
- Cable armouring should be earthed at one end only, preferably within the marshalling box.
- Any VT gas discharge trips and alarms shall be brought out from the VT to a separate facility in order to avoid disturbance to the security locks and seals on the tariff metering marshalling box.

11.4 Metering cubicle

11.4.1 General

As a minimum the metering cubicle shall provide accommodation for the energy meters, data loggers, test terminal blocks, MCBs and instrument transformer burden padding resistors. The cubicle shall also accommodate any other equipment necessary to interface the meters to external equipment for remote data interrogation.

The metering cubicles for two adjoining bays shall be installed in the Control Room. The maximum allowed number of meters installed in one cubicle (W:800mm, D:800mm) shall be six (6). The substation control building will house the metering data collection and communication system, with the connection between meters and that system to be done by fibre optic cables.

11.4.2 Construction

Main and Check meters may be housed in the same cubicle. When viewed from the cubicle front Main meters shall be on the left side and check meters on the right side. Wiring terminals shall also be arranged in the same manner with each circuit clearly segregated and labelled.

The metering cubicle shall be constructed to at least IP52 in accordance with IEC60529, be free standing and constructed from folded sheet steel of adequate thickness and be located on a base frame.

Access into the cubicle may be via a front swing frame door or rear door, this to be coordinated with the other cubicles installed in the same room. A transparent external front door shall be provided. The doors shall be lockable, provided with locks and keys and have provisions for sealing.

The cubicle dimensions shall be minimum 800mm wide and maximum height of 2400mm and have provisions for lifting, sizes to be coordinated with the other cubicles installed in the same room.

11.4.3 Test and Isolation

Separate test facilities shall be provided for each Meter to enable testing from the front of the metering panel with the primary circuit(s) in service. The test points shall be clearly identified and labelled.

The test facilities shall isolate all DC and AC incoming and outgoing circuits so that work can be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station.

It is preferred that test facilities match those provided in the substation protection and control cubicles.

Terminals shall provide shorting (where applicable) and isolation facilities.

11.4.4 Cubicle Auxiliary Equipment and Wiring

The cubicle shall have adequate internal lighting, a power point for hand tools and test/maintenance equipment, be suitably ventilated and heated with adjustable thermostatic and hygroscopic controls. A suitably rated MCB shall control the auxiliary AC respectively DC supply and give indication to the SCS of its operation.

A suitably rated MCB shall be provided for each 3ph measuring supply VT circuit and, where relevant, each metering auxiliary supply. The MCB shall provide isolation for the VT wiring to the meter and be located on the VT side of the test facility and any VT burdening resistors. The MCB shall be provided with sufficient auxiliary contacts wired out to a terminal block for raising an alarm within the SCS.

Auxiliary power supply wiring and terminations, except for meter auxiliary supplies from VTs, shall be segregated from meter wiring and terminations.

11.5Energy Meter

11.5.1 Construction

Energy meters shall be numerical and of the 3-phase 4-wire measuring principle and conform to IEC62053-22 accuracy class 0.2s for active meters and IEC62053-23 accuracy class 2.0 for reactive meters.

All meter functions shall be accessible from the front. The front cover shall provide a clear window for reading the display and all removable covers shall be sealable to prevent unauthorised access.

The meter shall be rear mount construction and have a degree of protection of IP51 (IEC60529).

The meter shall be powered from an auxiliary AC (via UPS) or DC. Upon normal supply failure meters shall be powered from auxiliary VT supplies.

The meter terminals shall be brass or nickel plated brass and accommodate cable cores of at least 6mm².

The meter shall have self-monitoring capability and raise a remote alarm via the substation control system (SCS) when faulty.

11.5.2 Measurements and Display

Separate Main and Check meters shall be provided for each measuring point.

Each meter shall measure active and reactive import and export energy with nominal measuring voltage of 110V ($110V/\sqrt{3}$) and nominal measuring current of 1A at a frequency of 50Hz. Maximum current shall be $\geq 6In$.

The display shall be a minimum seven-digit backlit LCD, single rate registers for each direction of energy flow. The registers shall be non-volatile.

Meter shall display readings in primary quantities. The meter parameters shall be configured via the metering software. Software access to the meter shall be password protected.

The energy meter shall be capable of measuring, displaying and record per interval at least the following: -

- Import and Export kWh, kVArh
- Import and Export kW, kVAr
- Reactive Energy in four quadrants.
- V, A
- Maximum Demand
- Total Harmonic Distortion (THD)

The principle measuring unit shall be kWh or kVArh however this shall be changeable to MWh and MVarh.

Meters shall be provided with adjustments for external measurement error compensation.

11.5.3 Data Storage

The record (load profile) for the above values shall be over a programme interval that shall provide at least 180 days of profile data across four channels.

All data shall be retrievable by hand held retriever, server, notebook or other communication media via the meters optical port, Ethernet or serial data ports. Other communication facilities shall be provided as necessary to interface the meter into the substation control system or remote meter data system.

Each energy meter shall have a minimum of three pulsed outputs and for connection to a data logger (if separately required). A single control shall set all outputs to the same units per pulse.

The Contractor shall integrate the energy meters into the Substation Automation System (SAS). The contractor shall ensure that the communication protocols used in the energy meters can be accommodated by the supplied SAS.

The difference between test and pulse outputs shall not exceed 0.01%. The pulsed outputs shall comply with the requirements of IEC62053-31.

11.5.4 Timing

The meter shall have an internal clock with back-up battery to last for 1 year and be capable of synchronization with other meters via a GPS clock signal.

The GPS auxiliary power supply shall be either AC (from a UPS) or DC.

11.5.5 Security

For purposes of security the meter shall have multi-level password protection for reading and programming.

11.5.6 Markings

Each meter shall be provided with a nameplate conforming to IEC 62052-11.

11.5.7 Software

The proprietary metering software shall be supplied in order to locally and remotely configure and retrieve data from the metering system.

11.5.8 Metering System Auxiliary Power Supply

Normal auxiliary power supplies shall be derived from station battery 110V DC supply.

Failure of the normal auxiliary supply shall cause the meters to draw alternative auxiliary power from the VT.

11.5.9 Testing

Type test reports must be submitted for all equipment supplied to demonstrate compliance to the appropriate standards.

Meter compensation adjustments shall be performed by the Contractor. Data necessary to perform these adjustments shall be supplied in the form of test certificates, lead resistances and working burdens.

Installation, setting, testing and commissioning of the metering system shall be carried out at site by the Contractor.

Site tests shall be performed by the Contractor in accordance with a test schedule prepared by the Contractor and agreed in advance with KETRACO. These tests shall include full functionality and safety testing of the equipment, cabling and items of plant supplied. On completion of tests the contractor shall provide a signed copy of the test procedure. The testing shall be done to the satisfaction of KETRACO.

11.6 Training and Capacity Building of Staff

KETRACO staff shall be adequately trained to:

- i. Be empowered skill wise on meters/metering and associated wiring;
- ii. Programme/re-programme the meters when necessary; and
- iii. Read the meters when required.
- iv. Establishment of a meter unit

This training aspect should be part of the pre-commissioning process.

12.Fault Monitoring System and Alarm System

12.1General

This specification covers the design (including all software), manufacture, factory testing, marking, packing, shipping, transportation to site, installation, on-site testing and commissioning of a Fault Monitoring System (FMS).

FMS shall be provided at new build substations and this specification provides the functional and performance requirements.

FMS shall be supplied for acquiring the power system real time data, and providing the historical information of its faults/disturbances with all possible events detected thereafter.

The FMS system shall continuously monitor analogue & event input signals, and upon detection of a fault/disturbance or event, it shall automatically:

- Capture and store fault data in the buffer memory.
- Process and upload the information to a data concentrator resident with all analysis software providing a local evaluation station.
- Capture and store additional fault/disturbance data without affecting any tasks in progress.

FMS shall provide, in analogue form, current and voltage information, and in digital form, event information such as outputs from protection relays, protection signalling equipment, and circuit breaker operation at the time of primary system faults.

In addition, FMS shall be able to perform calculation and fault location in order to help find the fault points in the shortest possible time.

When the FMS is triggered, the analogue and event channel input data, for a certain time prior to, and after the trigger pulse, shall be recorded with all channels relating to the same time reference. The FMS shall record the analogue and event data simultaneously.

The system shall process the recorded data locally and also be accessible remotely via the SCS LAN.

All records of fault data shall be processed in either the local or the NCC Master evaluation stations to determine:

- Type, presence, severity and duration of a fault
- Fault locations and persistency of faults
- Performance adequacy or inadequacy of protection, tele-protection signalling equipment and circuit breakers
- Any failures or operation outside the limits of performance and any malfunctions
- Cause and possible resolution of a problem.

The fault recorder concept shall be a distributed principal with measurement and signal acquisition units per diameter and a central unit to be installed in the substation control building, which collects and archives all the fault records from the different diameter acquisition units. The cubicles with the diameter acquisition units shall be installed in the Control Room belonging to the diameters. The connection between acquisition units and the central system shall be done by fibre optic cables.

12.1.1 Network Integration

Where compatible systems are provided at NCC/RCC fault record data shall be automatically transferred to the evaluation station for analysis.

12.1.2 FMS Architecture

The Manufacturer shall be cognizant that the FMS system offered must support, with hardware and software devices, a local analysis facility at the substation, and a seamless integration with NCC/RCC (where supported).

To facilitate fault analysis at each substation, the FMS system shall comprise a local evaluation facility set up with a suit of PC (data concentrator), monitor, printer, etc., which shall be implemented with complete application (analysis) software.

12.1.3 Accommodation

The FMS data acquisition units, master station, Local HMI and printer (where relevant) and other associated equipment shall be preferably housed in front access, swing-rack design however front and rear is acceptable but should not be a mixture of both at the same substation.

All equipment shall have dust-proof enclosures. All metal bases and frames of relays shall be earthed except where they are installed for special requirements.

12.2 Hardware Requirements

12.2.1 Data Acquisition Units (DAUs)

The DAUs of FMS shall be of the stand-alone type (not integrated with any protection or control systems) and connected via the substation LAN to the SCS Engineering Workstation.

Independent DAUs shall be supplied with a minimum of 8 analogue channels (voltages & currents) and 16 event channels for each incomer and outgoing transformer feeder circuit and OHL circuit. For other non-feeder circuits, such as coupler/section, busbars, etc. common DAUs with a large capacity shall be used. Separate common DAUs shall be provided for each system voltage.

The Contractor should note that the common DAUs are only acceptable provided that the channel allocation for each bay shall comply with the Data Sheet and this specification, and that the fault record for each bay (circuit) shall be independently processed and stored.

For future use, a separate DAU shall be provided with 16 analogue and 32 event channels. This shall be available as a spare-point wherein all the equipment is fully installed, and wired into FMS cubicles with all the modules in place, but not utilized.

The DAUs shall embody several data processing properties at both the field level where data are acquired and the analysis level where waveforms are processed and examined. Data acquisition shall be in the form of collecting current & voltage signals from the secondaries of current and voltage transformers and binary status information (contacts) from circuit breakers, protection relays, tele-protection signalling equipment, etc.

The DAUs and other FMS components (including the data processing and evaluation equipment) shall comply with requirements stated in IEC 60255-6 for thermal and environmental tests. The FMS system shall be designed to ensure correct performance even in the presence of radiated electromagnetic field disturbance (IEC 60255-22-3).

The DAUs shall be capable of retaining its selected parameterization and settings when its DC supply is removed and subsequently reinstated within 2 weeks.

The DAUs shall be designed with a non-volatile flash memory with a 500 Mb capacity. If internal batteries are used for backup purposes, then they shall have a nominal life of 10 years.

The fault records held within the DAU's memory shall be retained for 2 weeks upon loss of DC supply.

The DAU's shall be provided with an internal clock to time tag each fault record. The clock shall identify the date and time on each fault record to the nearest 1ms, which is necessary to compare fault data recorded at different substations. The internal clock shall be synchronized with the GPS standard time reference. The drift of the internal clock shall not be greater than 1 s/day, in the absence of a GPS time reference.

DAU local setup tools (software, cables and laptop computer) shall be included in the scope of supply.

12.2.2 Channel Requirements

The analogue channels for voltage and current inputs shall be rated at 110 V AC (phase-to-phase) and 1A AC respectively. The bandwidth of the analogue signals shall cover a frequency range of 20 Hz-1500 Hz. The analogue information shall have an amplitude resolution of at least 1:65500 using a 16-bit A/D converter.

The analogue channel for the current input shall be provided with the maximum amplitude of recording up to 30 times nominal. The accuracy of the current and voltage inputs shall be better than 0.5% of the full scale.

The event channels shall be capable of accepting either N/O or N/C contacts.

12.2.3 Trigger Facilities

It is necessary to trigger DAU's in order to acquire data during system fault and abnormal conditions. The DAUs shall be offered with various types of sensing algorithms, Boolean logic, and external events to detect the occurrence of a fault.

12.2.4 Trigger Time

The fault recorder shall have a pre-trigger recording time selectable within the range of 100ms - 500ms in steps of not greater than 50ms. The post-fault recording time shall be adjustable within the range of 100ms - 2000ms.

12.2.5 Event Channels

External binary triggering facilities shall be provided to enable FMS to capture the system fault information.

12.2.6 Analogue Channels

Each analogue channel shall be provided with at least one of the following independently selectable triggering facilities:

- Threshold Triggering & Variation Triggering: Current, Voltage and Frequency
- Negative phase sequence triggering: Current.

The threshold trigger shall take place when the voltage falls below or rises over a preset threshold or when the current rises over a preset threshold.

The variation triggering shall take place when the voltage falls or the current rises by a preset percentage of nominal maximum amplitude of recording in 1 cycle.

In the negative phase sequence current triggering, both over threshold and positive variation triggering shall be provided.

Manual triggering facility shall be provided on the hardware front panel.

The response time of an event trigger shall be sufficiently short to capture event durations of 2ms. However, triggering shall not take place for event duration of less than 0.5ms or for electrical noise. The response time of an analogue trigger shall not be greater than 40ms.

12.2.7 Signal Requirements

The FMS shall be configured for the analogue and event signals as follows:

Bay	Configuration	
	Analogue Channels	Event Channels
Feeder (Incomer & Transformer)	4 x current & 3 x voltage, 1 open delta (or residual voltage)	16
Outgoing Transformer Feeder	4 x Current & 3 x Voltage	16
Bus Coupler/Bus Section	4 x Current	16

Busbar	3 x Voltage	8
Frequency channel (per busbar)	1	-

The above number of channels/event signals shall be assumed, as a minimum requirement, however if at the time of implementation, more signals are deemed necessary, the same shall be provided. The list of channels to be wired up shall be subject to approval of KETRACO/KPLC.

12.2.8 Printer

Colour print facilities shall be provided. Printing either locally at the FMS and/or via the LAN connected SCS printers.

12.2.9 Self-Supervision & Alarms

On-line supervision is to be provided to detect hardware and software failures. All types of failures shall be detected and alarmed, which shall typically include the detection of internal equipment failures, loss of auxiliary (DC) supply, printer paper low/out.

The hardware shall be equipped with indicators for system power ON, power supply output present, watch dog time being reset, fault indication, etc.

Fault recorder operated and fault recorder faulty alarms shall be provided in the substation (SCS).

Individual modules, MCBs, operating buttons, and terminals shall be clearly identified by labels affixed in a permanent manner. All indication LEDs, particularly, those used for the event signals, shall be identified on the front of the equipment shelf.

12.2.10 Engineering Interface

The fault recording system shall be provided with interrogation facilities containing software and interface hardware for communication with a PC. Communication shall be achieved by local interrogation via the direct connection of a PC to the front panel RS232 or Ethernet port. Communications shall also be achieved remotely via the SCS over the substation LAN.

Where provided, the remote interrogation software package resident at NCC Evaluation Station shall be capable of downloading settings and trigger commands into the fault recorder.

12.2.11 Communication with NCC

The communication between the substation and the NCC Evaluation Station (where available) shall be provided via KETRACO's telecommunication networks. Standard communication protocol shall be used. The Contractor shall state in their offer which protocol is to be used.

12.2.12 Functional Requirements

The FMS shall have, as minimum, the following features:

- Be of a modern, fully numeric and modular design.
- Low power consumption and be powered by the station battery.
- Requisite software and hardware built-in both for stand-alone working and for operation over a network up to the master station.
- A memory (RAM) that is sufficient for capturing fault/disturbance and event data of at least 50 seconds at a sampling rate of 4000 Hz.
- An accurate crystal controlled clock with external GPS synchronization facility. The GPS of the SCS shall be utilized for the FMS.
- A battery to back up the system memory and clock, in the event of a power supply failure.
- Each event channel shall be adjustable for disabling its function, or for matching it to a normally closed or a normally open contact. Also, recording or suppression of recording by an event occurrence shall be adjustable.
- Time adjustable filter to suppress contact bounce.
- Scan rate of at least 2000 Hz per event channel.
- Scan rate of at least 4000 Hz per analogue channel.
- Analogue channels with an amplitude resolution of not less than sixteen bits.
- Recording initiation by individual analogue channels shall be adjustable by the setting of under/over limits.
- When the hardware memory is in danger of becoming full, an alarm must be produced in the station.
- A standard interface for connecting a hand terminal (PC), for retrieving data and reconfiguration of trigger values, date/time setting, parameter setting of analogue and event channels, and for system testing or fault diagnosing. This facility shall not be capable of modifying or deleting fault records held within the recorder's memory.
- Have indications on power supply failures, system failure, communication link interruption, or memory buffer full. The failures are to be externally signalled through potential free contacts to either common alarm annunciation or to the substation control system.
- Evaluation station shall be comprised of a latest PC with the available largest hard disk memory and fast scanning capacity at the time of awarding the contract. The evaluation station shall have a standard interface connected to a colour laser type printer of latest technology (suitable for at least A4 & A3 paper size), which is to be located in the control room. The print out shall at least invariably include date/time, station name, all the event and analogue channels with the X, Y axes scaled.
- In-built power supplies for the signalling contacts. The number of circuit breakers to be used shall be such as, by switching an MCB, which is associated with a particular acquisition station, it shall not cause any of the remaining recording unit to be out of service. This supply output shall be monitored.

12.3Evaluation Facilities

12.3.1 Analysis Objectives

The FMS shall provide sufficient data to perform the following analyses:

- Fault clearing
- Power swing conditions
- Under frequency conditions.

Since the data required for one type of analysis are quite different than that required for another type, the Contractor shall confirm that the FMS offered shall be suitable to perform all types of analysis. The FMS shall acquire data with a clear distinction of differences in the required frequency response and the duration of the event to be captured, depending upon the types of disturbance the power system being subjected to.

For fault clearing analysis, the FMS shall capture data with a high sampling rate of up to at least 4 kHz, and a short record length of up to 2 seconds.

For analysis of power swing and under frequency conditions, the FMS shall acquire data with a lower sampling rate of 15 Hz and a long record length of up to 5 minutes or more.

In fault clearing analysis the FMS shall process and compute the following information:

- The fault duration time and the magnitude fault current/voltage including the type of fault (single phase, multiphase, evolving) and the phases involved.
- Analogue waveform data on all voltages and currents to display harmonics, Ferroresonance conditions, transient voltages, breaker restrikes, or arcing.
- Distance to fault estimation.

For analysis of power swing, dynamic oscillation and under frequency conditions, the outputs computed by FMS shall include, but not be limited to, plots of volts, currents, frequency, apparent impedance's, negative sequence currents, power swings, etc.

The DAUs shall be able to switch over automatically to the required operational parameters and settings depending on the power system faults and disturbance conditions, and shall supply sufficient data to enable different types of analysis to be conducted.

12.3.2 Data for Relay Testing

The FMS system offered shall provide facilities to replay fault recorder files into protection relay test sets in order to reproduce the relaying performance under an actual fault condition. The fault data shall be provided as input to test sets in the COMTRADE format. Transient analysis of the relay performance required signal parameters such as peaks, RMS values, power, system frequency, phasor quantities, etc. The FMS shall provide the required information both in the time domain and in the frequency domain.

12.3.3 Fault Records

The fault records shall contain, in alpha numeric characters, the identity of the substation and circuit, the fault reference number, the trigger data, time and source, identification of individual analogue and event channels, amplitude scale, and time increment markers.

The fault record shall be available in the COMTRADE format.

A print out of settings and other programmed parameters shall be achievable on demand from the recorders.

The time coincidence error between recorded event and analogue channel shall not be greater than 1 ms. The reconstructed waveforms that are developed from the stored data shall be accurate within 1 percent of the input waveforms in amplitude and phase angle.

The fault locating function shall perform with an error accuracy of plus or minus 1 percent.

The overall accuracy of the printed output of the analogue channel shall be such that at a frequency of 50Hz the error between input and output shall not exceed 0.4 mm at any point between 10 percent and 100 percent of the nominal amplitude.

12.3.4 Software

The required FMS system shall have the requisite software for achieving the following:

- Analogue triggering (over voltage, under voltage, over current, over / under frequency, and voltage, current & frequency gradients)
- Triggering because of protection trips or CB status
- Software for maintaining a database for data uploaded from FMS units, keeping a register for parameter setting and running hardware and software diagnostic subroutine.

The operating system software shall be user friendly. The software packages at the substation evaluation station shall be suitable to run multitude of software for data collection from the acquisition units as well as data processing, storage, fault analysis, graphical representation, data communication (between local and master station).

At the NCC evaluation station (where available) similar software as for the substation evaluation station is also required.

12.4 Fault Evaluation Package

12.4.1 Fault Analysis

The software package shall include mathematical analysis features such as calculation and display against time of:

- Sequence components

- Harmonics
- Frequency
- Phase angles
- Real and reactive power
- Fault location
- Power swing
- X/R and time constant.

12.4.2 Analysis Tools & Facilities

The required evaluation software shall be an interactive tool for the evaluation and interpretation of fault recorder files. It shall execute the following tasks as a minimum:

- Viewing on the screen the identity of the substation, fault reference number, trigger date, time and source, identification of analogue and event channels, and amplitude scales, etc.
- Each analogue channel or each group of events shall be capable of being displayed individually or together with other selected channels. Each channel shall be capable of being amplified individually or with other selected channels.
- The display's time base shall be capable of being expanded or contracted.
- The instantaneous primary values of current and voltage shall be capable of being displayed at a movable cursor position. The instantaneous time with respect to a selectable cursor position shall also be displayed.
- Formatting of the menu (time scale, amplitude, axis height, colour, markers, clipping, and interpolation) shall be made possible.
- It shall have the facility either to show or not to show check value by cursor for the measured menu item.
- The software shall have the feature of calculating the signal from the recorded data.
- It shall perform the function of merging different fault event files on opening of the same in order to allow global analysis of data.
- It shall execute batch mode operation by opening the dialog box in which batch mode status can also be indicated.
- In the batch mode, operations such as calculation, automatic fault location, time calculations, print function; etc. shall be possible to be carried out.

12.4.3 Hardware Availability

Contractor shall state in their offer the FMS hardware availability while in service i.e. MTBF and MTTR values. Supporting document from the Contractor shall be enclosed.

12.4.4 Alarms

The alarm system equipment shall contain all alarms necessary for the safe and reliable operation of the station.

The system shall be solid state and completely hardwired to the various modules and contact devices.

All the logic elements shall be mounted on printed circuit boards with gold plated edge connectors and complete card shall be tropicalized.

The equipment shall have the following main features:

- Built-up from a basic units of 8 or 16 channels extendable to a large system
- Microprocessor based with communication facility. Self-monitoring with alarm on failure
- Easy fault detection and rectification
- Suitable for NO and NC contacts
- Re-transmission of alarms via output relays
- Grouping (at least 2) of alarms for remote transmission
- Generation of internal power for field contacts
- Push buttons for horn off, alarm acknowledge, reset, LED test and self-check with remote initiation facility for the same

On an incoming alarm the horn will sound and an LED will flash. The horn shall stop on pressing the horn off button or by a delay timer. Upon pressing the acknowledge button the flashing light will become steady. Simultaneously remote transmission of grouped alarms shall be cancelled. The LED shall reset after the alarm condition resets and on operating the reset button.

The alarm system equipment shall be installed in a separate panel.

13. Power Transformers

13.1 Scope of Works

The transformer supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KETRACO's personnel and warranty of the works.

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

Note 1: The majority of the transformers covered by this specification are 2-winding (or 2-winding) 23MVA, 132/33kV, ONAN/ONAF. .

13.2 Reference Documents

IEC 60076-1	- Power transformers - General.
IEC 60076-2	- Power transformers - Temperature rise.
IEC 60076-3	- Power transformers - Insulation levels, dielectric tests and external clearances in air.
IEC 60076-5	- Power transformers - Ability to withstand short circuit.
IEC 60076-7	- Loading guide for oil-immersed power transformers
IEC 60076-8	- Power transformers – Application guide (For calculation format)
IEC 60076-10	- Power transformers - Determination of sound levels.
IEC 60137	- Insulated bushings for alternating voltages above 1000 V.
IEC 60214	- On-load tap-changers.
IEC 60529	- Degrees of protection provided by enclosures
NEMA TR1	- Transformers, regulators and reactors [for audible sound levels]

13.3 General

Transformers shall be outdoor, oil-immersed, three-phase type, generally with on-load tap-changer. (Exceptions with off-circuit tap-changer are detailed in Clause 13.3.11, 'Voltage Control' of this specification.) They shall comply with the requirements of the schedules and standards listed in Clause 14.1 above and other relevant IEC standards. Any ambiguity shall be referred to the KETRACO for clarification at the time of tendering.

The transformers shall be suitable for continuous operation on a three-phase 50 Hz high voltage transmission system as specified in the Technical Schedules.

Transformers and associated equipment shall be designed in such a manner as to meet the requirements in this section, Technical Schedules and Drawings at ambient site conditions. Therefore, the temperature-rise limits given in IEC 60076-2 and IEC 60354 (i.e. hotspot) shall not be exceeded.

Note: the annual average temperature needs to be considered with the necessary correction to the IEC 60076-2 allowable temperature rises to ensure meeting the life criteria of the transformers.

Transformers shall meet the latest stage of development reached in design, construction and materials.

The transformers and all associated facilities (e.g. tap-changer) shall have the ability to withstand the effects of short-circuit currents, defined as symmetrical short circuit current in the Technical Schedules, when operating on any tapping position according to requirements of IEC 60076-5.

All metal parts of the transformer with the exception of the individual core laminations, core bolts and associated individual side plates shall be maintained at the same fixed potential. The earthing structure shall be designed to carry, without damage, the maximum possible earth fault current for a duration of at least equal to the short circuit withstand period of the main windings.

The design and manufacture of the transformers and auxiliary plant shall be such that the noise level is at a minimum and that the level of vibration does not adversely affect any clamping or produce excessive stress in any material. The transformer manufacturer shall supply sufficient information to the civil works contractor to ensure adequate design of the transformer mounting structure.

Noise level (Sound Pressure) limits are based on NEMA TR1 which are generally assessed as high for modern construction, consequently the limit for this specification has been reduced by 5 dB(A). It is assumed that this can be supplied without any cost penalty; bidders should comment if this is not acceptable. Where noise measurements are specified, they shall be made at the Manufacturer's works in the presence of KETRACO or their appointed representative.

If required by KETRACO, the transformers shall be subject to vibration tests.

The transformers shall be designed with particular attention to the suppression of harmonic currents, especially the third and fifth, so as to minimise interference with communications circuits.

The transformers shall be designed to ensure that leakage flux does not cause overheating in any part of the transformer.

Note: This specification covers the requirements for all system transformers, including EHV units on the KETRACO system. Simplified requirements may be acceptable for transformers of low to medium capacity where this can be demonstrated to be typical of good industry practice. When simplified requirements are proposed, they shall be clearly stated in the tender documents, showing any deviation from the specification and/or accompanying technical schedules.

13.3.1 Magnetic Circuit

The core shall be built up of high-grade, non-ageing, low-loss, high-permeability grain oriented steel sheets. Both sides of each steel sheet shall be insulated with a durable, hot oil and heat resistant baked enamel varnish or other chemical treatment.

The cores shall be clamped and braced to withstand, without damage or deformation, the forces caused by short-circuit stresses, transportation, or handling, and to prevent the shifting of the core laminations. The bolts, nuts, and end plates of the assembly and clamp structure shall be of a nonmagnetic type, and shall be effectively insulated and locked so that they ensure an even pressure on the whole core assembly and are not loosened by vibrations caused by transport and operation. The supporting framework of the cores shall be designed to avoid the presence of pockets which could prevent complete draining of the tank or cause the trapping of air when filling during service.

Suitable axial cooling ducts shall be provided to ensure free circulation of oil and efficient cooling of the core. The ducts shall be so dimensioned that the maximum temperature at any point remains within the admissible limits.

Particular care shall be given to the design and construction of the corner joints between columns and yokes to avoid concentration of mechanical and magnetic stresses

Adequate metallic bridges shall be provided between the core lamination packets in order to keep all portions of the core assembly at the same potential.

Lifting eyes or lugs shall be provided at suitable points of the core assembly.

The core shall be earthed to the clamping structure at one point only through a removable link with a captive bolt and nut, placed for convenient access adjacent an inspection housing on the tank cover or tank wall. All earthing connections with the exception of those from individual core clamping rings, shall have a cross sectional area of not less than 80 mm². Connections inserted between laminations shall have a cross sectional area of not less than 20 mm².

The core shall be free from overfluxing liable to cause damage or to cause maloperation of the protection equipment when the transformer is operating under the continuous overvoltage condition specified in the Technical Schedules. Under this steady overvoltage condition, the maximum flux density must not exceed 1.9 Tesla and the magnetizing current must not exceed 5 per cent of the rated load current at normal rated voltage.

13.3.2 Windings

The windings shall be of high conductivity electrolytic copper. High purity cellulosic Kraft Paper shall be used for the principal conductor insulation.

The conductors shall be transposed at sufficient intervals to minimize eddy currents and equalize the current and temperature distribution along the winding. Coils shall be constructed to avoid abrasion of the insulation, (e.g. on transposed conductors), allowing for the expansion and contraction set up by the changes of temperature or the vibration encountered during normal operation.

Windings shall be so designed as to obtain an optimal value for series and shunt capacities in order to ensure a favourable distribution of the voltage for full impulse waves and chopped impulse waves.

Leads from winding to bushings shall be adequately supported to prevent damage from vibration and short-circuit forces.

Permanent current-carrying joints or splices shall be welded or brazed, properly formed, finished and insulated to avoid concentration of dielectric stresses.

The windings shall be subjected to a thorough shrinking and stabilising process. Compensation devices shall be provided for possible further shrinkage of the coils in service.

The coils, windings and leads shall be sufficiently braced and fastened to form rigid assemblies, preventing any relative movement due to transport, vibrations or other circumstances that may occur in service.

The windings shall be designed to reduce to a minimum the out-of-balance forces inherent in the transformers. Tappings shall be arranged at such positions on the windings as will preserve, as far as possible, electro-magnetic balance at all voltage ratios.

Tappings shall not be brought out from the inside of a coil; nor from intermediate turns.

The winding shall be capable of withstanding the forces to which it is subjected under all conditions, particularly the forces due to a short circuit between terminals or between any terminal and earth, with full voltage maintained on all other windings intended for connection to external sources of supply and allowing for any feedback through windings connected to rotating machines.

The assembled core and windings shall be vacuum and/or vapour-phased processed to ensure optimum moisture removal.

13.3.3 Tertiary Windings

Tertiary windings may be specified either as an auxiliary third winding or as a stabilising winding. When specified as a third winding the general terms for primary and secondary windings applies (as above), appropriate to the assigned tertiary voltage and MVA rating.

The tertiary windings of star/star connected transformers are, unless otherwise specified, stabilising windings for control of zero sequence current and for harmonic suppression. Additional information is given in the 'Neutral and Tertiary Connections' part of this specification.

For transformers rated 100 MVA and above, the stabilising winding shall be brought out by two bushings at one corner of the delta; these are to be connected and grounded in service.

A single bushing may be used at ratings below 100 MVA.

13.3.4 Neutral Earthing

According to general effective earthing policy of KETRACO, 400 kV, 220kV, 132kV and 66 kV systems, neutral points of transformers shall be directly connected to earth. Additional information is given in Clause 13.3.13, 'Neutral and Tertiary Connections' part of this specification.

13.3.5 Tank

The transformer tank shall be of welded construction with bolted cover, fabricated from steel plate of a suitable strength grade to meet the following requirements.

The tank shall be of adequate strength so that, when containing the core plus coil assembly and fully oil filled, any packing, lifting, rolling and handling shall not cause overstressing of any part of the tank or leakage. The main tank body, tap changing compartments, radiators and associated piping facilities shall be capable of withstanding full vacuum when empty of oil.

Each tank shall be provided with minimum of four jacking pads conveniently located to allow the raising or lowering of the completely mounted and oil filled transformer. The load carrying capacity of each jacking pad shall not be less than 50% of the total weight of the transformer. Lifting eyes or lugs for lifting the complete transformer and tank cover and facilities for the pulling and pushing of the transformer in any direction shall be provided for each unit. Tank stiffeners and mounting brackets shall be continuously welded to the tank.

Wherever possible, the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 20mm^(note 2) and, if necessary, shall be protected against mechanical damage.

The shape and arrangement of the tank cover and external stiffeners shall permit rainwater and desert sand to flow easily and completely to the ground.

All oil-tight joints shall be made with machined flanges and approved types of gasket.

The gaskets shall be tight under all prevailing service and atmospheric conditions; especially against the hot oil (synthetic rubber or neoprene-bonded cork is not permitted). Means shall be provided to prevent over-compression of the gaskets. The tanks shall be provided with bolted type manholes for easy inspection of bushings and windings.

The tank cover shall be fitted with thermometer pockets, for oil and winding temperature indicators, with a captive screw cap and be located in the position of maximum oil temperature at continuous maximum rating.

A pressure relief device of self-re-setting type and sufficient size capable of functioning without electrical power, shall be provided for the rapid release of any pressure that may be generated within the tank and which might result in damage to the equipment, but it shall be capable of maintaining the oil tightness of the transformer under all conditions of normal service. The device shall operate at a static pressure of less than the hydraulic test pressure for transformer tanks and shall be designed to prevent further oil flow from the transformer during its operation.

The relief device shall be mounted on the main tank and if mounted on the cover it shall be fitted with a skirt projecting inside the tank to prevent an accumulation of gas within the device. Two sets of contacts shall be provided to initiate the alarm and trip relays.

Terminals shall be provided close to each corner at the base of the tank for earthing purposes and each shall be designed to meet system fault levels.

The following plates shall be fixed to the tank at an approximate height of 1.75 m above the ground level: -

- a. A rating plate bearing the data specified in IEC 60076.
- b. A diagram plate on which the transformer tapping voltages in kilovolts shall also be indicated for each tap, together with the transformer impedances at minimum and maximum voltage ratios and for the principal tapping.
- c. A property plate of approved design and wording.
- d. A title plate.
- e. A valve location plate showing the location and function of all valves, drain and air release plugs and oil sampling devices.

13.3.6 Valves

Valves shall be of the fully sealing full-way type and shall be opened by turning counter-clockwise when facing the hand wheel. They shall be suitable for operation between the minimum ambient and the maximum oil temperatures stated in the Schedules. All valves shall be lockable with appropriate sub-master series padlocks. Padlocks shall be provided for locking all valves in the "open" and "closed" positions. Valves other than filter and drain valves shall be provided with an indicator, readily visible from ground level, to show clearly the position of the valve.

All valve hand wheels shall be fitted with nameplates that shall be chromium plated brass not less than 3 mm thick with the engraving filed with enamel. All valves shall be fitted with spoked hand wheels, the spokes and rims of which shall be smooth and where necessary, for appearance, shall be chromium plated.

Each transformer tank shall be fitted at least with the following:

- One 50 mm valve at the top and one 50 mm valve at the bottom of the tank, mounted diagonally opposite each other, for connection to oil circulating and oil filtering equipment. The lower valve shall also function as a drain valve, for which a suitable combine arrangement shall be made.
- Oil sampling devices at the top and bottom of the main tank.
- All parts containing oil, and liable to trap air during filling, shall be fitted with a flanged type air release plug at their highest point.
- Valves shall be provided on both sides of the gas and oil actuated relays.

All valves opening to atmosphere shall be fitted with blanking plates.

13.3.7 Conservator

Transformers rated at 10 MVA and above shall be fitted with an oil conservator. Sealed construction or corrugated tanks may be offered for lower ratings.

The conservator shall be made of welded steel. It shall be designed to withstand full vacuum. The conservator shall be of sufficient volume to enable expansion and contraction of oil within the highest and lowest oil levels in the conservator.

The conservator vessel shall be mounted at the highest point of the oil system and shall be connected to the highest point of the tank through a straight sloping pipe. Adequate isolating valves shall permit the removal of the main and tap-changer Buchholz relays while the conservator is still connected to the tank by a pipe bypassing the relays.

For the power transformers, the conservator vessel shall contain two compartments, one for oil in the main tank and the other for the oil associated with the current making and breaking contacts of the tap change equipment. There shall be no communication between the two compartments in respect of the oil and air spaces. Each compartment shall be provided with the fittings detailed in this clause as if it were a separate conservator vessel.

For transformers rated above 20 MVA, each conservator shall include a synthetic diaphragm (or equivalent, e.g. an airbag) ensuring an airtight seal between the transformer oil and the external air. A description of the proposed system shall be submitted with Tender. Additionally, the air outlet from each conservator vessel or its compartment shall be connected to a dehumidifying breather mounted at approximately 1.4 m above the ground level.

Where silica gel type breathers are used, they shall be of adequate capacity and of the maintenance-free type, with integrated heater, capable of automatic recharge. Breathers shall be fitted with oil traps and contain a minimum of 2.5 kg of silica gel. Breather compartments and oil cup shall be made of glass. The breather and associated pipework shall be firmly fixed to the transformer tank.

As an alternative to the air-bag/diaphragm method, an automatic repetitive cycle type breather may be offered. (Note: A diaphragm restricts the operation of this class of breather and consequently, the diaphragm requirement is deleted when an automatic repetitive cycle type breather is specified.)

Each conservator compartment shall be equipped with filling valve, drain valve, lifting lugs, etc. An oil level gauge complete with low-level alarm shall be fitted to each conservator. The indicated minimum oil level shall occur when the feed pipe to the main tank is covered with not less than 12 mm depth of oil. The oil levels at 15°C, 35°C and 90°C shall be marked on the gauge.

The front cover of all gauges shall be made of glass.

13.3.8 Transformer Oil

The transformer oil shall comply with IEC 60296 and other relevant IEC standards if not otherwise stated in this Tender Documents. The oil shall be a highly refined mineral oil suitable for use as an insulating and cooling medium in transformers. On the existing KETRACO system, Shell Diala S4 ZX-I oil has been used. To avoid possible difficulties and eliminate the risk of incompatibility, mixing of different oils (brand or type) in the same equipment is not permitted.

13.3.9 Cooling Plant

Transformers rated up to and including 10 MVA shall be ONAN cooled. For ratings above 10 MVA but below 20 MVA, there is an option of ONAN (only) or ONAN/ONAF. The choice of cooling in this range shall be made on an assessment of the economic considerations, unless otherwise specified in the schedules.

Two-stage cooling (ONAN/ONAF/OFAF or ONAN/ONAF1/ONAF2) shall be used for transformers rated 100 MVA and higher and facilities shall be provided at the marshalling kiosk or cubicle for the selection of AUTOMATIC or MANUAL control of the cooling plant motors. The transformer manufacturer shall select his preferred arrangement, based on his economic and operational assessment. Unless specified otherwise in the schedules, single-stage cooling (e.g. ONAN/ONAF) shall be supplied for transformers rated above 20 MVA, but below 100 MVA.

Radiators and coolers shall be hot dip galvanized, before painting; their design shall be such as to allow ease of cleaning and painting when in position. Design features offering reduced maintenance requirements such as unpainted radiators (i.e. galvanised only) may be acceptable if there is no visual impact and if the manufacturer can demonstrate long-term and trouble-free experience with this finish in similar environments. If the manufacturer wishes to offer unpainted radiators for consideration, it must be stated clearly in the tender documents.

Detachable radiators and separate cooler assemblies connected to the main tank shall be provided with machined flanged inlet and outlet pipes.

A minimum of two cooler banks shall be provided for all transformers having ratings of 30 MVA and above. Where forced oil cooling is employed, two 100% rated pumps shall be supplied with one as standby, to be automatically operated in the event of failure of the other.

Plugs shall be fitted at the top and bottom of each radiator for filling and draining.

Starting or stopping of the forced-oil circulation pumps shall not cause mal-operation of the gas and oil actuated relays. The oil circuit of all coolers shall be provided with the following as appropriate to tank mounted or separate bank coolers: -

- a. A valve at each point of connection to the transformer tank.
- b. A valve in the main oil connection at the bottom of each cooler.
- c. Loose blanking plates to permit the blanking off of the main oil connection to the top of each cooler.
- d. A 50 mm oil-filtering valve at the top and bottom of each cooler, the bottom valve shall also function as a drain valve.
- e. A thermometer pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each cooler.
- f. Visual oil flow indicators in the pipework adjacent to the coolers. In the event that this will offer impedance to oil flow under ONAN conditions a differential pressure gauge of approved design and manufacture may be connected across the pumps, as an alternative.

The material of the tube plates and tubes shall be such that corrosion shall not take place due to galvanic action.

Where separately mounted cooling equipment is provided a flexible piece shall be included in each oil pipe connection between the transformer and the oil coolers. Drain plugs shall be provided in order that each section of pipework can be drained independently.

Complete set of loose blanking plates to suit the blanking of radiator and cooler connections to the main transformer tank shall be supplied complete with gaskets and delivered to KETRACO stores.

All flange joints that are separated from the main transformer tank by gaskets shall be connected thereto via adequately rated copper earthing connections. Connecting bolts shall not serve the purpose of earth continuity.

Each forced oil cooler shall be provided with a fully weatherproof motor driven oil pump. The motor shall be of the submersible type. It shall be possible to remove the pump and motor from the oil circuit without having to lower the level of the oil in the transformer or coolers.

Where forced air-cooling is provided it shall be possible to remove the fan, complete with its motor and supporting structure without disturbing or dismantling the cooler framework or pipework. The fans shall not be mounted directly on the radiator fins or radiators itself. Fans shall be numbered and have clearly marked direction of rotation.

Stainless steel wire mesh guards shall be provided to prevent accidental contact with the fan blades. Metal guards shall also be provided over all other moving parts. The guards shall be designed so that neither the blades nor other moving parts can be touched by a Standard Test Finger to IEC 60947-1.

Control of cooling shall be provided at the marshalling kiosk or cubicle with facilities for the selection of automatic or manual control of the cooling plant motors and remote indication/alarms.

13.3.10Cooler Control

Each motor or group of motors shall be provided with a three-pole electrically operated contactor and with control gear of approved design for starting and stopping manually.

Where forced cooling is used on transformers, provision shall be included under this contract for automatic starting and stopping from contacts on the winding temperature indicating devices. The control equipment shall be provided with a short time delay device to prevent the starting of more than one motor, or group of motors in the case of multiple cooling, at a time.

Where motors are operated in groups the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring in a single motor.

The control arrangements are to be designed to prevent the starting of motors totalling more than 15 kW simultaneously either manually or automatically. Phase failure relays are to be provided in the main cooler supply circuit.

All contacts and other parts that may require periodic renewal, adjustment or inspection shall be readily accessible.

All wiring for the control gear accommodated in the marshalling kiosk together with all necessary cable boxes and terminations and all wiring between the marshalling kiosk and the motors shall be included in the contract.

Two independent sources of power shall be made available to ensure loss of cooling capacity for a single contingency is not greater than 50 per cent.

13.3.11 Voltage Control

Unless otherwise specified, transformers with an HV U_m equal to 36 kV or higher shall be equipped with an on-load tap-changer (OLTC) on the high voltage winding. The on-load tap-changer shall comply with the requirements of IEC 60214 and other relevant IEC standards if not otherwise specified in these Specifications. It shall be possible for the power to flow in both directions.

Generally, transformers rated at U_m equal to 12 kV will be equipped with an off-load (DETC) tap-changer with a range of plus/minus 5% in four steps (five positions).

The OLTC shall be based on the Jansen principles and shall feature low-maintenance characteristics, preferably with belt-type (oil-free) transmission gear. Leading European or Japanese manufacturers of international standing shall provide the OLTC; units from recent licensees are not acceptable.

The diverter switch unit shall be placed in a separate gas tight compartment, which shall be, like the whole tap-changer, integrated in the transformer tank (in-tank mounting). The diverter switch shall have an oil system completely separated from other transformer's oil and shall be equipped with a conservator, pressure relief device with alarm/trip contacts and other devices stated for the main tank. A separate gas actuated relay is to be provided in the connection between the on-load tap-changer tank and conservator.

Note: Diverter switches with vacuum type interrupters are also acceptable.

The diverter switch compartment shall be easily accessible for inspection and it shall be possible to remove the diverter switch without difficulties for maintenance purposes. The inspection and maintenance of the diverter switch shall be possible without lowering the oil level in the main tank. One set of each type of lifting tackle shall be supplied to facilitate removal of the tap-changer unit. Necessary attachment facilities shall be incorporated in the main tank design.

Any enclosed compartment not oil-filled shall be adequately ventilated and designed to prevent the ingress of vermin. All contactors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation.

Means shall be provided to ensure that the operating mechanism can be locked only when the switches are making full contact.

The driving motor shall be rated for 415/240 V a.c. and shall be equipped with thermal overload and overcurrent protection to be installed in the motor drive cubicle. Control voltage inside the motor drive cubicle shall be from the station control supply of 110V. D.C. Limit switches shall be provided to prevent the tap-changer mechanism overrunning. These shall be directly connected to the operating motor circuit. In addition, mechanical stops shall be fitted to prevent the mechanism overrunning under any conditions. For on-load tap-changer equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap changing equipment. The terminals of the operating motor shall be clearly and permanently inscribed with numbers corresponding to those on the leads attached thereto.

A device shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.

The tap-changer shall be arranged for local hand and electrical operation, remote electrical operation and for automatic control.

Equipment for local and remote electrical and local hand operation shall comply with the following conditions:

- It shall not be possible to operate the electric drive when the hand operating gear is in use;
- It shall not be possible for any two electrical control points to be in operation at the same time;
- Each step movement shall require separate initiation at the control point;
- All electrical control switches and the local operation gear shall be clearly labelled in an approved manner to indicate the direction of tap changing;
- The remote or supervisory-remote raise/lower control shall be blocked when the AVC selector is in "automatic" position;
- The local control switches shall be housed in the marshalling kiosk. These switches shall be so arranged that it is necessary for the AVC selector to be in a non-automatic position and the "local/remote" selector switch, located in the transformer marshalling kiosk, to be in the "local" position before operation is possible. Under these conditions the local selector switch shall have overriding control. If the "local/remote" switch is not in "local" position, then local operation of tap-changer shall not be possible.

The equipment shall be arranged so as to ensure that when a step movement has been commenced it shall be completed independently of the operation of the control relays or switches or failure of auxiliary supply or any other contingency.

The control and signalling equipment shall be provided:

- To give an indication mechanically at the transformer and electrically at the remote control point of the tapping in use. The indicator at the transformer shall show the number of tapping in use and the indicator at the remote control point shall show clearly the actual voltage ratio in kilovolts and the tap number representing this ratio. The numbers shall range from 1 upwards. Position 1 shall refer to the maximum LV no-load voltage and the highest number position shall refer to the minimum LV no-load voltage, for the nominal HV voltage.
- To give an indication at the remote control point that a tap change is in progress by means of an illuminated lamp and alarm buzzer. If the tap change is not completed within the specified time the buzzer shall continue to sound until switched off by hand but the lamp shall remain illuminated until the tap change is completed.
- To give an indication at the remote control point by means of an approved illuminated indicator and the buzzer alarm as described above when the units of a group of transformers arranged to operate in parallel are operating at different ratios.
- To read with digital circuit voltmeter based on L.C.D. displays.

An automatic voltage control relay and all other associated equipment shall be provided for each transformer with on-load tap-changer. The relay shall be responsive to variation in the measured voltage and cause the necessary tap change to be made to restore the voltage to the desired level within pre-determined limits.

The automatic voltage control relay shall be suitable to work in automatic independent control mode, where the tap-changer is controlled irrespectively of the method of control selected for the other associated transformer, and automatic parallel control mode, where in a group of parallel working transformers it shall be possible to select any transformer for master control.

During a master/follower tap change operation, tap changing shall be sequential of slightly time staggered to ensure that at any time only one transformer is changing tap.

The reference voltage shall be taken from voltage transformers on the low voltage side of the power transformer.

The relay setting voltage, expressed as a percentage of the relay nominal voltage, shall be adjustable over a range of not less than ± 10 per cent of nominal.

The relay sensitivity shall be adjustable and shall suit the chosen tap change step.

On-load tap change transformers provided with fully automatic control and required to operate in parallel as a group shall be provided with the means to ensure proportionate sharing of watts and VARs.

All transformers operating in a group shall be on the same tap. Operation with a tap difference between transformers in a group shall be automatically prevented by an "out-of-step" device and an "out-of-step" alarm signal shall be transmitted to control point(s) after an agreed time interval. The tap change scheme shall be arranged so that the maximum difference between the transformers during a tap changing sequence is one tap.

For transformers which differ significantly from each other, in electrical characteristics and/or when they have substantial loads of differing types, it may be necessary to operate with more than one tap position difference in order to improve sharing between transformers. In such cases schemes based on voltage/current compounding to achieve the desired objectives shall be provided. Alternatively, a programmable control equipment (microprocessor) shall be provided.

The load compensation shall be provided.

All equipment shall be suitable for operation within the limits 85 per cent/110 per cent of the auxiliary voltage supply. In the event of the reference supply voltage being outside the specified operating limits the voltage control relay shall initiate an alarm and block further operation of the tap-changer until voltage is restored.

AVC relay shall be suitable for supervisory-remote adjustment of a setting voltage (set point control).

Requirements for supplementary adjustment of the voltage setting for operational reasons, (other than load shedding), will not exceed 5 steps nor an effective setting change of 10 per cent.

13.3.12 Terminations

Alternative termination arrangements are possible for the HV, LV and TV connections. The appropriate terminations for a particular project shall be identified in the Technical Data Sheets which accompany this specification.

Unless otherwise specified the termination will be brown-glazed outdoor bushings with IEC Class IV (31 mm/kV) creepage distance which shall include the diameter correction factor (k_D) appropriate to the insulator diameter.

The following termination options with their appropriate codes are possible:

- AIS = Transformer to Air bushing = Standard arrangement
- GIB = Connection to GIS or cable via Gas Insulated Busduct
- CSC = Separable cable connector with oil filled box on transformer
- CSE = Cable termination in oil-filled cable-sealing end chamber
- CAF = Air-filled cable box

13.3.13 Neutral and Tertiary Connections

Unless otherwise specified, Neutral terminations shall be via outdoor bushings grounded via an insulated copper connection secured to the transformer tank

Where tertiary stabilising winding connections are brought out, they shall be via outdoor bushings in accordance with the requirements given earlier and grounded to the tank via a removable link (or links). A reduced creepage distance for bushings, which are grounded in service, is acceptable but the specific creepage distance should be at least 25 mm/kV.

When tertiary bushings are required to provide an auxiliary supply or for the provision of reactive compensation, they shall retain the full project specific creepage distance of 31 mm/kV.

13.3.14 Protection, Measuring and Indicating Devices

The power transformers shall be equipped with a range of protection, measuring and indicating devices supplied by the transformer manufacturer, to include:

- Buchholz relay shall be fitted to transformer main tank, and on each compartment where oil is separated from the other oil in the transformer.
- Diverter switch chamber shall be equipped with an oil surge actuated relay.

They shall have:

- Alarm contacts which close when gas collects or at low oil level;
- Redundant tripping contacts which close following an oil surge, and gas collection in the 2nd stage.

- The normally open, electrically separate, alarm and tripping contacts shall not be exposed to oil.
- Each relay shall be provided with a test cock to take a flexible pipe connection for checking the operation of the relay from ground level.

Winding temperature indicators shall be associated with one phase only and shall be provided for each winding.

One indicator shall basically serve as a thermometer for winding temperature, mounted in the control cubicle. It shall be of conventional construction with a sensing bulb positioned in a separate pocket, arranged in the top oil capillary connected with a dial. A separate pointer to register the maximum temperature reached shall be incorporated in the dial. Two adjustable trip/alarm contacts shall be provided.

The second winding temperature indicator shall be preferably of electronic simulated design with adjustable contacts for cooling control, trip and alarm and with mA output suitable for remote and supervisory measuring of winding temperature. It shall be connected to a resistance (platinum 100 W at 0°C) inside a stainless steel tube placed in a pocket located in the top oil capillary.

The characteristics of the winding temperature indication devices shall be forwarded to KETRACO for approval prior to the delivery of the transformers and shall also be included in the operating and maintenance instructions.

- A dial type oil thermometer with two (alarm/trip) adjustable contacts shall be mounted in the control cubicle. It shall be of conventional construction with a sensing bulb positioned in a separate pocket arranged in the top oil capillary and connected with a dial.
- An oil thermometer, connected to a resistance (platinum 100 W at 0°C) inside a stainless steel tube placed in a pocket located in the oil, suitable for remote and supervisory measuring.

All indicating instruments shall have hard glass front covers.

Note: The above describes protection for medium and large transformers; distribution type and small transformers may have reduced requirements typical of the industry standard.

13.3.15 Topping Up with Oil and Drying Out on Site

If oil is to be added to a transformer at site prior to commissioning, the oil in the transformer shall first be tested for dielectric strength and water content and each container of additional oil shall be similarly tested. All tests shall be witnessed by KETRACO.

Should it be found necessary to resort to oil treatment before a transformer is commissioned, the Contractor shall submit to KETRACO, in writing, a full description of the process to be adopted, the equipment to be used and statement of the precautions being taken to prevent fire or explosion. Similarly, if a transformer should arrive on site without positive pressure of gas in the tank, it shall be dried out at Site at the Contractor's expense using a heating and vacuum process, which has been approved by KETRACO. Insulation resistance values shall be taken throughout the drying process to indicate clearly the point of full moisture removal.

Clear instructions, in English shall be included in the Maintenance Instructions regarding any special precautionary measures, which must be taken before vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand vacuum treatment shall be provided for each type of transformer. The maximum vacuum which the complete transformer, filled with oil, can safely withstand without any special precautionary measures being taken shall be stated in the Maintenance Instructions.

13.3.16 Control Cubicles

Each transformer shall be fitted with a control cubicle of welded galvanized sheet steel housing, mounted on the transformer tank, in a position easily accessible from the ground level. The cabinet shall contain all control and protective equipment for the cooling system, as well as the termination of all secondary circuits.

The internal arrangement of the cabinet shall keep the various circuits clearly separate from each other, permitting easy and safe independent maintenance and repair of each of them without disturbing the others.

Additionally, for the power transformers, tap-changer cubicle for local control shall be provided as required in previous clauses.

All control cubicles shall be of IP 65 degree of protection, weather, vermin and insect-proof with sufficient ventilation and equipped with humidity controlled heating and sufficient illumination switched on and off by door contacts as well as one socket outlet 240V a.c, 16 A. Separate sunshades shall be provided for each cubicle. Wherever applicable, window panels shall be fitted with laminated glass only.

13.3.17 Corrosion Protection and Painting

The corrosion protection and painting shall meet requirements as stated elsewhere in the tender documents.

Conservator vessel^(note 1), radiators, fan grills^(note 2), pipework, control boxes or cubicles, marshalling cubicles shall be hot-dip galvanized and painted.

Note 1: Where these are too large to galvanise, the same corrosion protection treatment as the tank shall be used.

Note 2: Not applicable to stainless steel grills.

The proposed method for tank corrosion protection manufacturer shall submit for approval.

External surfaces shall be treated with anticorrosive and water-resistant paint and internal surfaces with oil-resistant anti condensation paint.

In any case the manufacturer shall submit for approval the proposed painting coats with their chemical content and recommended application guide of the manufacturer.

The equipment must be so designed that any features that may encourage the formation of rust, are avoided.

13.4 Performance Guarantees and Rejection

The Contractor shall guarantee that the transformers comply with the performance stated in the Technical Schedules. Tolerances shall not exceed the values specified in IEC 60076 or those given in the Technical Schedules.

The loss evaluation is to be applied at the maximum ratings and at the principal tap positions.

13.4.1 Performance Evaluation (Bid Stage)

The evaluation regarding load and no-load losses will be performed according to the following criteria. For every one kW in excess of the offered transformers with the lowest loss the price of the same type of proposed transformer shall be increased by: (Same as what specified in clause 1.7 of Section III)

- \$ 9000 (nine thousand US Dollar) for no-load losses (P_o)
- \$ 4000 (four thousand US Dollar) for load losses (P_k)

13.4.2 Penalties for Deviation from Losses Guarantees

After Factory Acceptance test, if any case of the tested load loss and no-load loss values differ from the guaranteed ones, the below penalties will be applied as liquidated damages. for every one kW exceeding the guaranteed value as per Technical Schedules the Contractor will pay:

- \$ 9000 (nine thousand US Dollar) for no-load losses (P_o).
- \$ 4000 (four thousand US Dollar) for load losses (P_k)

13.4.3 Penalties for Deviation from Temperature Rise Guarantees

The temperature rise of windings shall be determined by type test. If, according to the results of the tests carried out within the scope of the Contract, the measured temperature rise exceeds the guaranteed value, the price for all transformers shall be reduced as a compensation for decreased life expectancy. The compensation shall be computed as follows:

Temperature Rise Over the Admissible Limit (K)	Compensation in Percent of the Total F.O.B. Price of the Transformer
0 – 1.99	0
2 – 2.99	4.5
3 – 3.99	9.0
4 – 5.00	13.5

No additional payment will be payable for measured temperature rise of less than the guaranteed maximum.

KETRACO may during tests at works, reject a power transformer for the following reasons:

- If any of the losses exceed 10% of the guaranteed values or do not fulfil the requirements of clause 1.7.e of section III (Specific additional evaluation criteria);
- If the impedance voltage exceeds tolerance values specified by IEC of the guaranteed value;
- If the temperature rise exceeds more than 5 K of the prescribed values.

13.5 Fire Protection

The manufacturer shall include in his offer a suitable fire protection for Main Transformers (equal to and above 100 MVA), using Nitrogen Injection and Oil Evacuation System (NIFPS) as per KETRACO, KEBS, IEEE 979, NFPA 850 requirements, Detailed requirements have been mentioned in clause No. 18.25.6.

Nitrogen Injection and Oil Evacuation System shall be designed, installed and tested in accordance with NFPA/IEC, consisting of:

- Fire Extinguishing Cubicle (FEC),
- Control box,
- Fire detectors
- Signal box,
- Transformer Conservator Isolation Valve (TCIV) and oil drain pipe suitable for transformer oil quantity,
- Electrical Resistance Welded pipes with support & fitting as per standard norms for connection between transformer & FEC,
- Electrical resistance welded Gas Injection pipes & fittings as per standard norms for oil connection between FEC and oil pit,
- Fire survival cables and Fire Retardant Low Smoke (FRLS) Armored Cables,
- Erection, testing, commissioning (including all civil (Plinth of FEC & Oil Pit), structural work, electrical, mechanical, instrumentation jobs) of Nitrogen Injection Fire Protection systems cubicle.

Complete systems, complying to the relevant NFPA standards, shall be provided with all components required for smooth automatic operation.

Manual release by means of release valves in break glass boxes must also be possible.

Such break glass boxes shall also be provided next to each individual transformer.

All pipe work shall be made of seamless steel and hot-dip galvanised. The threaded ends of galvanised pipes shall, after installation, be properly protected against corrosion and painted with red paint, RAL 3000.

Drains and vents shall be provided as required.

Adequate drainage for the area to be protected shall be arranged for safe disposal of escaping flammable liquids and to prevent the spread of fire.

Fire department connections shall be provided as required by NFPA.

Hydraulic calculations shall be provided.

The transformers shall be protected by fire barrier walls as described in the civil works section clause 17.22.11.

13.6Online Condition Monitoring

For all transformers rated 100 MVA and above, the manufacturer shall include in the offer a modern Transformer Monitoring System with the following minimum features:

DGA detection— It shall be suitable for three fault gases (H₂, CO, C₂H₂). The sensor shall use the principle of gas chromatography. The transformer DG unit must extract transformer oil from the transformer through suitable pump, and return the oil back into the transformer as needed. It shall have the feature of periodic self-calibration for accuracy of measurement.

Moisture in Oil sensor; bidder shall offer composite unit for dissolved gas and moisture in oil

- A remote temperature device for measurement of top-oil temperature & winding temperature.
- Load current measurement via a current transformer on HV side or LV side

OLTC monitoring unit-Tap Changer monitoring system shall be able to communicate with the central OLCM system

The system shall be equipped with a modem and Ethernet outputs for connection to the substation communication system.

Further details are specified in the Technical Data Sheets.

13.7Transformer Inspection and Testing

13.7.1 General

All tests shall be performed in accordance with IEC 60076, IEC 60060, IEC 60270 and other relevant IEC Standards.

13.7.2 Factory Tests

Routine and Type tests shall be generally in accordance with the requirements of IEC 60076-1, -2, -3, -4, -5 and -10 appropriate to the voltage class of the transformer under consideration. Additionally, some tests in the class

identified as 'Special' in IEC 60076 are included, which may in practice be effectively a Routine or Type Test, as appropriate. These are included in Clause 13.7.5.

The following list of tests is generally in accordance with the requirements for Large and Medium classes of transformers; further data will be included in the Technical Schedules.

13.7.3 Routine Tests

Tests which include partial discharge measurements shall be made after the principal dielectric withstand tests and after temperature rise type tests.

The following routine tests shall be performed:

1. Measurement of winding resistances of all phases (phase to neutral, where applicable) and at all tap positions
2. Measurement of voltage ratio and check of voltage vector relationship
3. Measurement of impedance voltage (principal tapping) short-circuit impedance and load loss.
4. Dissolved gas-in-oil analysis by chromatography prior to dielectric tests and after completion of dielectric tests
5. Measurement of no-load losses and no-load current at rated frequency and nominal voltage.
6. Lightning impulse (LI) withstand test: Transformers with HV $U_m > 72.5$ kV.
7. Switching Impulse (SI) withstand test: Transformers with HV $U_m \geq 245$ kV
8. Induced-voltage test with partial discharge measurement.
- a. Long Duration AC (ACLD): $U_m \geq 245$ kV

The test steps U_1 (withstand level) and U_2 (PD measurement level) will be at the enhanced values of $1.8 U_m$ and $1.6 U_m$ respectively. The test sequence and PD limits shall be as given in IEC 60076-3. The phase to ground test values for transformers with HV windings rated at 220 kV and 400 kV are given in the following table.

HV U_r (kV)	HV U_m (kV)	U_1 (kV)	U_2 (kV)	PD test duration (minutes)	Max PD (pC)
220	245	255	226	30	500
400	420	436	388	60	500

- b. Short Duration AC (ACSD): $U_m \leq 170$ kV
9. Separate source voltage test.

10. Tests on on-load tap-changers.
11. Oil test and function tests of auxiliary equipment.
12. Measurement of insulation of core.

13.7.4 Type Tests

The following type tests shall be performed:

1. Temperature Rise Test
These tests shall be carried out with the transformer at tap positions giving highest losses and with the standby cooling unit out of service.
2. Dissolved gas-in-oil analyses by chromatography prior to and after the temperature rise test
3. Lightning Impulse (LI) test ($U_m \leq 72.5 \text{ kV}$)
These tests shall be carried out in accordance with IEC Recommendations on the HV and LV line terminals and on the neutral terminals. Tap-changers shall be in the position of minimum, principal and maximum tap as each phase is tested in turn (A-B-C).
4. Switching impulse (SI) tests are applicable as a Routine Tests on transformers having an HV $U_m \geq 245 \text{ kV}$. There is currently no requirement to apply this test as a Type Test at $U_m < 245 \text{ kV}$.
5. Short-circuit: In-lieu evidence from demonstrably similar units and/or mechanical and thermal calculations shall be provided to demonstrate clear margins of short-circuit current withstand at system fault levels for all transformers. All tests and calculations shall be fully in accordance with IEC 60076-5.

13.7.5 Special Tests

The following 'special' category tests shall be performed only when specified in the Schedules of Technical Information and may be on each unit (equivalent to a routine test) or on one unit (equivalent to a type test) as indicated:

1. Dielectric tests in accordance with IEC 60076-3; tests appropriate to the HV side transformer voltage class are identified under Routine and Type Tests and in the schedules. In terms of the system voltages, the applicable special dielectric tests are:
 - a. Chopped wave lightning impulse. This test is a requirement at all system voltages on line terminals and shall be at 110% of the full wave impulse level. (Type or routine test as appropriate to transformer HV U_m .)
 - b. $U_m = 145 \text{ kV}$: The long duration AC (ACLD) is a special optional test at this voltage, in the manner of a routine test, i.e. on all transformers when specified. Unless otherwise specified, this will not be required on KETRACO contracts

- c. $U_m = 245$ kV: The short duration AC (ACSD) is a special option at this voltage, in the manner of a routine test, i.e. on all transformers. (Note: In accordance with IEC 60076-3, if the ACSD is specified the requirement for a routine switching impulse test is deleted.)
 - d. $U_m > 245$ kV: The ACSD test may be included as special option as an additional routine test. Unless otherwise specified, this will not be required on KETRACO contracts
2. Measurement of zero-sequence impedance: Routine test for all transformers with U_m equal to or greater than 12 kV.
 3. Determination of sound levels to IEC 60076-10: Type test for all transformers with U_m equal or greater than 12 kV.
 4. Measurement of the harmonics of the no-load current: Routine test for all transformers with U_m equal to or greater than 36 kV.
 6. Measurement of the power by the fan motors and oil pumps (Power Transformers): Type test.
 7. Determination of capacitance, windings to earth and between windings: Routine test for all transformers with U_m equal to or greater than 36 kV.
 8. Measurement of insulation resistance to earth and loss angle of insulation system capacitances: Routine test for all transformers with U_m equal to or greater than 36 kV.

13.7.6 Site Tests

The following tests, after installation on Site shall be performed:

1. Verification of correct and complete erection.
2. Verification of the soundness of porcelain surfaces and sealing.
3. Verification of correct connections to the earthing system.
4. Checking of auxiliary and control wiring and cabling and operation of all electrical LV equipment.
5. Voltage tests of all electrical LV circuits.
6. Verification of the operation of the cooling system.
7. Measurement of the physical, chemical, and electrical characteristics of the oil after filling and shortly prior to transformer energization.
8. Verification of turns ratio with measurement of charging current using an L.V. supply:
9. Resistance measurements of windings with records of oil & ambient temperatures.
10. Insulation resistance tests.

11. Frequency response analysis (FRA-test) with a DOBLE-SFRA device (or equivalent) using swapped frequency in a range of 10 Hz to 2 MHz. The measurements shall be taken with tap changer at tap position "1".
12. Oil tightness test on tank assembled with radiator 0.3 bar over oil level, 24 hrs (on oil-filled cable termination boxes at 0.2 bar, 5hrs.
13. Measurement of Winding Insulation Resistance (R15s, R60s, R180s, R600s). The absorption ratio R60/R15 shall not exceed 3.0 (R10/R1 shall not exceed 1.1 according to American Standards) after oil-treatment. Results shall be compared with the factory test results.

and other necessary checks and verifications.

13.7.7 Tests on Transformer Components

Tests during and after manufacture shall be carried out on the transformer components in order to verify compliance with the Specifications, good workmanship and their capability to perform the required duties when in service.

Unless otherwise specifically mentioned these tests shall be made in accordance with the one of the applicable international standards, subject to the approval of KETRACO, or according to a method proposed by the Contractor and approved by KETRACO.

13.7.8 Transformer Tanks

13.7.8.1 Type Tests

Vacuum:

One transformer tank, tap changing compartment, radiator and cooler of each size shall be subjected when empty of oil to the vacuum test level specified in the Schedules. There shall be no permanent deflection of the stiffeners, nor shall the permanent deflection of the panels exceed the value specified in the following table:

Major dimension of panel between Stiffeners meters vertical or horizontal	Maximum permanent deflection
Up to 1.5 m	3 mm
1.5 m – 3.0 m	8 mm
Above 3.0 m	13 mm

A further test at a vacuum equivalent to 3 m bar absolute pressure for a period of 8 hours shall be made for the purpose of checking the mechanical withstand capability of the tank; during this test no damage or fractures shall occur. This test is only applicable to units of 220kV and above and may be combined with other tests or made during the processing of the unit.

Pressure:

One transformer tank of each size shall be subjected to a pressure corresponding to the normal pressure plus 35 kN/m². After the release of the excess pressure there shall be no permanent deflection of the stiffeners nor shall the permanent deflection of panels between stiffeners exceed the value specified in the above table. This test may be combined with a routine oil leakage test.

The tap changer barrier shall be shown to withstand an over pressure test of normal pressure plus 35 kN/m² for 12 hours.

Pressure Relief Device:

When required by KETRACO one pressure relief device of each size shall be subjected to increasing oil pressure and shall operate before reaching normal pressure plus 35 kN/m².

The operating pressure shall be recorded on the test certificate.

13.7.8.2 Routine Tests

Oil leakage - All tanks and oil filled compartments including all forms of radiator shall be tested for oil tightness by being completely filled with oil of a viscosity not greater than that of IEC 60296 insulating oil at a temperature of 150°C and subjected to a pressure equal to the normal pressure plus 35 kN/m². This pressure shall be maintained for a period of not less than 24 hours, during which time no leakage shall occur.

The tap changer barrier shall be subjected to normal oil pressure head for 24 hours, during which time there shall be no leakage from the panel or bushings.

Detachable radiators may be tested as separate units.

13.7.9 Fans, Motors, Pipework, Oil Sampling Devices and Valves**17.7.9.1 Type Tests**

Motors - Performance tests shall be in accordance with IEC 60034-1 however, certificates of type tests in accordance with IEC will be accepted.

Except for non-return valves, all valves and oil sampling devices which are subject to oil pressure in service or during maintenance shall withstand, when empty of oil, absolute pressure not exceeding 350 m bars. In the case of valves this test is to be applied to the body only. This type test shall subsequently be followed by a repeat oil leakage test.

13.7.9.2 Routine Tests

Oil filled equipment - The bodies of all oil pumps complete with submerged motors, if any, and the oil pipework, oil sampling devices and valves shall withstand an hydraulic pressure of 140 kN/m² for 15 minutes.

Fans - Static and dynamic balance shall be checked on all fan impellers.

Control gear - All control gear shall be subjected to the tests specified in the appropriate IEC.

Motors - Each machine shall be subjected to the following tests where applicable:

1. Measurement of winding resistance (cold).
2. No load test at rated voltage for determination of fixed losses.
3. An overvoltage test at 1.5 times rated voltage applied with the machine running at no load, for a period of 3 minutes, to test interturn insulation.
4. High voltage in accordance with IEC 60034-1.

13.7.10 Oil

13.7.10.1 Sample Tests

Samples of oil from each consignment shall be tested in accordance with IEC 60296 before despatch.

Subject to the agreement of KETRACO a test certificate, confirming that the oil from which the consignment was drawn has been tested in accordance with IEC 60296, may be accepted. Before commissioning any transformer, the electric strength of its oil shall be check-tested and the results approved by KETRACO.

13.7.11 Gas and Oil Actuated Relays

13.7.11.1 Routine Tests

The following tests shall be made on relays when completely assembled. Where oil is referred to, it shall have a viscosity not greater than that of IEC 60296 insulating oil at 150°C.

Oil leakage - The relay, when filled with oil shall be subjected to an internal pressure of 140 kN/m² for 15 minutes. No leakage shall occur either from the casing or into normally oil free spaces, such as floats, within the casing.

Gas Collection:

1. With the relay mounted as in service and at a rising angle of 5 degrees (tank to conservator) and full of oil, gas shall be introduced into the relay until the gas collection contacts close. The oil level contacts shall not close when gas is escaping freely from the relay on the conservator side. These contacts shall, however, close when the pipework is empty of oil.
2. The empty relay shall be tilted, as if mounted in pipework rising from tank to conservator, at an increasing angle until the gas collection contacts open. The angle of tilt shall then be reduced and the gas collection contacts shall close before the angle is reduced to less than 13 degrees to the horizontal.
3. With the relay mounted at a falling angle of 16 degrees to the horizontal and full of oil, the gas collection contacts shall be open.

Oil surge - with the relay mounted as in service and full of oil at approximately 150°C, the surge contacts shall close within the steady oil flow limits specified in the Schedules. This operation shall not be adversely affected when the gas collection contacts have already closed and gas is escaping freely.

Voltage - with the relay empty of oil, a voltage of 2kV shall be applied in turn between each of the electrical circuits and the casing for one minute, the remaining circuits being connected to the casing.

13.7.11.2 Sample Test

At the discretion of KETRACO, the following tests shall be made:

13.7.12 Variation of performance with mounting angle with the mounting conditions as in service, the mounting angle shall be varied within the rising angle limit 10 and 90 and tests repeated in the manner prescribed for the routine tests.

13.7.13 Voltage Control Equipment

Type and routine tests shall be carried out in accordance with IEC 60214.

13.7.13.1 Tests on Bushings

It is not intended to test the bushings separately during the transformer factory tests.

All bushings supplied including spares, shall be supplied with full documentation in accordance with IEC 60137 and/or IEC 61639, plus additional items as follows:

1. Routine test certificates. All condenser-graded bushings shall have a routine lightning impulse withstand test of five full wave negative impulses at a level not less than the transformer rating.
2. Type test reports, which shall include confirmation of creepage distance and pollution tests. The lightning impulse type test shall include chopped impulses and is applicable to all condenser-graded bushings.
3. Bushing temperature rises shall be based on local ambient temperatures.
4. Installation and maintenance instructions

13.7.13.2 Structures

A representative sample of each type of support structure being provided shall be assembled prior to despatch to site, and loads applied which simulate the specified design parameters.

13.7.13.3 Galvanizing

Samples selected by KETRACO of all galvanized material shall be subjected to the galvanizing tests set out in BS EN 10244-2 (Testing of Zinc Coating on Galvanized Wires) or BS EN ISO 1461 (Testing of Zinc Coating on Galvanized Articles other than Wire) whichever is applicable.

13.7.14 Handling Devices and Lifting Tackle

13.7.14.1 Routine Tests

Mechanical Tests:

All handling devices and lifting tackle supplied for maintenance purposes under this Contract shall, unless they are built into and form part of the equipment, be tested and marked and certificates of the test provided in the manner required by the appropriate regulations.

Operational Tests:

Lifting tackle built into and forming part of the equipment shall be operated with the maximum working load to the IEC or BS Specifications.

13.7.15 Dielectric Tests on Auxiliary and Control Circuits

All secondary wiring, including panel wiring and control circuits and all apparatus connected directly thereto shall withstand a high voltage test of 2000V to earth unless otherwise specified.

13.8 Installation/Dismantling Requirements

The transformer shall be designed for outdoor installation;

Arrangements are to be provided for the hauling of transformers.

13.9 Packing, Shipping and Transport

If the transformer is to be transported with oil it shall be filled to such a level as to cover the windings completely.

If the transformers are to be shipped without oil, the tank shall be filled with dry nitrogen gas, and automatic pressure regulating equipment shall be provided to maintain the pressure of the gas. Transformers to be transported with gas shall be filled and maintained by the Contractor at a pressure in excess of atmospheric pressure until the gas is replaced by oil. The gas pressure before despatch and upon receipt on site shall be recorded. Means shall be provided for measuring the pressure in the tank.

Where oil for the first filling is to be provided it shall be supplied by the manufacturer in non-returnable drums.

All openings for transformer components, e.g. bushings which have been removed from the transformers during transport, shall be covered by blanking-off plates. Condenser type bushings shall be shipped with self-contained oil filled tanks. Transformers shall be equipped with instruments to register "Shock" loading suffered during transit.

Transformers shall be equipped with Impact recorders (to record acceleration values of vibration and shock) of KETRACO approved type.

Manufacturer shall advise for the acceptable "shock" limit criteria prior to transformers shipment.

Impact recorders (impact recorders with electronic data storage), capable of indicating all horizontal and vertical impacts, shall be rigidly attached to each transformer.

Provisions must be made to ensure that these indicators are sealed, that they will be completely functional without interruption of indicated records during the entire period of shipment, including loading and unloading, and to ensure that KETRACO will receive clearly indicated data by breaking the seal. Instructions for interpretation of the recorded data and a user manual for the equipment shall be provided prior to shipment.

All parts shall be carefully packed for transport in such a manner that they are protected against mechanical injury and the injurious effects of water and climatic conditions encountered during transit to their destination, as well as during long storage before erection.

Manufacturers should give special consideration to five-limb transformers, which may require temporary support of the unwound limbs during transport.

The Contractor shall prepare and submit for the approval of KETRACO drawings and complete instructions about the means and methods to be used for the installing and removing of heavy equipment such as transformers.

13.10 Documentation with Bid

The Bid shall contain at least the following information and documents, failure of provision of the mentioned documents will lead to disqualification:

General arrangement drawings, showing particulars of all associated equipment and accessories, their overall dimensions, shipping and lifting dimensions, mass of the complete transformers, their components, and oil, etc. as well as details about the required foundations.

Schematic diagram of cooling system.

Manufacturing specification of the proposed types of transformers and associated equipment.

Reference lists of transformers of the same types as quoted, installed in similar climatic and service conditions.

Minimum five (5) written recommendations from clients/ utilities for previously, the last five years, supplied power transformers of similar or higher size.

Transportation methodology from port to site

Detailed description of core assembly comprising:

- Properties of materials used for the core and coil assembly,
- Core construction,

- Core clamps,
- Yoke/limb joints,
- Oil ducts.

Detailed technical information on the coil assembly including the following:

- Winding construction,
- Wire preparation and insulation,
- Interturn insulation,
- Taps,
- Coil clamping processing,
- Detailed description of facilities and methods proposed for carrying out the test,
- Descriptive catalogues and literature on the proposed types of transformers, protective relays and cooling systems.

Type test certificates from an independent testing authority or independently witnessed;

Quality Management System Manual and ISO Certificate of the equipment manufacturer.

14. Earthing / Auxiliary Transformers

14.1 General

Earthing/auxiliary transformers shall be in accordance with IEC 60076 and generally to the requirements of the Power Transformer section of this technical specification, as applied to transformers with a U_m of 12kV and with a rating up to 10MVA. This document gives supplementary specification for the class of Earthing/Auxiliary Transformer.

Earthing/auxiliary transformers shall be capable of withstanding for a period of 30 seconds the application of normal 3-phase line voltage to the line terminals of the interconnected star winding with one-line terminal and the neutral terminal connected solidly to earth.

The interconnected star winding of each earthing/auxiliary transformer, when at its maximum temperature due to continuous full load on the auxiliary winding, shall be designed to carry for thirty seconds without injurious heating an earth fault current not less than the full load lower voltage winding current of the main transformer to which it is connected or the following current, whichever is the greater:

- Lower voltage of main transformer kV 11
- Earth fault current required Amp. 1000

The earthing/auxiliary transformers shall have zero sequence impedance equal to the positive sequence impedance.

Where required, the transformers shall be protected by fire barrier walls as described in the civil works section of the Employers Requirements.

The Contractor shall verify the need for a earthing resistor to be installed in the primary star point connection to earth. The supply and installation of these resistors, if needed, including cubicles and all accessories, shall be included in the contract price.

14.2 Construction

The construction and general requirements of the earthing/auxiliary transformers shall be in accordance with that specified for 2-winding transformers with ratings up to 10MVA in of the Power Transformer section of this technical specification. This includes but is not limited to the following features:

- Off-circuit tap-changer with $\pm 5\%$ voltage variation in 4 equal steps
- ONAN cooling
- Oil preservation system: May be conservator with Buchholz and dehydrating breather or sealed type (gas cushion or corrugated tank). Where corrugated type is offered, the manufacturer shall provide adequate reinforcement to prevent damage during transport, installation and service.
- HV connections shall be housed in an air-filled cable box suitable for separable connectors for XLPE cable; these shall be of the Euromold type or equivalent.
- The LV (auxiliary) terminals of the earthing/auxiliary transformer shall be brought out into a weatherproof cable box fitted with a lockable, hinged lockable door. The cable box shall incorporate an adequately rated fuse-switch unit suitable for cable connections.
- The installation of protective current transformers (CTs) in primary and secondary neutrals is required. CT details including class and rating are included in the Technical Data Sheets. Primary located CTs shall be located in-tank.

14.3 Testing

Routine and Type tests shall be generally in accordance with the requirements of IEC 60076-1 and IEC 60076-3, appropriate to the voltage class of the transformer under consideration. Additionally, some tests in the class identified as 'Special' in IEC 60076 are included, which may in practice be effectively a Routine or Type Test, as appropriate.

14.3.1 Routine Tests

The following routine tests shall be performed:

- Measurement of winding resistances at all tap positions
- Measurement of voltage ratio and check of voltage vector relationship

- Measurement of impedance voltage (principal tapping) short-circuits impedance and load loss.
- Measurement of no-load losses and no-load current at rated frequency and nominal voltage.
- Induced-voltage test with partial discharge measurement.
- Short Duration AC (ACSD)
- Separate source voltage test.
- Oil test and function tests.
- Measurement of insulation of core.
- Measurement of insulation resistance (R15, R60, R600) at 2500 V DC. The polarisation index R10min: R1min shall not be less than 1.0.
- Measurement of ratio and polarity check of current transformers

14.3.2 Type Tests

The following type tests shall be performed:

Temperature Rise Test: This test shall be carried out with the transformer at tap positions giving highest losses. The temperature rise qualification of the earthing/auxiliary transformers shall be based on the sum of two factors; the first is a test in accordance with IEC 60076-2, at the auxiliary rating when the temperature rises of the main and auxiliary windings will be measured. The second factor will be the calculated rise according to IEC 60076-5 at the 30-second duty rating. The total temperature rise will be the sum of both figures and the overall winding temperature shall be less than 250°C.

Lightning Impulse (LI) test: This test shall be carried out in accordance with IEC 60076-3 on the HV and neutral terminals. Tap-changers shall be in the position of minimum, principal and maximum tap as each phase is tested in turn (A-B-C).

In-lieu evidence from demonstrably similar units and/or mechanical and thermal calculations shall be provided to demonstrate clear margins of short-circuit current withstand at system fault levels for all transformers. All tests and calculations shall be in accordance with IEC 60076-5.

14.3.3 Special Tests

The following 'special' category tests shall be performed when specified the Schedules of Technical Information and may be on each unit (equivalent to a routine test) or on one unit (equivalent to a type test) as indicated:

- Measurement of zero-sequence impedance: (Routine test)
- Determination of sound levels to IEC 60076-10: (Type test).
- Measurement of the harmonics of the no-load current: (Routine test).

14.4 Documentation

14.4.1 Documentation with Bid

The Bid shall contain at least the following information and documents, failure of provision of the mentioned documents will lead to disqualification:

1. General arrangement drawings;
2. Manufacturing specification of the proposed types of transformer;
3. Catalogues, literature and reference lists of proposed equipment;
4. Type test certificates from an independent testing authority or independently witnessed;
5. Quality Management System Manual and ISO Certificate of the equipment manufacturer.

14.4.2 Documentation after Award of Contract

All documents required for KETRACO's approval shall be submitted by the Contractor.

15. Optical Fibre Cable for Pilot & Telephone/ Data Application

15.1 Scope

This specification details the requirements for the design, manufacture and testing of optical fibre cable and accessories for application as Pilot & Telephone/data cable with EHV power cable circuits.

IP-Phones & integration telephone system shall be provided.

Fiber Optic and Multiplex equipment for Tele-protection, voice and data communication between substations to be provided according to KETRACO requirements.

15.2 FO Cable and Accessories

This section contains equipment requirements for pilot fibre optic cable and accessories. Design criteria shall be in accordance with IEC 60793-1, 2 60794-1, 2 and ITU-T (G.655) recommendations as well as Telecommunication system requirements Type test certificate for the fibre optic cable is required.

15.2.1 Fibre Optic Pilot Cable

The Contractor shall include design, manufacture, supply, installation including hardware and splicing, supply of spares, testing, commissioning, remedying of defects, and maintaining the works during the defect liability period and any incidental work necessary for the proper completion of the work in accordance with the Specification.

The fibre optic pilot cable shall have the following main characteristics:

- Fibres contained in loose tube.

- The fibre shall be of single mode type according to ITU-T Recommendation G.655 suitable for transmission of information at the ITU-T recommended rates of either 2, 8, 34, 140, 155 or 622 Mb/s.
- The fibre shall have dual operative windows, at 1550 nm and 1625 nm.
- Minimum of 48 fibre cores.
- Maximum optical attenuation shall be 0.22 dB/km for 1550 nm, and 0.24 dB/km for 1625 nm.

Each individual fibre shall be colour coded for identification purposes, with details of the colour coding scheme adopted being provided in the Tender.

The Tenderer shall provide a drawing showing a cross-section of the cable indicating the dimensions of each element it contains. The drawing shall provide a clear illustration of the design and make-up of the cable. Technical descriptions detailing the fibre optic cable performance shall be provided.

All necessary civil works and installation materials required to complete the fibre optic cable system shall be included in the Contract.

All fibre optic cables shall have a design life of at least 25 years.

15.2.2 Fibre Optic Joint Closures

Fibre optic joint closures for fibre optic communication / pilot cables (if any) shall have the following characteristics

Splice capacity	min. 48 fibres with a loose buffered
Installation alternatives	direct buried, in manholes, on portal supports
Attenuation	max 0.05 dB/splice

15.2.3 Optical Terminal Boxes

Optical terminal boxes for fibre communication and approach cables shall have the following characteristics

Capacity	min. 3 fibre optic cables, each with 48 fibres
Installations	wall - mounted type
Attenuation	0.5 – 1 dB/per connector
	0.05 dB/per splice

Optical connectors

F.C. - P.C. type

15.3 Installation

15.3.2 Fibre Optic Cable

The following requirements shall be fulfilled:

- The cables shall be laid in plastic ducts (diameter approx. 40 mm), buried in the ground, using "blow-in" technique.
- Fibre optic pilot cables shall be laid in the same trench together with a power cable.
- Trenches shall be excavated to form straight lines running parallel to the building grid lines, wherever possible. Cables shall be routed in accordance with tender drawings and KETRACO's instructions.
- The plastic duct with the cable shall be laid over a bed of sand, approx. 200 mm thick.
- Joint closure (if any) shall be installed at every 1.5 km (delivery length, approximate average value) in the same joint pit with power cables.
- Backfilling of the trenches shall not commence until the cables have been inspected by KETRACO. Backfilling shall be carried out in layers not thicker than 150 mm and shall be well consolidated by punning of each layer.
- Each cable shall be protected from mechanical damage over the entire buried length by means of reinforced concrete covers. The covers shall have a minimum width of 150 mm and shall interlock to resist lateral displacement following installation. The covers shall be laid centrally approximately 200 mm above the cable during backfilling of the trench.
- The design of the hydraulically pressed concrete covers shall be subject to approval by KETRACO.
- Cable warning tape shall be installed 250 mm above the cable covers during backfilling of the trench. The tape shall be manufactured from high grade PVC and shall be 150 mm wide with a minimum thickness of 0.1 mm. The tape shall be bright coloured with warning messages printed in black continuously along its length. The printing shall be minimum 200 mm high; the wording shall be subject to approval of KETRACO. The printing shall be fully resistant to deterioration effects of direct burial.
- Where the cable passes under a roadway, reinforced concrete trench or similar structure, as indicated on the site layout drawings, the Contractor shall supply and install PVC ducts of approximately 110 mm diameter, rather than 40 mm diameter.

15.3.3 Optical Fibre Joints

The Contractor shall design, supply and install optical fibre cable joints. Each cable joint shall include termination box, mounting hardware, optical fibre splice kits, cable entry seals and all accessories required to produce a

permanent optical joint. Details of the proposed optical fibre joints shall be submitted by the Contractor for the approval of KETRACO.

Each termination box shall be capable of being hermetically sealed after jointing, and hermetically sealed after re-opening. The quality and type of termination boxes shall be determined by the Contractor and subject to approval by KETRACO.

Optical fibre splices shall be of the fusion type and the optical attenuation of each splice shall be less than 0.05 dB/splice.

15.3.4 Terminations

The interface between the fibre optical transmission system and the fibres of the optical cable shall be at the optical terminal boxes using low loss de-mountable optical connectors of the plug-in type. The maximum insertion loss for a pair of mated connectors shall be 0.25 dB.

In order to cater for system failures, system expansions and re-routing etc., manual patching facilities shall be provided.

Mating connectors shall be provided as part of the Contract. Caps shall be provided for each coupler to prevent dust ingress to the couplers of unused fibres. The Tenderer shall state the manufacture and type of connectors proposed. All connectors shall be so positioned to facilitate easy cleaning and inspection.

All spare fibres shall be terminated with appropriate optical connectors.

15.3.5 Cable Joint Enclosures

It is preferred that a universal joint enclosure is proposed for all types of cable. The enclosure shall provide adequate protection for splices, and shall provide storage for sufficient length of fibre for at least ten future splices. The size of the enclosure shall be of sufficient size to meet the minimum bending radius requirement of the fibre optic cable.

The enclosure shall either be made from a high stability polypropylene material, or constructed from metal. Where metal is used, all surfaces shall be protected by galvanising. The enclosure shall be made weatherproof by the use of a corrosion-resistant sealing compound. Where metal is used, an integral earth terminal shall be provided.

15.3.6 Optical Terminal Boxes

Optical terminal boxes (OTBs) shall be provided by the Contractor to facilitate the termination of incoming fibres into the substation.

The OTBs shall be wall mounted in the substation telecommunication room. Optical fibres shall be terminated by detachable connectors, complying with the requirements of IEC 60874, at the optical terminal box and shall be properly labelled with fibre identity, destination or source, go or return.

All fibre terminal boxes shall have an earth connection provided, and shall be protected from corrosion by painting or galvanising.

At the overhead line (OHL) to EHV power cable interconnection point, the fibre optic cable and the OPGW shall be joined in splice boxes located on the tower legs at the locations where the fibre optic cable and OPGW are dead ended. The supply and installation of the splice box is part of the Lot 2 Contractor scope of works.

15.4 Testing

15.4.2 Type Tests

The type tests as specified here shall be carried out in the presence of the Engineer's Representative on the complete item of each kind of equipment at the Manufacturers works in accordance with the latest revision of relevant ITU -T and IEC Publications, except where otherwise specified. The test results shall be furnished to the Engineer for consideration after conclusion of tests.

The following type tests shall be performed:

For the Optical Fibre Pilot Cable (before assembly)

1. Mode Field Diameter Test (variable aperture ITU-T G655)
2. Cladding Diameter and Non-circularity Test (near field ITU-T G655)
3. Mode Field Concentricity Error Test (near field ITU-T G655)
4. Tensile Strength Test (Weibull IEC 60793-1 UTS measurement)
5. Microbending Sensitivity Test
6. Torsion Test
7. Flexing Test
8. Abrasion Test
9. Spectral - Attenuation Cutback test (cutback ITU - T G 655)
10. Chromatic Dispersion Test (phase shift variation ITU-T G655)
11. Cut-off Wave-length Test (multi-mode reference ITU-T G655)
12. Point Defects Test (backscattering ITU-T G655)
13. Temperature Cycling Test (transmitted power IEC 60793-1)
14. Min. /Max. Temperature Test (to be done under the temperature cycling test)
15. Temperature - Shock Test (to be done under the temperature cycling test)
16. Temperature dependence of attenuation test (to be done under the temperature cycling test)
17. Accelerated Oxygen Ageing Test

For the completed Fibre Optic Pilot Cable:

1. Overall Diameter measurement
2. Optical Cable Length measurement
3. Bend, low and high temperature test (IEC 60794 1 E11)
4. Cyclic Flexing test (IEC 60794 1 E6)
5. Impact Test (IEC 60794 1 E4)
6. Compressive Loading and bending Test
7. Tensile, loading and bending test (IEC 60794 1 E1)
8. Spectral-Attenuation Cutback Test and Backscatter Light Test (IEC 60793 - 4)
9. Temperature Humidity Cycling Test (IEC 60794 1 F1)
10. Cut-off Wavelength Test (ITU - T G650)
11. Accelerated Oxygen Ageing Test

Type test for:

1. Optical Joint Box, and
2. Optical Terminal Box

shall be carried according to IEC Publications, where applicable.

15.4.3 Routine Tests

The routine tests shall be carried out on all drums of cables to be supplied in accordance with the requirements set out in the relevant ITU-T and IEC Publications. The test results shall be furnished to the inspector for consideration immediately after conclusion of tests.

The following test shall be performed:

1. Overall Diameter Measurement
2. Length of Fibre Measurement
3. Cable Length Measurement
4. Fibre Point Defects Test
5. Fibre Attenuation Test

Routine test for:

1. Optical Joint Box, and
2. Optical Terminal Box

shall be carried out according to IEC Publications, where applicable.

15.4.4 Special Tests

The full set of the routine tests shall be repeated on the selected drums among the drums ready for shipment in the presence of the Engineer.

15.5 Commissioning

On arrival on site and during and after completion of erection, all cable drums shall be inspected and tested to insure that there shall be no delay in commissioning due to supply of incorrect or damaged equipment. The site tests are subdivided into two stages:

- Test During and After Installation, and
- Commissioning Test.

In order to ensure correct installation of the equipment as well as to prove that the cables from all drums have been correctly installed, the following Tests During and After Installation shall be performed:

1. Fibre Optic Pilot Cable Length Measurement,
2. Verification of Fibre Optic Pilot Cable Continuity, and
3. Optical Attenuation Measurement.

The main objective of the commissioning tests is to check the proper and safe operation of the cable and in particular to verify and confirm performance guarantees as defined in the Technical Specifications and the Schedules of Technical Information.

The following commissioning test shall be done:

1. Optical Attenuation Test.

16.Civil Works

16.1 Description

This document describes in detail the standard building requirements for Substations. It outlines the issues and requirements that must be considered as part of the overall Substation design and planning process. By nature it is a generic specification and site specific details may be provided to supplement the advice within this document to suit the local environment and/or plant specific requirements.

The designer must have due regard at all times to designing a Substation that complies with all current Kenyan legislation and legal requirements.

Third party considerations, designers risk assessments, developer's requirements, government agencies, etc may influence the adopted design but it is essential that the requirements of this document are embedded within the final design of the Works.

16.2 General Scope

The principal function of the Civil design is to provide buildings, structures and civil infrastructure to house and support the electrical equipment and ensure a safe environment for operational and maintenance staff as well as the general public.

The general scope of civil works shall include but not be limited to the following:

- The work includes site clearance, site surfacing and back filling wherever needed and leveling.
- Contractor is obliged to send a model file with drawings and report calculation to be checked by Engineer. Documents specially the ones, which are related to buildings and structures, will be rejected if model files have not been sent.
- All buildings to be constructed and equipped as per bid drawings and scope, with reinforced concrete frames, masonry walling, bolted connections preferably (welding may be adopted for steel roof trusses)
- Concrete cable trenches to be provided as per bid drawings, if the drawings exist, or to the satisfaction of the Engineer
- Substation Control Building Civil works (including Excavation, concrete works, backfilling, and roofing) together with building services such as Lighting, Fire Detection and hand held capsule fire extinguishers, and access control
- Substation Guard House and Telecom Collocation Room Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services such as Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand held capsule fire extinguishers, Eyewash facility and access control
- Substation Diesel generator house Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services (e.g. Lighting, Small Power System, Fire Detection and hand-held fire extinguishers)

- Substation Storage Warehouse Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g. Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand held capsule fire extinguishers, Eyewash facility and access control, etc.
- Technical staff Housing Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g. Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand held capsule fire extinguishers, furniture and furnishing
- Security staff Housing Civil works (including Excavation, concrete works, backfilling, and etc.) together with building services e.g. Lighting, Small Power System, Water Supply and Sewage System, HVAC, Water Solar Heating, Fire Detection and hand held capsule fire extinguishers, furniture and furnishing
- Water supply system shall be improved. The contractor shall be required to connect to the existing water distribution system around the substation area. In case of lack of a water distribution system a borehole shall be sunk. The water supply for the control building and guard house is via an overhead tank. Main water reservoir of 30,000 litres (as minimum) capacity to be provided at Rumuruti SS , adequate to serve requirements of control building, staff housing, Regional office and guard houses, automatic level controls shall be provided. Also, 10,000 litres elevated water tanks shall be considered near the control building, Regional office and staff housing with required pumps to be fed from the main water reservoir. For Kabarnet substation additional 10,000 liters water tank shall be provided and interconnected with the existing water supply system. It is to be noted that water pums to be solar pumped.
- Fire Detection and Alarm System for Buildings
- Standard drainage system integration with the existing substation drawinage, including flood protection and storm water canals shall be implemented for complete dewatering of the compound and external storm water. Canals shall be surfaced by stone pitching. All waste drainage shall be taken to septic tank and soak away pit. The design for the plumbing and drainage system should ensure smooth operations in the substation.
- Flood protection and storm water canals around the whole substation perimeter for complete dewatering of the compound and external storm water. Canals shall be surfaced by stone pitching.
- Compound boundary wall/chain-link fence with barbed wire equipped with electric shock facilities for the substation plot, fencing, gates, concrete trenches/ tunnels/ duct banks, and etc. shall be constructed, which their design shall be subjected to approval of Client/Engineer.
- Retaining wall should be implemented when there is a considerable level difference in the site. In the extension substations, the existing retaining walls shall be extended for extension area to ensure the required stability of the equipment's foundation.
- Outdoor galvanized steel apparatus support structures and foundations, grading and leveling of the site and spreading of crushed aggregates over all unpaved areas.
- Foundations, concrete firewalls and oil pits for transformers and Earthing & Auxiliary transformers. Grading, Fencing, Oil pit sizing shall be based on approved calculations. In addition, burnt oil pit (common for a couple) transformers shall be provided and its sizing shall be subject to approved calculations. The transformer's and firefighting system shall be based on Nitrogen injection.
- Walkways of pedestrian, such as from gate to the control building, from parking to control building

- Internal access roads to switchyard and to buildings shall be implemented to bituminous standard. Necessary warnings / signage shall also be fixed. Suitable slopes / drains / manholes shall be provided for water to flow to the substation drainage system. The road shall have adequate lighting which is automatically controlled based on the ambient light intensity.

16.3 Guard House with Telecom collocation room

Effective area of this building shall be according to bid drawings in one floor with gable roof. Spaces are including: guard room, kitchen, ladies and gents' toilets and washrooms, customer equipment room, main equipment room and battery room, according to bid drawings. It shall be constructed using a reinforced concrete frame with in-fill, insulated block work walls and a reinforced concrete roof slabs. An outdoor lean-to sunshade with profiled steel sheet roof shall be provided for the water dowsers.

The telecom rooms are constructed next to the guard room to be known as the "Telecom Collocation Room" for the purpose of hosting other service providers who will be using KETRACO infrastructure such as OPGW fibres. The general scope of works for Telecom room shall entail:

- i. Construction of main and customer telecom collocation rooms;
- ii. Construction of cable tranches and covers from the main control building's telecom room to the Customer Equipment room;
- iii. Access road in concrete paving blocks finish;
- iv. General drainage works and rehabilitation; and
- v. Making good all disturbed areas.

The Telecom Collocation room shall contain the following rooms (with the respective minimum dimensions in meter Length*Width*Height and details as per bid drawing):

- Customer Equipment Room (with minimum dimensions 6.9m*5.2m*3.5m) – One double leaf entrance door (large enough to wheel in and out control cabinets), one single leaf door into the main Equipment Room, external windows (facing the substation) (1.2m*1.5m), one row of minimum 4 equipment cabinets each with overhead and underground cable trenches linking to the main control building telecom room and control and protection rooms.
- Main Equipment Room (with minimum dimensions 5.2m*2.5m*3.5m) – KETRACO equipment room with ODF cabinets.
- Battery/Storage Room (with minimum dimensions 3.5m*2m*3.5m) – One large door (minimum 0.9m wide large enough to wheel in and out equipment). The placing of this room shall also be away from public access and preferably facing the direction of the substation.
- Ladies and Gents Washrooms (with minimum dimensions 3.2m*2.8m*3m) –fitted with a fully functioning sink installed external between the washrooms. The access of these facilities shall be away from public and secured (preferably facing the direction of the substation and away from the road).

Telecommunication collocation Room

Area of this building shall be according to bid drawings in one floor with sloping roof. Spaces are including: customer equipment room, main equipment room, battery room, office and toilets according to bid drawings.

16.4 Control Rooms (CRs)

For the housing of the diameter's protection, control, metering and fault recorder cubicles, Control Rooms shall be foreseen.

The No. of cubicles shall be approved by the Client/Engineer and for each cubicle, a dimension of 2200mm height, 800mm width and 800mm depth is supposed.

16.4.1 Other Requirements

The Control Rooms shall be equipped with raised floor to house the power, control and signal cabling.

The Control Rooms shall be designed to ensure that internal noise, vibration, temperature and dust levels are kept within lowest acceptable limits to provide proper operating conditions for the equipment which is to be installed and a comfortable working environment for the operation and maintenance staff throughout the year.

The houses shall be protected against the ingress of moisture according to DIN 18195, "Water-proofing of buildings" and the common rules of IEC 61936-1 "Power installations exceeding 1 kV a.c." are to be considered.

The air conditioning, heating and ventilation system shall be adequate to maintain the permissible operation conditions of the equipment under extreme weather conditions and to allow working of maintenance personnel. The design parameters of the houses and the complete equipment in the houses shall allow the operation without running cooling or heating under normally expected weather conditions.

The houses shall be designed and supplied complete with following services:

- Lighting and Small Power (with inside 300 lux / entry outside 150 lux level). Also an emergency lighting will have to be installed.
- Fire detection/alarm systems (acoustic alarm and signalization in the substation control room) and portable ABC 5 kg fire extinguishers.
- Air conditioning, heating and ventilation system
- Insulation of Walls/Doors/Roof-Ceiling
- Installation at least 0.20 m above the nominal ground level
- Raised floor with a minimum height of 0.80m
- Internal/external painting with color (according to KETRACO's standard design).
- Labelling (name identification, no smoking, unauthorized entrance prohibited, etc.)

- CCTV (Closed-circuit television)
- Telephony system

Design Life and Maintenance

The civil works shall be designed for a minimum life of 40 years with a minimum of maintenance during this period. The designer shall consider all future maintenance requirements together with possible addition and alterations to the installed plant.

In addition to general maintenance, provision is to be made for the future removal and replacement of all items of plant. This provision shall include consideration for maintaining wayleaves and access agreements throughout the life of the Substation.

16.5 Standard Specifications

The British Standards and Codes of Practice specifically referred to in this Specification are listed below for convenient reference. The absence of any relevant BS or CP from the list shall not relieve the Contractor of his obligation to comply with such BS or CP as required by this Specification.

Number	Title
BS 4	Structural steel sections. Specification for hot-rolled sections.
BS EN 197-1:2011	Specification for Portland Cement
BS EN 13043	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
BS EN 295	Vitrified clay pipes and fittings and pipe joints for drains and sewers. Performance requirements.
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control.
BS EN 771	Specification for masonry units. Clay masonry units.
BS EN 197-1:2011	Cement. Composition, specifications and conformity criteria for common cements
BS EN 295	Vitrified clay pipes and fittings and pipe joints for drains and sewers
BS 405	Specification for uncoated expanded metal carbon steel sheets for general purposes.
BS EN 13808:2005	Bitumen road emulsions (anionic and cationic). Specification for bitumen road emulsions
BS 434-2	Bitumen road emulsions. Code of practice for the use of cationic bitumen emulsions on roads and other paved areas
BS EN 1993-1-1:2005, BS EN 1993-1-10:2005	Specification for the use of Structural Steel in building. Metric units
BS EN 598: 2007+A1:2009	Ductile Iron Pipes, Fittings, Accessories and Their Joints for Sewerage Applications - Requirements and Test Methods
BS EN 752	Drain and Sewer Systems Outside Buildings (Parts 2-14)
BS EN 932 Parts 1 to 6	Testing for General properties for aggregates.
BS EN 12620: 2002 + A1 :2008	Aggregates for concrete

Number	Title
BS EN 934-2:2009 parts 1 to 6	Concreting Admixtures
BS EN 13279 Parts 1 and 2	Gypsum binders and gypsum plasters.
BS 1196	Specification for clayware field drain pipes and junctions.
BS EN 13139	Aggregates for mortars
BS EN 845 Parts 1, 2 & 3	Specification for ancillary components for masonry
BS EN 13101:2002	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity.
BS 1377	Methods of test for soils for civil engineering purposes.
BS EN 1401 – 2 & 3	Plastics piping systems for non-pressure underground drainage and sewerage. Unplasticized polyvinylchloride (PVC-U). Specifications for pipes, fittings and the system
BS 1521	Specification for waterproof building papers.
BS EN 1610	Construction and testing of drains and sewers
BS 1722	Fences.
BS EN 771-1 to 6	Specification for masonry units.
BS 4190	Specification for ISO metric black hexagon bolts, screws and nuts.
BS ISO 8992	Fasteners. General requirements for bolts, screws, studs and nuts
BS EN 10080:2005	Steel for the reinforcement of concrete. Weldable reinforcing steel. General
BS 4449:2005 + A2:2009	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification
BS 4460	Specification for unplasticised polyvinyl chloride (PVC) pipes and plastic fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage.
BS 4483	Specification for steel fabric for the reinforcement of concrete.
BS 4514	Specification for unplasticised PVC soil and ventilation pipes, fittings and accessories.
BS EN998-1 & 2	Specification for ready-mixed building mortars.
BS EN 10067	Hot-rolled structural steel sections. Bulb Flat
BS EN 10056-1	Hot-rolled structural steel sections. Equal and unequal angles
BS EN 10210-2	Hot-rolled structural steel sections. Specification for hot rolled sections
BS 4987 Parts 1 and 2	Specification for Coated macadam for roads and other paved areas.
BS EN 1995	Structural use of timber.
BS 8500	Concrete. Specification for the procedures to be used in producing and transporting concrete
BS 8500, BS EN 206-1	Methods for specifying concrete, including ready-mixed concrete
BS 9999:2008	Fire Precautions in the Design and Construction of Buildings
BS EN 1996	Code of practice for use of masonry
BS 5911	Precast concrete pipes, fittings and ancillary products.
BS 5930: 1999	Code of practice for site investigations
BS 5950	Structural use of steelwork in building.

Number	Title
BS 6031	Code of practice for earthworks.
BS EN 12056-3:2000	Code of practice for drainage of roofs and paved areas.
BS EN 1991-1-1:2002, BS EN 1991-1-7:2006	Loading for buildings. Code of practice for dead and imposed loads
BS EN 1991-1-4:2005	Loading for buildings. Code of practice for wind loads.
BS EN 1991-1-3:2003	Loading for buildings. Code of practice for imposed roof loads
BS EN 1339	Precast concrete flags, kerbs, channels, edgings and quadrants.
BS EN 1997-1:2004	Code of practice for foundations
BS EN 1992-3:2006	Code of practice for design of concrete structures for retaining aqueous liquids
BS EN 14161:2011	Code of practice for pipelines. Pipelines on land: general
BS EN 1992-1-1:2004	Structural use of concrete. Code of practice for design and construction
BS EN 752-1:1996, BS EN 752-2:1997, BS EN 752-3:1997	Code of practice for building drainage.
BS EN 10210-1	Hot finished structural hollow sections of non-alloy and fine grain structural steels.
BS EN 12056	Gravity drainage systems inside buildings
BS ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods

16.6 Surveying Instruments

The Contractor shall keep on site such surveying instruments as are necessary for the complete and accurate setting out and construction of the works. These instruments shall be modern, shall be maintained in excellent condition, and shall be accurate in all respects. They shall be kept available for use by the Project Manager if so required, and their accuracy and adjustment shall be regularly checked in an approved manner.

16.7 Site Surveys

16.7.1 Topographical and Condition Surveys

At award of contract the Contractor shall conduct a complete topographical and condition survey of the Site and the surrounding area. These surveys shall be agreed with the Project Manager before any work starts on the site.

The purpose of the topographical survey of the Site and the surrounding area is to determine and agree with the Project Manager the existing levels. It is also envisaged that this data will allow the Contractor to allocate a relatively local low area in which any surface water run-off from the site can be directed for subsequent natural evaporation; ideally this zone will be well away from the working area of the site.

The condition survey will comprise a visual survey to record any aspect of the site and its surroundings which may have an impact on the construction or subsequent operation of the Works. The survey will include but not be limited to the following:

- a. observing the vegetation (changes in colour of vegetation may indicate changes in soil conditions)
- b. the presence of any buildings or habitation
- c. the presence of overhead obstructions, (transmission or distribution lines)
- d. tree or tree roots and any changes the removal of the trees may have upon the site
- e. geological outcrops or erosion
- f. signs of previous occupation
- g. wild life
- h. access routes etc.

The condition survey should be accompanied by a comprehensive photographic record.

16.7.2 Ground Investigation

The purpose of the Ground Investigation is to determine the nature of the sub-surface soil conditions which exist within the Site and to determine the most suitable type of foundation types. The ground investigation shall be carried out in accordance with the latest edition of the "Specification for ground investigation" published by the Institute of Civil Project Managers.

16.7.3 Data Provided by Client

The accuracy of any subsoil and survey information supplied to the Contractor (if any) is given in good faith but is not guaranteed, and any variation between this information and actual site conditions will not be accepted as the basis of a claim or reason for variation of unit rates in the Contract.

16.7.4 Scope of Ground Investigation

The Contractor shall satisfy himself regarding the geotechnical condition of site and any matters relating to the extent and magnitude of the proposed development. He shall carry out all soil investigations necessary to establish the basis for the proposed plant and building arrangements and foundation designs. A part of this work will include a contamination survey to the site to identify the presence or otherwise of contaminated materials.

According to the scope of work in the contract the boreholes (6 No. for substation) shall be augured to a maximum depth of 6m below existing grade by a rotary drilling rig equipped with conventional soil sampling and testing tool. Trial pits (3 No. for substation) shall be hand-dug to 1m depth after ensuring stability of the immediate subsurface. The excavated faces shall be examined and logged capturing the depths of the various layers and their physical characteristics. The proposed locations of boreholes and trial pits by contractor, shall be subject to Client's approval.

Samples obtained during the investigations are to be available for inspection by the Project Manager at the site.

The Contractor is to provide an interpretative geotechnical report for review by the Project Manager to confirm the criteria to be used in the foundation designs. This report shall include at least the following information:

- a. A detailed record of all factual information obtained in the field and via laboratory testing, including detailed borelogs, description of the different layers, stability of side slopes etc,
- b. Identification of all elements of contaminated material providing advice on their extent and the potential impact on personal health and durability of construction materials,
- c. Accurate logging of groundwater levels including global and perched,
- d. The results of the investigations into the soil resistivity and thermal resistance necessary for the design of the earthing rods,
- e. Foundation design parameters,
- f. Detailed recommendations regarding any specialist foundation solutions, including piling, ground improvement techniques etc.,
- g. Location of the site and Coordination of the substation,
- h. Boreholes (Trail pits) coordination and logs information,
- i. Depth of the Boreholes and trial pits,
- j. The Ground Water Conditions and specially the Ground Water Level,
- k. General geological Information of the region,
- l. Permeability and Consistency tests,
- m. Seismicity of the construction site,
- n. Earthquake acceleration coefficient,
- o. Results of the SPT (sand penetration test),
- p. Results of the Hydrometer test, Particle size analysis, Determination of Atterberg limits,
- q. Results of the Direct Shear Test,
- r. Chemical analysis of soil samples for determining soil properties and recommendations for the concrete criteria considering the Sulphate and chloride content of the samples and prevailing exposure conditions,
- s. Important characteristics of the soil layers like Cohesion coefficient (C) , Angle of internal friction (ϕ),
- t. Immediate settlement and Consolidation settlement,
- u. Modulus of subgrade reactions (Ks),
- v. Coefficient of lateral earth pressure,
- w. Allowable slope of excavation,
- x. Depth of the poor soil,
- y. Recommendations for the foundation type,
- z. Cement type and water-cement ratio,
- aa. Allowable bearing capacity (q_{all}),
- bb. Soil Collapse potential,

- cc. Soil Liquefaction,
- dd. Earth resistivity test report,
- ee. Thermal resistivity test report,
- ff. Corrosion study report and
- gg. Conclusions and Guidelines.

Within this geographical region it is possible that highly expansive soils may exist naturally and as such the above testing regime should identify their presence or otherwise. However, to ensure that the requisite testing is carried out it is recommended that at least the following properties are determined from soil samples taken from within the foundation zones, i.e. this will probably be within the top 3m of natural ground.

- a. The percentage of elements in the make-up of the soil with particular reference to montmorillonite, chilkinite and kaolinite and any other element which could cause volumetric change to occur. These percentages shall be determined for every 0.5m of depth.
- b. The volumetric change which the sample will undergo when exposed to water
- c. The pressures which the sample will exert when undergoing volumetric change
- d. The long term effect of a cycle of wetting and drying (i.e. does the swelling and shrinking repeat itself with the same intensity or do the effects diminish with repetition)

16.7.4.1 Datum

A datum to which all levels are to be related will be defined or established at a convenient point by the Project Manager. The Contractor shall then establish a minimum of four temporary bench marks, approximately equally spaced round the site, which shall be related to the datum. Each temporary bench mark shall be securely set in concrete, and shall be protected from damage or disturbance.

16.7.4.2 Setting Out

The Project Manager will establish two lines mutually at right angles from which the Contractor shall set out the works. Each of these main lines shall be defined by not less than four steel pins set in concrete at points indicated by the Project Manager. The Contractor shall supply all necessary labour and materials for this purpose.

16.7.4.3 Dimensions and Levels

All dimensions and levels shown on the drawings shall be verified on site by the Contractor.

16.7.5 Water, Electricity and Other Services

The Contractor shall be responsible for supplying all water, electricity and other services required for the construction of the Works and for any other purpose in connection with the Works.

Water pump and borehole with reservoir tank of capacity adequate to serve requirement of control building, residential houses, guard houses etc. with automatic level controls shall be provided.

For supplying water to the control building, guard house, staff housing and other facilities, the contractor shall supply, construct and mount 5000-liter water tanks made of 3mm thick galvanized flat metal sheet complete with metal stiffeners (Bracings), inlet pipe, outlet pipe, vent pipe, overflow pipe, drain pipe, iron posts or equivalent support and necessary accessories and a water system to circulate water from overhead reservoir to the 5000-liter capacity water tanks at each residential houses, control building and guard houses with automatic controls.

Galvanised steel pipes shall be supplied and installed for cold water distribution from the main inlet to the water tank and from the water tank to all sanitary fixtures according to the design accessories such as bends, unions etc.

The contractor shall determine the most practical way to provide water and submit the design of the water supply system for approval.

16.7.6 Inclement Weather

No payment will be made to the Contractor in respect of loss of output of plant or labour due to inclement weather.

16.7.7 Labour, plant and materials

The Contractor shall provide on the site, and elsewhere as required, sufficient labour, plant, materials and all other things necessary to construct the works in accordance with the agreed programme.

16.7.8 Programme

The Contractor shall construct the works in compliance with the outline programme appended to the Form of Tender, and shall submit for approval a detailed programme in accordance with the Conditions of Contract.

16.7.9 Provision of Testing Equipment

The Contractor shall provide a laboratory testing facility on site, alternatively tests can be done at an accredited laboratory. This shall comprise a purpose built facility capable of testing concrete, aggregates and soil samples as prescribed in the various codes of practice applicable to this project. As a minimum the following equipment shall be provided which shall be accurate and maintained in good condition:

Curing bath(s) for concrete samples plus compressive testing machines

Full set of testing equipment for the testing of soils, as prescribed in the various codes of practice applicable to this Project. This will include weighing scales, ovens, sieves, oedometers, shear box testing equipment, etc.

Project Manager shall be invited to all laboratory tests well in advance.

Wherever on site testing is impractical then alternative specialist subcontractors are to be employed by the Contractor to carry out this work, all associated costs being borne by the Contractor.

16.8 Design Process

16.8.1 Management of the Design

The Contractor shall prepare a 'Basis of Design' (BOD) for each element of the civil and structural works. A list of BOD's shall be prepared and this shall be submitted to the Project Manager within twenty-eight days after the Award of Contract for review and comment. The 'Basis of Design' shall include:

- a. A concise description of the form of each element,
- b. A statement of assumptions made,
- c. Loading and performance criteria,
- d. The particular editions of all Standards, Codes of Practice and References used,
- e. A description of the design approach including statements on the use of any computer programs and checking procedures adopted.
- f. Working methods,
- g. Plant utilization,
- h. Construction sequence,
- i. Safety arrangements.
- j. Output file from a value engineering exercise on the proposed works

These documents will establish the basis for formal reviews and appraisal of the design analysis. The Contractor shall submit these to the Project Manager for review at least 2 months prior to the commencement of the relevant construction activity in order that the Contractor can consider any comments made by the Project Manager at the most opportune time.

The development of the BOD's and the detailed civil design shall be reflected in the design and construction sections of the Contract programme.

Acceptance or rejection of the Contractor's BOD, calculations or drawings by the Project Manager shall not relieve the Contractor of any of his obligations to meet all the requirements of the Contract. The Contractor shall make any changes in the design, which are necessary to comply with the Contract.

16.8.2 Detailed Design Submissions

Following the review of the Basis of Design, the Contractor shall provide such detailed design submissions supported by comprehensive design calculations and drawings of the works as considered necessary by the Project Manager for his appraisal. The design calculations and drawings shall be submitted to the Project Manager in a phased manner.

These submissions will be reviewed at regular meetings held between the Project Manager, the Contractor and the Contractor's Civil Designer.

16.9 Loading

16.9.1 General

The loading applied to all buildings and structures shall comprise a combination of dead, imposed, wind, thermal, accidental and seismic. All loading shall be ascertained from the applicable codes of practice and standards applicable to this project.

16.9.2 Design Loads

It is anticipated that Equipment suppliers will give the weights and sizes of all 'heavy equipment', i.e. transformers, coolers, switchgear etc. specific to each project. These are to include dismantled transportation weights. Allowances shall be made for equipment and cables which are to be hung from the roof and ceilings of the various buildings/structures with regards to the overall load to these elements.

16.9.3 Internal Overpressure

A notional internal blast incident generated by an electrical fault requires the building fabric in the switchroom to be designed to retain integrity under a 5kN/m^2 ultimate overpressure load internally. Around the transformers the building fabric is to be designed to retain integrity under a 10kN/m^2 ultimate overpressure load.

Materials are to be considered at ultimate strength.

The building is to be designed such that the catastrophic loss of a wall will not result in building collapse or collapse of structures above the substation.

16.9.4 Floor Loads

The Contractor is to advise on the minimum characteristic loads that the floors within the substation building are to be designed to. Characteristic design loads are based on accommodating all equipment. All other floor loads are to be in accordance with BS 6399-1 1996.

16.10 Materials and Workmanship

16.10.1 General

Materials and workmanship are to be of best quality. All materials used in the works shall be new and of the best quality of their respective kinds. They shall comply with the requirements of the latest edition of any relevant Kenyan or British Standard and/or Code of Practice where such exist, and current at the date of bidding.

All workmanship shall be of the highest standard, and shall be executed by competent men skilled in their respective trades.

16.10.2 Samples

In addition to the special provisions made in this Specification for sampling and testing of materials by particular methods, samples of any materials and workmanship proposed to be used in the Works may be called for at any time during the Contract by the Project Manager and shall be furnished by the Contractor without delay and at the expense of the Contractor. Samples when approved shall be regarded as the acceptable standard, and any material or workmanship subsequently not complying with that standard shall be rejected and replaced by those of acceptable standard at the expense of the Contractor. Sample storage boxes shall be provided by the Contractor free of cost if requested by the Project Manager.

16.10.3 Tests

Whenever considered desirable by the Project Manager, Inspectors may be sent to manufacturer's or subcontractors' premises to test materials or inspect their manufacture. In addition the following will apply:

- a. Where specified or requested the Contractor shall obtain from the manufacturer and send to the Project Manager certificates of test, proof sheets, mill sheets, etc., showing that materials have been tested in accordance with this Specification or the relevant Kenyan or British Standard.
- b. Notwithstanding any tests which may be directed to be carried out at a manufacturer's and/or subcontractor's works, the Project Manager may carry out any tests or further tests he considers necessary or desirable after delivery of materials to the site.
- c. The Contractor shall provide all labour, equipment and facilities necessary for the carrying out of tests both in works and on site.
- d. The cost of routine tests required by Kenyan Standards or British Standards and this Specification shall be borne by the Contractor. The cost of other tests shall be borne in accordance with the Conditions of Contract.

16.10.4 Names of Suppliers and Copies of Orders

16.10.4.1 All Materials

If so required, and before ordering material of any description, the Contractor shall submit for approval the names of makers or suppliers proposed. Copies of orders shall also be submitted if so required. The Project Manager may at any time withdraw his previously given approval to obtaining materials from any maker or supplier should such maker or supplier fail to supply materials of the specified quality or quantity in the requisite time.

16.10.4.2 Rejection of Materials and Workmanship

The Project Manager shall at any time have power to reject materials and workmanship not complying with this Specification or with the Drawings. Materials so rejected shall be immediately removed from site and replaced by materials of an approved standard at the expense of the Contractor. Rejected workmanship shall be broken out and replaced by work of an acceptable standard including the supply of new materials by the Contractor, at the expense of the Contractor, and without delay.

16.10.5 Site Clearance and Demolition

16.10.5.1 Clearance of Vegetation

Unless otherwise directed or shown on the Drawings all bushes, trees and vegetation generally on the site shall be cleared and burned or removed to a tip provided by the Contractor. Where the Drawings or the Project Manager direct that any of these items are to remain undisturbed, the Contractor shall take all necessary action to prevent damage to them.

16.10.5.2 Demolition of Structures

Buildings or other structures or foundations to be removed shall be demolished by approved methods, which shall ensure that no damage is caused to any structures which are to remain.

16.10.5.3 Wells and Existing Excavations

Any wells or other existing excavations on the site shall be completely filled with approved material in layers not exceeding two hundred (200) mm, well rammed and compacted or by puddling with water. When these wells or excavations occur under, or within, three metres of new load bearing construction, they shall be filled with cement stabilised soil consisting of one (1) part cement and fifteen (15) parts sieved soil, thoroughly mixed and with a minimum quantity of water added to make a workable mix.

16.10.5.4 Explosives

Explosives shall not be used in the Works.

16.10.6 Earthworks and Excavation

16.10.6.1 Character of Ground

The Contractor must satisfy himself as to the ground conditions on the site, including the character of the strata to be excavated, obstructions, possibility of flooding and suchlike, and shall employ excavation techniques and equipment best suited to the site conditions.

16.10.6.2 Earthworks and Excavation Generally

Unless otherwise stated in the Contract the rates for earthworks and excavation shall be held to include for excavation in any material except rock.

16.10.6.3 Rock Excavation

The term "rock" shall mean a material which in the opinion of the Project Manager cannot be excavated except by means of explosives or compressed air drilling equipment. Boulders over one quarter (0.25) cubic metres in volume will be classed as rock and those of lesser volume as normal excavation.

16.10.6.4 Excavations for Foundations

Excavations shall be taken take out the minimum sizes necessary for the proper construction of the works, and excavations shall not be kept open for periods longer than that reasonably required to construct the works. The Contractor shall take all precautions necessary to ensure that the bottoms of excavations are protected from deterioration and that the excavations are carried out in such a manner that adjacent foundations, pipes or such like are not undermined, damaged or weakened in anyway. Any excavation taken out below the proper level without approval shall be made good at the expense of the Contractor using concrete or other material as directed.

16.10.6.5 Support of Excavations

The Contractor shall be responsible for the stability of the sides of the excavations, and shall provide and install all timbering and shoring necessary to ensure stability. If any slips occur, they shall, as soon as practicable, be made good in an approved manner at the expense of the Contractor. Shoring shall not be removed until the possibility of damaging the works by earth pressure has passed. No payment for shoring or timber left in shall be made, unless agreed in writing by the Project Manager.

16.10.6.6 Works to be put in Dry Excavations

All excavations shall be kept free from water and the Contractor shall take whatever action is necessary to achieve this. Pumping, well pointing and other means necessary to maintain the excavations free from water shall be at the expense of the Contractor, and carried out in an approved manner.

16.10.6.7 Inspection and Trimming of Excavations

Unless otherwise agreed, the bottoms of all excavations shall be inspected and approved before concrete is placed. Soft areas shall be excavated and filled in with concrete or other suitable material as directed. The excavations shall be properly trimmed and levelled before the placing of blinding or foundation concrete.

16.10.6.8 Backfill

As soon as possible after the permanent works are sufficiently hard and have been inspected and approved, backfill shall be placed where necessary and thoroughly consolidated in layers not exceeding two hundred (200) millimetres in depth.

16.10.6.9 Disposal of Surplus

Surplus excavated material not required or not approved for fill or backfill shall be loaded and deposited either on or off site as directed. The Contractor shall not delay disposal of surplus material after receipt of instructions from the Project Manager.

16.10.6.10 Hardcore

Hardcore shall consist of clean, hard, natural broken stone, rubble or gravel all to pass an eighty (80) millimetre ring, but retained on a thirty (30) millimetre ring.

16.10.6.11 Weed-killer

Weed-killer shall be spread over areas to be covered with site surfacing before such surfacing is laid. The weed-killer shall be of approved make which does not cause corrosion of metals. It shall be used strictly in accordance with the manufacturer's instructions.

16.10.6.12 Site Surfacing

Site surfacing shall consist of clean, hard natural gravel or crushed stone all to pass a thirty (30) millimetre ring but all retained on a ten (10) millimetre ring. Site surfacing shall be spread after installation of services and cables, each strip and suchlike by other Contractors. It shall be spread where indicated on the Drawings on a properly levelled or graded surface, free from weeds, to a compacted thickness of one hundred and fifty (150) millimetres and lightly rolled.

The site surfacing material shall be spread over a heavy-duty (1000 Gauge) black polythene sheeting to suppress emergence of weeds. The sheeting shall be overlayed over the duly prepared finished platform.

16.10.7 Concrete, Reinforced Concrete and Mortar**16.10.7.1 General**

To achieve the service life specified, a high quality, durable concrete shall be provided to protect reinforcement, embedded metals and concrete against attack from aggressive chemicals such as chlorides, sulphates and other agents.

The Contractor shall take the following key exposure categories into account whilst preparing the design mix(es) requirements. Design mix(es) shall be subject to the Project Company's/Project Manager's approval.

- Dry internal environments;
- Wet internal environments;
- External environments not exposed to seawater or seawater spray;
- External environments exposed to seawater spray/splash zone;
- External environments exposed to seawater immersion.

As mentioned previously the Contractor shall establish by soil investigation the aggressive chemical environmental conditions for concrete exposure. Concentration levels of airborne and below ground chloride and sulphate salts and any other aggressive chemical agents shall be determined. The below ground conditions for concrete shall be assessed in accordance with the requirements of BRE Special Digest 1 "Concrete in aggressive ground".

The Contractor shall, as a minimum requirement, comply with the specified concrete mix design, and the specified additional protective measures noted herein.

All structural concrete shall develop a minimum compressive cube strength (f_c) of 25N/mm² at 28 days.

Blinding concrete shall have a minimum 28 day cube strength of 15.0N/mm².

In the event that slip formed construction is offered for any part of the works then a special concrete design shall be developed by the Contractor and offered to the Project Company/Project Manager for approval.

For all reinforced concrete, the following minimum mix design requirements shall be provided.

- | | |
|---|---|
| • Cement Type | Type I, ASTM C 150 |
| • Cement replacement | Ground granulated blast furnace slag to BS6699, BS EN 15167-1:2006 |
| • The cement and GGBS shall be blended at the point of batching in the following proportions by weight: | 120kg minimum OPC but not less than 30% of the total cementitious quantity + 280kg minimum GGBS |
| • Minimum total cementitious quantity | 370 - 380kg/m ³ |
| • Maximum water/cement ratio | 0.42 – 0.45 |

Admixtures shall be selected by the Contractor to accommodate his requirements for placing of fresh concrete. However, their inclusion must be approved by the Project Manager prior to their use.

Compliance with any concrete mix design in this Specification shall not relieve the Contractor of his responsibility for the final concrete mix design. The Contractor shall demonstrate to the satisfaction of the Project Manager that the intended durability of the concrete mix for the required design life can be satisfied for the particular exposure environment.

The Contractor shall be responsible for ensuring that all constituent materials used for the concrete works (e.g. cementitious, aggregate, reinforcement, water, admixtures etc.) comply with recognised international material standards and methods of testing and meet the requirements of this Specification. The use of proposed constituent materials shall be agreed with the Project Manager prior to their use on the Project.

The following values of minimum reinforcement cover shall be provided:

Concrete exposed to seawater; upper tidal range and splash zone	75mm
Concrete exposed to seawater; permanently submerged	75mm
Concrete buried below ground in contact with the ground	75mm
External superstructure, away from splash zone	75mm
Internal superstructure, beams, columns	40mm
Internal superstructure, slabs	30mm

In addition the Contractor shall provide sufficient concrete cover and overall cross-sectional dimensions to ensure the correct fire protection to the various elements of structure (where fire protection is required) are achieved. This shall be in accordance with BS 8110.

For below ground concrete protective measures shall, as a minimum be provided to meet the requirements of BRE Digest No 1 and as specified below. The contractor shall assess sulphate, chloride and pH levels existing in representative soil and groundwater samples as part of his programme of supplementary geotechnical investigation of the site. The concrete protective measures set out below shall be upgraded where necessary based on the recommendations of the Kenyan and British Codes of Practice.

Location	Sulphate levels below 6.0g/l (groundwater) 6.7g/l (soil).	Sulphate levels in excess of 6.0g/l (groundwater) 6.7g/l (soil).
Parts of structure in contact with the soil above the capillary rise zone	Bitumen emulsion paint	Bitumen emulsion paint and minimum cover to reinforcement shall be 100mm.
Parts of the structure within the capillary rise zone or below ground water level.	Bitumen emulsion paint and minimum cover to reinforcement shall be 100mm.	Bitumen emulsion paint and minimum cover to reinforcement shall be 100mm.
Precast concrete piles	Steel moulds.	Steel moulds

Note that the depth of the capillary rise zone shall be taken as 1.5m above the highest ground water level. Sulphate levels shall be determined by the Contractor's soil investigation.

Bitumastic paint shall be applied on top of all blinding concrete except where horizontal shear resistance is required.

Embedded materials shall be accurately fabricated and assembled to suit the construction interface required.

All steel embedments in concrete shall be accurately positioned and securely anchored either directly to the formwork or by templates prior to pouring the concrete. Pockets for later insertion of assemblies generally will not be allowed.

Embedments shall be clean both before they are installed and after placement of the concrete.

Where embedments are required for major equipment items then anchor bolts, attachments and embedments shall be located and secured prior to concrete placement with accurately made steel templates. Tolerances shall be as specified by the equipment manufacturer, but shall be not greater than ± 3 mm on plan and verticality. Templates shall be interconnected and braced with steel members that maintain the anchor bolt alignment and position.

Welding of embedments, to the reinforcement cage to secure their location, will not be accepted.

Corrosion protection shall be provided to all embedments, suitable to the environment in which they are cast. Generally, the following exposure conditions shall be considered as a minimum:

- Dry internal environments;
- Wet internal environments;
- External environments not exposed to seawater or seawater spray;
- External environments exposed to seawater spray/splash zone;
- External environments exposed to seawater immersion.

The materials that will be used for embedded items shall comprise either carbon steel or stainless steel. The selection of material will be based on strength and durability requirements. Additionally, the choice of material may be dictated by interfacing issues with plant requirements.

The necessity of welding plant fixings etc. to embedments exposed at the concrete surface in exposed environments shall be considered at design stage and wherever possible alternative fixing details shall be provided in order to preserve the original corrosion protective coatings.

16.10.7.2 Cement

The cement used throughout the works shall be best quality Portland cement and shall conform in every respect with BS 12 or the equivalent Kenyan Standard. Other cements may be used only with written approval, or on written instructions, and shall conform in every respect with the relevant KS and BS.

16.10.7.3 Special Additives

Air entraining, water reducing, set accelerating, set retarding, or other additives can be used with the prior written approval of the Project Manager, following comparative concrete durability and compression strength tests carried out on concrete made with and without additives. Tests with additives shall give durability and compressive strength at least equal to those without additives except that water reducing agents shall increase the compressive strength by ten (10) percent. The use of all additives shall be strictly supervised. Any admixtures used shall comply with the relevant part of BS EN 480. Calcium chloride or admixtures based on calcium chloride shall not be used.

16.10.7.4 Delivery and Storage of Cement

The cement shall be delivered to the Site in bulk or in sound and properly sealed bags and while being loaded or unloaded whether conveyed in vehicles or by mechanical means, and during transit to the concrete mixers, must be protected from the weather by effective coverings. Efficient screens are to be supplied and erected to prevent wastage of cement during strong winds.

If the cement is delivered in bulk, the Contractor shall provide at his own cost approved silos of adequate size and number to store sufficient cement to ensure continuity of work. The cement shall be placed in these silos immediately when it has been delivered on the Site. Suitable precautions shall be taken during unloading to ensure that the resulting dust does not constitute a nuisance.

If the cement is delivered in bags, the Contractor shall provide at his own cost perfectly waterproof and well-ventilated sheds having a floor of wood or concrete raised at least 150mm, above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of work. Each consignment of each type of cement shall be stacked separately therein. On delivery at the Work the cement shall at once be placed in these sheds and shall be used in the order in which it has been delivered.

16.10.7.5 Coarse Aggregate

Coarse aggregate for concrete shall be clean, hard, strong, fine grained, non-friable, non-porous and durable stone of approved quality and shall be obtained from an approved source. It shall be roughly cubical or rounded in shape and be free from dust.

16.10.7.6 Fine Aggregate

The fine aggregate for concrete shall be clean, sharp sand, or other suitable and approved material, and shall be free from all impurities.

The fine aggregate for mortar shall, unless otherwise specified, be rounded sand or other suitable and approved material and shall be free from all impurities. The clay, silt or fine dust shall not exceed five (5) percent by volume. The sand shall consist of particles between two point three six (2.36) millimetres and six hundred (600) millimetres in size.

16.10.7.7 Storage of Aggregates

The coarse and fine aggregates shall be stored on site in bins or on clean, dry, hard surfaces, and be kept free from all sources of contamination. Aggregates of different gradings shall be stored separately, and no new aggregate shall be mixed with existing stocks until tested and approved.

16.10.7.8 Water

Water used for mixing concrete and mortar shall be clean, fresh water obtained from an approved source and free from harmful chemicals, oils, organic matter and other impurities.

16.10.7.9 Steel Bar Reinforcement

Steel reinforcement shall comply with one of the following:

- Carbon steel bars for the reinforcement of concrete – BS 4449
- Cold reduced steel bars for the reinforcement of concrete – BS 4482
- Steel fabric for the reinforcement of concrete – BS 4483.

All bar reinforcement shall be hot rolled steel except where the use of cold worked steel is specified on the Drawings or otherwise approved.

The bars shall be round and free from corrosion, cracks, surface flaws, laminations, rough, jagged and imperfect edges and other defects, and the tolerance by weight shall not exceed two and one half (2.5) per cent.

The bar reinforcement shall be new, clean and of the lengths and diameters described on the Drawings and Schedules. Bars shall be transported and stored so that they remain clean, straight, undamaged and free from corrosion, rust or scale. Bars of different diameters shall be separately bundled.

Where environmental conditions dictate the use of epoxy coated or stainless steel reinforcement bars shall be used; the use of these being at the discretion of the designer.

16.10.7.10 Steel Fabric Reinforcement

Unless otherwise specified or described on the Drawings or in the Bills of Quantities, all fabric reinforcement shall comprise hard drawn steel wire fabric and shall comply in all respects with BS 4483. Each consignment of steel fabric reinforcement shall be accompanied by a test certificate giving the results of tests on the material carried out in accordance with BS 4483.

Steel fabric reinforcement shall be new, clean, free from corrosion, rust or millscale, and shall be transported to and stored on site so that it remains clean, undistorted and otherwise undamaged. Fabrics of different type or weights shall be separately bundled or rolled.

16.10.7.11 Tying Wire

The tying wire for reinforcement shall be one and one half (1.5) millimetres in diameter annealed soft iron tying wire.

16.10.7.12 Threaded Inserts

The threaded inserts for casting into concrete shall be electro-galvanized and of malleable iron or mild steel.

16.10.7.13 Waterproofing Admixture

Waterproof concrete and mortar shall be used where shown on the Drawings. Waterproofing shall be by the use of a reliable and approved brand of admixture. The admixture shall be used strictly in accordance with the manufacturer's instructions.

16.10.7.14 Availability of Materials

The Contractor shall be deemed to have satisfied himself that suitable materials for concrete and mortar can be obtained in sufficient quantities to carry out the works.

16.10.7.15 Approval of Supplies

As soon as possible after the Contract has been placed the Contractor shall submit a list giving details of the sources from which he proposes to obtain concrete and mortar materials. Only materials from approved sources shall be brought to site, but the Project Manager will be prepared to extend his approval to other satisfactory sources of supply which may be proposed by the Contractor. Approval of a source of supply shall not imply acceptance of material found not to conform to this Specification.

16.10.7.16 Preliminary Tests of Concrete Ingredients

After submission of the list of approved sources of supply of concrete materials, the Contractor shall, when required obtain representative samples of water and of fine and coarse aggregate in sufficient quantities for testing as directed by the Project Manager. The tests to be carried out shall be decided by the Project Manager, and shall be carried out by the Project Manager and/or at an independent laboratory. The test will normally consist of mechanical, and if necessary chemical, analysis of the aggregate plus chemical analysis of the water.

As soon as possible after the Contract has been placed, the Contractor shall prepare trial mixes of the proposed concrete mixes and subject them to various tests, including:

- Compressive strength tests at 7 and 28 days
- Slump tests
- Expansivity tests to aggregates and concrete

Testing of the concrete samples shall be carried out by an independent authority to be agreed with the Project Manager. When concrete grades have been approved, the Contractor shall not vary the proportions without approval.

16.10.7.17 Testing on Site

Samples of concrete shall be taken from the works at a rate of one sample per 20m³ or one sample per 20 batches, whichever is the lesser. Test cubes shall be made from these samples in sets of six. All concrete testing is included in the Contract.

Test cubes shall be made, cured, stored and transported and test in compression in accordance with BS EN 12350.

Concrete may be assumed satisfactory if the cube strengths at 7 days are 50% of the 28 day strength. Should the 7 day values be below 50% of the final strength the concrete may still be assumed satisfactory if the 28-day test results conform with the target strengths. If the results of both the 7 day and 28-day works cube tests show crushing strengths less than those specified, the Project Manager may suspend all concreting work and order further tests to ascertain if the concrete placed in the works is acceptable. Any concrete found not to comply with the Specification shall be broken out and replaced, or otherwise rectified, to the satisfaction of the Project Manager.

All remedial measures including cutting-out, reinstating, mix adjustment, further testing and the like, which, in the opinion of the Project Manager, are required shall be at the expense of the Contractor.

16.10.7.18 Measurement of Materials

In proportioning concrete, the quantity of cement shall be determined by weight and when the cement is supplied in bags the concrete shall be mixed in batches using one or more complete bags of cement. The quantities of fine and coarse aggregate should be determined by weight but where written approval has been obtained from the Project Manager may be determined by volume.

16.10.7.19 Mixing of Concrete

The concrete materials shall be weight batched and mixed with mechanical mixers. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposition in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their content while running.

All equipment shall be thoroughly cleaned before use or re-use for other grades of concrete.

16.10.7.20 Workability of Concrete

The concrete shall be of a dense, homogeneous nature produced with the minimum quantity of water necessary to ensure a compact mass sufficiently workable to enable proper placing and consolidation in corners and around

reinforcement, and to give the specified finish, strength, density or other required qualities. The water/cement ratio for each grade of concrete shall be agreed with the Project Manager.

The control of the workability of concrete shall be maintained by application of Slump Tests carried out in accordance with the procedure laid down in BS 1881. Slump tests shall be made at least twice daily or as directed and a record of results kept on site for periodic review.

16.10.7.21 Transporting

Concrete shall be distributed from the mixers to final position in the works as rapidly as possible and by approved methods which will prevent segregation or loss of ingredients. All equipment shall be thoroughly cleaned before use or re-use for other grades of concrete.

16.10.7.22 Placing

Not more than thirty (30) minutes after water is first added to the mix and before initial set has occurred, the final placing of the concrete shall be completed. On no account shall water be added after the initial mixing.

All concrete surfaces in contact with the earth shall be suitably protected with a bituminous membrane.

Concrete shall be introduced into the forms, between pre-determined construction joints, as near as practicable to its final position in a manner which will not cause segregation of the mix or displacement of the reinforcement or forms.

Concrete shall not be dropped from a height greater than one (1) metre unless 'tremmie' techniques are adopted. The placing and consolidation of concrete shall be done in a manner which will not disturb previously placed concrete.

Before the placing of the concrete the formwork and reinforcement shall be inspected and approved by the Project Manager. The Contractor shall invite the Project Manager well in advance to these inspections.

16.10.7.23 Compacting of Concrete

Concrete shall be consolidated by an approved method of ramming, tamping or vibration. It shall be carefully worked round reinforcement and embedded fixtures, into corners and against the forms to produce a dense uniform mass free from defects. Care shall be exercised to ensure the whole depth is thoroughly compacted without disturbance to parts of the work already placed. Excessive ramming and tamping shall be avoided.

16.10.7.24 Mechanical Vibration

All concrete shall be vibrated unless otherwise directed. Vibration shall be additional to hand compacting and numbers and types of vibrators shall be approved before use. Vibrators shall be the immersion type operated at an approved frequency and external formwork vibrators may only be used on agreed sections of the works.

Operators of vibrating tools shall have received adequate instruction and training in their use. Every care shall be taken to avoid contact of vibrators with the reinforcement or previously placed concrete. Excessive vibration shall be avoided.

16.10.7.25 Construction Joints

Concreting shall be carried out continuously up to approved construction joints with moulded bonding chases. Unless otherwise approved or instructed concrete shall be placed to the full depth of slabs, beams and the like and shall be placed in horizontal layers not exceeding one and one half (1.5) metres deep in walls, columns and similar members.

Construction joints shall be formed in the horizontal and vertical planes by means of stop boards which allow the reinforcement to run through. Where practicable, laitance shall be removed whilst the concrete is still soft so as to expose the coarse aggregate. Where concrete already deposited has set but not set hard the laitance shall be removed and the coarse aggregate exposed by wire-brushing and washing.

At joints where the placed concrete has set hard any skin or laitance shall be removed by hacking, care being taken to avoid damage to the aggregate.

Immediately before concreting proceeds the roughened joint surface shall be thoroughly cleaned and loose matter removed, then treated with a layer, 12mm thick, of cement mortar 1:1 mix. The concrete shall be immediately deposited and punned into the cement mortar.

Where construction joints will be permanently visible, the cement mortar shall be kept back from the exposed face of the concrete.

16.10.7.26 Contraction Joints

Contraction joints in concrete slabs and walls shall be formed in positions and to details shown on the Drawings or as directed by the Project Manager. The joints shall be straight and vertical except where otherwise approved and concrete surface levels on both sides of the joint shall be flush. The joints shall be sealed with 'Compriband' bituminised polyurethane foam strip, pre-compressed before insertion and installed in accordance with the recommendation of the manufacturers, Compriband (Great Britain) Ltd, or 'Pliastic' tropical grade rubber bitumen compound, produce of Expandite Ltd, poured hot into horizontal joints or other approved product of equal properties and quality.

16.10.7.27 Expansion and Deflection Joints

Expansion and deflection joints shall be formed in positions and to the details shown on the Drawings or as directed.

Joints shall be straight and vertical except where otherwise approved and concrete surface faces shall be flush on both sides of the joint.

The joints shall be filled with 'Flexcell' non-extruding wood fibre bitumen impregnated boarding, and sealed with 'Pliastic' tropical grade rubber bitumen compound, both products of Expandite Ltd, or other approved products of equal properties and quality.

16.10.7.28 Protection of Concrete

Proper protection shall be provided to prevent cement from being taken or washed away and the concrete from being diluted during the process of storing, handling, transporting, apportioning and mixing the materials, and transporting, placing, compacting and curing the concrete.

All foundations constructed below the water table and within the capillary rise zone are to be suitably protected from chemically aggressive ground conditions by tanking with a bitumen type membrane if required by the Ground Investigation Results.

Care should be taken to ensure that concrete during hardening is not disturbed by direct or indirect loading, movement or projecting reinforcement, vibration or other similar effects. All concrete shall be protected from the harmful effects of sunshine, wind and rain and foundation concrete shall also be protected from damage by storm or subsoil water.

16.10.7.29 Curing

It is vitally important that prolonged moist curing is carried out in order to achieve long-term durability.

Exposed surfaces shall be protected from wind and low humidity until the concrete has reached sufficient maturity.

Start the curing immediately after finishing, to prevent rapid surface drying.

Keep the surface continuously moist or by the application of impermeable sheeting for at least 10 days to avoid plastic shrinkage cracking caused by faster surface moisture evaporation than the rate of moisture migrating to the surface.

For floor construction where a surface treatment such as power floating or the like is to be used curing agent should be applied immediately after the completion of the surface treatment.

16.10.7.30 Bending of Reinforcement

All steel bars are to be accurately bent cold to the shapes and sizes indicated on the Drawings and Schedules unless otherwise approved. Bending dimensions shall be in accordance with BS 8666 unless otherwise stated. Re-bending of bars and bending in position in the works shall not be allowed.

16.10.7.31 Welding of Reinforcement

Spot or track welding for positioning bars in heavily reinforced areas will only be allowed with the express permission of the Project Manager. Extension of lengths of reinforcement by welding will not be permitted.

Welding will be approved only in low stress members, and lap welding will not be approved in any circumstances.

16.10.7.31 Fixing of Reinforcement

Before fixing in the works bars shall be seen to be free from pitting, mud, oil, paint, loose rust or scale or other adherents harmful to the bond or strength of the reinforcement. Bars shall be fixed rigidly and accurately in position in accordance with the working drawings, unless otherwise approved by the Project Manager.

Reinforcement at all intersections shall be securely tied together with soft annealed tying wire the ends of which shall be cut and bent inwards. Cover to the reinforcement shall be as stated previously and sufficient spacers and chairs or precast concrete or plastic of approved design shall be provided to maintain the specified cover and position. No insertion of bars in previously placed concrete shall be permitted. Projecting bars shall be adequately protected from displacement. The fixing of reinforcement in the works shall be approved before concrete is placed.

16.10.7.32 Formwork

Formwork shall be constructed from timber, metal, plastic or concrete, lined as necessary for special finishes and designed with the quality and strength required to ensure rigidity throughout placing, ramming, vibration and setting of the concrete, without detrimental effect.

Formwork shall be erected true to line, level and shapes required using a minimum of approved internal ties. Faces in contact with the concrete shall be true and free from defect, jointed to prevent loss of water or fines, in panels or units which permit easy handling, and designed to permit sideforms to be struck independently of soffit shuttering. Ties or spaces remaining embedded shall have the minimum cover specified for reinforcement. Forms for exposed concrete beams, girder casings and columns shall provide for a twenty-five (25) millimetre chamfer on external corners. Formwork described as wrot shall be planed timber, plywood, smooth steel or other material of a similar smooth surface. Samples showing the standard of finish may be required.

Forms for concrete surfaces not exposed shall be described as 'rough' and may be timber as left from the saw or approved similar material.

Construction joints in the works shall be so arranged to provide a 'starter' to which the forms for the next lift may be clamped. Wedges and clamps shall be kept tight during vibration operations. Before commencement or resumption of concreting, the interior of forms shall be cleaned and free of sawdust, shavings, dust, mud or other debris and openings shall be formed to facilitate this cleaning and inspection. The inside of the forms shall be treated with a coating of an approved substance to prevent adhesion. Care shall be taken to prevent this substance being in contact with the reinforcement.

16.10.7.33 Inspection and Approval of Formwork

All formwork moulds and reinforcement shall be subject to inspection and approval by the Project Manager immediately prior to the placing of concrete.

16.10.7.34 Removal of Formwork

Formwork shall be kept in position, fully supported, until the concrete has hardened and gained sufficient strength to carry itself and any loads likely to be imposed upon it. Stripping must be effected in such a manner and at such a time that no shock or other injury is caused to the concrete. The responsibility for safe removal rests with the Contractor but the Project Manager may delay the time of striking if he deems it necessary.

Minimum periods, in the absence of agreement to the contrary, between completion of concreting and removal of forms are given below but due regard must be paid to the method of curing and prevailing conditions during this period.

Removal of formwork	
Positions in works	Minimum period before striking formwork
Removal of shuttering to sides of rafts, walls, beams and columns	2 days
Removal of shuttering to slabs, beams and arches (props left under)	6 days
Removal of props to slabs, beams and arches	16 days
Lifting to precast members	16 days

16.10.7.35 Precast Concrete Members

Precast concrete members shall be used in the works and only where specified on the Drawings or approved by the Project Manager.

All the requirements for concrete, formwork and reinforcement shall apply equally to the moulds for precast members and concreting shall be carried out in one continuous operation.

Precast members shall not be disturbed or lifted until the minimum periods specified for formwork removal have elapsed.

16.10.7.36 Replacement of Damaged Concrete

In the event of any portion of the concrete work being damaged so that in the opinion of the Project Manager it does not fulfil the requirements of the Contract, the replacement or reinstatement shall be carried out at the expense of the Contractor to the directions of the Project Manager.

16.10.7.37 Finish of Concrete Surfaces

i. Concrete cast against formwork

The following finishes to concrete surfaces, unless otherwise specified or shown on the drawings, shall be as follows: -

Class A1: All permanently exposed surfaces, including exposed sides of foundations.

Class A1 surfaces shall be dense, fair, smooth, even, free from honeycombing, water and air holes and other blemishes, true to line and surface and free from board or panel marking.

They shall be of uniform colour. Rendering of defective surfaces shall not be permitted, and, if ordered by the Project Manager, the Contractor shall at his own expense cut out to expose reinforcement and make good any unsatisfactory work. All areas so treated shall be rubbed down and kept moist for several days.

Class A2: Surfaces to be covered by backfill, plasters or the like.

Class A2 surfaces shall be dense, even, free from honeycombing and true to line and surface.

Any special finishes will be to details or instructions given by the Project Manager.

ii. Concrete not cast against formwork

The following finishes shall be provided unless otherwise specified or shown on the drawings: -

Class B1: All permanently exposed surfaces, including tops of equipment foundations, wall copings, window sills, precast items (except paving flags).

Class B2: Paving flags and paths. Floors and slabs to be surfaced with blocks, tiles or waterproofing materials.

Class B3: Roads, buried concrete and floors or slabs to be covered by screed.

Class B1 surfaces shall first be levelled and screeded to produce a true surface. After the moisture film has disappeared, and the concrete has hardened sufficiently, the surface shall be finished with a steel trowel under firm pressure to give a smooth, dense, even and hard surface free from all marks and defects.

Class B2 surfaces shall be levelled and screeded to produce a true surface, and be finished with wooden or steel float to give a level surface free from screed marks. Excessive floating shall be avoided.

Class B3 surfaces shall be levelled and screeded to produce a true and uniform surface.

16.10.7.38 Holes, Pockets, Threaded Inserts, etc.

Holes, cavities and fixings shall be provided in the works only at the positions indicated on the drawings or as directed and they shall be incorporated as necessary during the work of concreting. Unless otherwise agreed a tolerance in position of plus or minus (5) millimetres shall be allowed. Inserts and bolts shall be fixed square in the works by means of temporary bolts or nuts, and then concrete cast around them. The projecting portions of such fixings, and concrete within fifty (50) millimetres of them, shall be bitumastic painted and all threads well-greased on completion of the work. Holes and pockets shall be stripped down clean on completion.

16.10.7.39 Ties to Blockwork

Galvanized steel dowel ties ten (10) millimetres diameter, one hundred and fifty (150) millimetres long shall be bedded for half their length in the structural concrete where it abuts concrete blockwork infill panels. Ties shall be fixed at their correct positions to meet blockwork joints at a maximum of one (1) metre centres. Positions of ties will not normally be indicated on the Drawings.

16.10.7.40 Blinding

Under all foundations and elsewhere as indicated on the Drawings a layer of concrete grade f_{ck} 15/20 shall be laid immediately the excavation is carried down to foundation level. The blinding surface shall be thoroughly clean before foundation concrete is deposited thereon. Sumps shall be provided where necessary to facilitate the control of drained water.

16.10.7.41 Structural Steel

Steel sections shall be new and shapes shall conform to the Kenyan and/or British Standards. All structural steel sections shall be hot rolled with a minimum grade 460 in accordance with BS EN 1994. As a minimum the following shall apply:

Hot rolled sections	BS 4	Part 1 and addenda
Hot rolled hollow section	BS EN 10210	
Weldable structural steels	BS EN 10025	
Black bolts, screws and nuts	BS 916	

The structural steelwork shall be designed, fabricated and erected in accordance with BS 5950: "The structural use of steelwork in building" - unless otherwise described, directed or permitted.

Auto/manually fabricated welded sections shall only be permitted when a suitable rolled section does not exist i.e. when section required is greater than the largest rolled section size available from the manufacturer/mill.

All bolts in elevated steelwork connections shall be minimum grade 8.8 high strength bolts to suit the required design. All holding down bolts shall be minimum grade 4.6. Finishes etc. shall be selected such, to eliminate galvanic corrosion. Bolt finishes shall conform with the finishes applied to the steelwork elements to which they connect. Welded connections will comply with the relevant Kenyan or British standard.

The Contractor shall select coating systems on consideration of climatic conditions prevailing at the site. Such systems shall have a design life to first maintenance of at least 20 years. As a minimum an atmospheric environment category of C5-M, C4 or Im2 should be considered for all structures, as defined in BS EN ISO 12944. The C5-M classification shall apply to all areas within 100m of a sea shore line, the C4 classification shall apply to areas more than 100m from the shoreline and the I_m^2 shall apply to all submerged structures.

In the case of paint applied systems these shall consist of shop applied coatings and site applied finishing coat(s) all in accordance with BS EN ISO 12944. The final site coat(s) shall be applied after steelwork erection/alignment and bolt tightening activities have been completed, unless otherwise agreed with the Project Manager.

Where zinc coatings are proposed as protection against corrosion the guidelines of BS EN ISO 14713 (Protection against corrosion of iron and steel in structures – Zinc and Aluminium coatings – Guidelines) shall be used. Galvanized steel elements exposed to seawater spray, those located in the seawater structures and those in drainage sumps etc. shall be suitable for a Class C5 exposure as defined in BS EN ISO 14713.

Some items of secondary steelwork shall be hot dip galvanized to BS EN ISO 1461 i.e. steel flooring, ladders, sheeting rails, purlins, access stair stringers, treads and handrails.

16.10.7.42 Grouting

Non-shrink grouts are to be used for grouting machine base plates and column bases.

Where specifically noted on final construction drawings or directed by the Project Manager, grouting shall be with premixed, expansive cement, non-metallic, inorganic, non-shrink grout. Grout shall be manufactured by a firm normally engaged in the manufacture of such items, having a proven record of successful installations, and acceptable to the Project Manager. Grout shall be mixed and placed in strict accordance with the manufacturer's recommendations. Compressive strength of grout shall be not less than 350 kg/cm² after 7 days and not less than 600 kg/cm² after 28 days.

16.10.8 Concrete Blockwork

16.10.8.1 Concrete Blocks for Building

Concrete blocks shall be made in approved machines incorporating mechanical vibration. All blocks, unless otherwise described on the Drawings or in the Bills of Quantities shall conform to BS 5628 Structural use of unreinforced blockwork as regards constituent materials, grading of aggregates, mix properties, dimensions of blocks, methods of manufacture, curing, testing, specified strengths and drying shrinkage characteristics. If any blocks tested do not meet the requirements of the tests, all blocks from the same batch shall be rejected.

16.10.8.2 Surface of Concrete Blocks

Where walls are to be painted or have similar finishes, the blocks shall be fair face. Where walls are to be rendered, tiled or similarly covered the surface shall be of a suitable rough texture to provide a good key.

16.10.8.3 Mortar

Concrete block walls shall be constructed using mortar which complies with the requirements of BS EN 998-2:2010 Specification for Mortar for masonry.

16.10.8.4 Building Block work Walls

Walls shall be built to the dimensions and levels shown on the Drawings, and shall be carried up in level courses with true perpendiculars. No section of blockwork shall lead any other section by more than four courses at any

one time. All blocks shall be thoroughly wetted before laying, and the tops of blocks shall also be wetted before the next course is laid.

16.10.8.5 Joints

The total thickness of any four horizontal joints shall not exceed forty (40) millimetres. All joints shall be fully flushed up as work proceeds.

16.10.8.6 Bond

Each block shall be centred over the vertical joint in the course below.

Blocks of special sizes necessary to form proper bonding at angles, openings, intersections, etc. which cannot be made in a standard machine may be made in specially constructed moulds. In all other respects they shall be of a quality equal to the standard blocks.

16.10.8.7 Finish to Walls

Where walls are not to be rendered or tiled, the blocks shall be fair face and shall have flush joints, struck as work proceeds.

Where walls are to be rendered or tiled, the surface shall be of rough texture, and all joints shall be raked out to form a key.

16.10.8.8 Filling of Cavities

The cavities in blocks shall be filled with Grade 15/20 concrete from foundation level up to damp proof course as work proceeds. Cavities adjacent to door, window and such openings shall be similarly filled. Fixings for doors and windows shall be built in as the walls are built.

16.10.8.9 Completion

Upon completion of blockwork, it shall be thoroughly washed down and left clean.

16.10.8.10 Protection of work

Partially completed work shall be adequately protected from damage by rain, heat or any other cause.

16.10.9 Drainage

16.10.9.1 Surface Water Drainage Systems

The surface water and foul drainage systems shall be separate and shall be designed in accordance with BS EN 752 Parts 1 to 4 "Drain and sewer systems outside buildings". Manhole and chamber covers shall be heavy duty throughout. The Contractor shall be responsible for determining the adequacy of the drainage systems. He shall prepare calculations for submittal to the local authorities and to the Project Manager that take into consideration the estimated sewer flows.

All drainage ditches shall be lined, either with concrete or stone pitched walling. The entire open drainage system shall also be fitted with open steel gratings that shall be recessed into the top edge of the concrete walling. The gratings shall be of flat bar on edge, galvanized after manufacture, with openings sufficient to allow the passage of surface water but not stones or rubbish, and shall be capable of taking superimposed loads from foot traffic (but not vehicular traffic). The gratings shall be arranged to present a neat appearance with all sections to a standard size, and edges properly finished. The gratings shall be arranged in short sections for ease of removal and refitting.

Where the drainage system passes under roads it shall be in reinforced pipework or pipes laid within concrete ductwork.

The gradients to which all sizes of drains and sewers shall be laid, shall be completely sufficient to ensure self-cleaning velocities in the pipes.

Minimum self-cleaning velocity shall be taken to be:

In pipes up to 225mm diameter 0.75m/sec to 0.9m/sec

In pipes between 225mm and 600mm diameter 0.75m/sec

Maximum self-cleaning velocity shall be taken to be:

1.8m/sec under reasonable circumstances and

3.0m/sec absolute maximum

16.10.9.2 Manholes and Inspection Chambers

Manholes and Inspection Chambers shall be constructed in accordance with BS EN 1917:2002. They shall be built in masonry or concrete with galvanized step irons and cast iron covers and frames. Heavy duty cover and frames shall be used for trafficked areas.

16.10.9.3 Drainage during Construction

The Contractor shall maintain all existing drains and drainage channels in good order during the period of the works, and also cut any additional temporary channels which may be necessary to prevent flooding of the Site until the permanent drains have been laid. Particular attention shall be directed to dealing with ground and surface water before, during and after construction as these may present problems during the rainy season.

16.10.9.4 Waste Water Drainage

All waste drainage shall be taken to a septic tank. A septic tank is a type of settlement tank intended to provide quiescent conditions for settlement of sludge and the development of anaerobic conditions for the decomposition of organic matter. Raw sewage is fed to the tank, and settled sewage is discharged to the soakaway by means of an overflow pipe. The capacity of the septic tank shall be sufficient to cater for the load arising from the sub-station.

The septic holding tank shall be constructed in a manner and using appropriate materials so as to remain water tight at all times and be strong enough to withstand heavy vehicular traffic. It shall be GRP or made of concrete.

Openings and covers shall be provided to permit easy access and all covers shall be of the heavy duty type suitable for vehicular traffic. Ventilation shall be provided by a ventilation pipe terminating in a copper wire balloon to prevent the access of adventitious matter. The construction and internal configuration of the tank shall be in accordance with the current environmental regulations.

A soakaway pit of adequate capacity shall be constructed as part of the sub-station development. It is essential that the soakaway walls shall be built with solid concrete blocks in mortar which contains lime putty to which an approved waterproofing agent has been added. All joints in blockwork shall be well filled with mortar. The liquid effluent from the septic tank shall be drained to the soakaway pit. The soakaway pit shall be covered by a reinforced concrete slab with access through a manhole cover. The dimensions of the soakaway pit shall be determined by the percolation characteristics of the local soil as determined by a standards test and the result expressed as minutes/mm reduction in surface level.

The Sanitary system within the buildings will be developed by the Contractor as per standards referred to in the specification and continued into the general outdoor sanitary sewer system and finally to the septic tank and connected to the existing system.

16.10.9.5 Stormwater Drainage

The capacity of the surface water drainage system shall be designed in accordance with an international standard using a storm return period of 1 in 5 years. The surface water drainage shall include all necessary gutters, down pipes, gullies, traps, catch pits manholes etc. All water likely to contain oil shall be passed through approved oil separators before passing into the drainage system. The quality of the discharge shall be acceptable in all respects to the local water and environmental authorities.

The stormwater system for drainage from buildings shall comprise down pipes into gullies and buried pipes discharging into existing water courses and channels. Where it is not possible to obtain sufficient cover to bury the pipes the water shall be conveyed in reinforced concrete channels, laid to falls which shall ensure that the channels are self-cleansing. The drainage channels shall be covered with an open grid galvanized grating as specified above.

The stormwater system for the Site general shall consist of lined channels (concrete or stone pitched walling) or pipework, manholes and stand traps that shall discharge to open ground outside the site boundary. Discharged water shall not be permitted to pond within 50m of the site boundary.

16.10.9.6 Pipes for Stormwater Drainage

- a. **Concrete pipes and fittings:** These shall conform to BS 5911, and shall be obtained from an approved manufacturer. They shall be suitable for flexible jointing unless otherwise approved.
- b. **Porous concrete pipes:** Porous concrete pipes shall be used where indicated on the Drawings and shall conform to BS 5911-114:1992. They shall be wholly porous with ogee joints.

The structural design of pipework shall be in accordance with the pipe manufacturer's recommendations in respect of pipe grade, trench dimensions and pipe bedding.

16.10.9.7 Bends, Gullies and Fittings

All bends, gullies and fittings used in the drainage systems shall be of the same materials and of equally high quality as the adjacent pipework.

16.10.9.8 Catchpit Covers

Where concrete slabs covers are required they shall be pre-cast and have a strength of 35N/mm³ after 28 days. Where cast iron covers are required they shall conform with BS EN 124. Covers to be watertight and prevent ingress of surface water.

16.10.9.9 Step Irons

Manhole step irons shall comply with BS EN 13101:2002 or be of equal strength and dimensions. They shall be galvanized or coated with best quality bitumastic composition.

16.10.9.10 Inspection of Pipes

All pipes and fittings shall be examined before laying and any found to be damaged, defective or otherwise unsound shall not be used in the works.

16.10.9.11 Excavation and Backfill

Trench excavations for drains shall be carried out with the minimum disturbance to adjacent ground and in such a way that existing or new work shall not be undermined. Where trenches are to be backfilled with hardcore, gravel or the like, or where open channels are to be constructed, excavated material shall be removed immediately after excavation. No backfill shall be placed until pipes, etc. have been inspected, tested and approved. Backfill shall be carefully placed by hand tools round pipes etc. and rammed in layers not exceeding one hundred (100) millimetres thick in a manner which will not cause damage. When a minimum thickness of three hundred (300) millimetres above the pipes has been so placed, normal methods of backfilling and ramming may be adopted.

16.10.9.12 Laying of Pipes

Pipes and fittings shall be of the types, qualities and sizes specified by the designer. They shall be laid to the lines and levels shown, and the barrel of each pipe shall bear firmly and uniformly on the trench bottom or prepared foundation bed, any projections in the trench bottom which could cause damage to pipes being first removed. Pipes shall be kept clean during and after laying, and open ends shall be provided with temporary plugs to prevent entry of foreign matter. Each pipes shall be accurately boned to gradient between sight rails and drain laying shall commence at the lowest end and proceed uphill. Pipes shall be laid with the sockets leading uphill.

16.10.9.13 Jointing of Pipes Generally

The jointing of pipes shall be carried out as specified below. The pipes to be jointed shall be accurately centred and butted together, and joints shall be made only by experienced drain layers using the special tools recommended for the particular type of joint. Joints shall generally be of a flexible type.

16.10.9.14 Flexible and Proprietary Joints

The joints in concrete, asbestos cement, unplasticized PVC and pitch fibre pipes designed for flexible jointing shall be made in accordance with the manufacturer's instructions and relevant British Standards. Unless otherwise directed or agreed, the joints in concrete and asbestos cement pipes shall be of the compressed rubber ring type, and when loose collars are used these shall be accurately located over the centre of the joints.

16.10.9.15 Rigid Jointing of Spigot and Socket Pipes

Concrete, asbestos cement or salt glazed ware spigot and socket pipes for rigid jointing shall be used only where specified or directed. They shall be jointing by inserting and caulking one complete ring of tarred gasket which shall centre the pipes and prevent mortar from entering the pipes. The joint shall then be completed by filling with mortar which contains lime putty. The mortar shall be well rammed into the joint and finished with a 45° bevel. Joints shall be undisturbed and kept covered with wet sacking for 7 days.

16.10.9.16 Porous Pipe Joints

Joints in porous pipes shall be made by butting the pipes tightly together so that no soil or the like can enter the pipes. If, due to minor changes of line or gradient, a joint cannot be completely closed, it shall be wrapped with bituminous felt and surrounded with weak concrete.

16.10.9.17 Concrete Surroundings

Where required the pipes shall be bedded on or surrounded by Grade 12/15 concrete with an aggregate size of 20mm.

16.10.9.18 Catchpits

Details and sizes of bases, benching, covers and manholes generally shall be obtained from typical manhole details shown on the Drawings. Unless otherwise directed catchpit walls shall be built with solid concrete blocks, as specified, in Grade B mortar to which an approved waterproofing agent has been added. All joints in blockwork shall be well filled with mortar.

Catchpits deeper than (1) metre shall be provided with step irons. Precast concrete relieving blocks manufactured with Grade 25/20 concrete shall be provided and set in the blockwork walls over each pipe.

16.10.9.19 Testing of Drains

All drains, other than open channel, stone filled drains and porous drains, shall be of watertight construction, and all waste water and surface water drains shall be subjected to a water test before backfilling of trenches is commenced. Drains may be tested in sections, and catchpits may be tested separately. The Contractor shall submit to the Project Manager for approval his proposals for testing. The drains shall withstand, without leakage, a water pressure of not less than one and one half (1.5) metres at any point for a period of 20 minutes or such other time as the Project Manager may direct. All necessary plugs, temporary connections and other equipment and all labour required for the tests shall be provided by the Contractor and at the expense of the Contractor. For testing of pipes in areas where an adequate supply of water is not readily available, the Project Manager will accept an air (smoke) pressure test, always provided that the method of testing is approved. Further testing may be called for after backfilling of trenches to ensure that pipes have not been damaged during that operation.

Open drainage channels shall be tested to ensure that they are completely self-draining, with a continuous fall and no ponding of water in the base.

16.10.9.20 Regulations

The regulations and recommendations of any relevant drainage or sanitary authority shall be fully observed, and the Contractor shall be responsible for acquainting himself with any such regulations.

16.10.9.21 Oil Containment

Power transformers shall be sited in oil containment areas and drain via a flame trap to an underground facility to remove oil away from a fire in the event of an incident. The capacity of the underground containment shall be equal to the volume of oil contained within the transformer plus 50% to allow for rainwater and firefighting materials externally applied by the firefighting service.

Where there is more than one power transformer on a site, it may be economic to link the oil containment drainage areas of these to a single underground tank with capacity for the largest transformer alone. Connecting pipe work shall be designed to ensure rapid discharge of oil to the underground facility that, together with the pipe work, shall be resistant to transformer oil at a temperature of up to 80°C. Underground oil containment facilities shall be provided with a means of inspection and allow for pumping out of accumulated rainwater or oil.

The area within the transformer enclosure shall be designed as a water retaining structure to BS 8007 and coated with 2 coats of bituminous paint and be surfaced with a 100 mm thick layer of gravel on steel grating. It shall be tested in accordance with Part 19 of Section 5 of QCS.

The road immediately adjacent to transformers used by oil handling equipment for maintenance will also drain to the containment facility to prevent ground pollution in the event of accidental spillage.

16.10.9.22 Fire and Blast Design Requirements

Plant within close proximity of power transformers/reactors shall be protected by fire barrier walls. Protection shall be provided for other circuits and transformers/reactors, control equipment, and external property according to the recommendations of NFPA 850.

Fire barrier walls and building fireproof walls will be designed for 4-hour fire resistance and a blast pressure of 0.5 kN/ m². The fire barrier wall height shall be a minimum of 500mm above the highest part of the transformers.

16.10.10 Permanent Access Roads

16.10.10.1 General

The permanent road system within the site shall be designed to allow for adequate access and emergency situations during operation and maintenance. The road system shall form an integral part of the existing road system.

The substation access road shall be to bituminous standard, complete with drainage facilities and culverts as necessary shall be constructed by the contractor, the length of this road as stipulated in the price sheets.

The permanent roads within the site are to be designed in accordance with accepted international standards that shall be proposed by the Contractor and agreed by the Project Manager on the basis of a 25 year life with 50 commercial vehicles per day. Due account is required to be taken in the road design of abnormal loads during both the construction phase and also during the operational life of the plant resulting from heavy maintenance.

All permanent roads are required to be of such geometrical alignments (longitudinal gradient, cross-fall, radius and width) to accommodate the movement of heavy goods vehicles at the design road speed of 15mph.

Road markings and signs shall be in accordance with the Department of Transport publication 'Traffic Signs Manual Volumes 1 to 14'.

Footpaths shall be of 1500mm nominal width and designed for an accidental wheel load of 20kN. Footpaths shall be either precast concrete flags or bitumen macadam.

Within the plant area height limit gauges shall be provided where height clearances are limited and in particular where there is danger from overhead lines.

Safety barriers shall be provided where there are exceptional local hazards or where specific plant protection is required. These barriers will be of the Armco or substantial bollard type.

External access road from the nearest main road up to substation gate to be implemented. The proposed route of access road shall be in line with the Substation layout and existing pathway. The substation access roads shall be made to bituminous standards. The road shall be connected to existing major roads via a standard road junction to the approval of the highway authorities. The width of the main carriageway shall be 7 m (two 3.5 m lanes) with 1 m shoulder on each side. The road shall be lined with channels and kerbs for drainage, with storm water draining into Inverted Block Drains (IBDs) on either sides of the road, road markings and signs. The slope from the shoulders to the invert level of IBD shall be lined to Employer's Representative approval.

16.10.10.2 Codes and Standards

Materials and workmanship shall comply with the latest revisions of the following Codes and Standards: -

- BS 13108 Bituminous mixtures. Material specifications.
- Department for Transport "Specification for Highway Works".
- Department of Environment "Traffic Signs Manual".
- BS EN 12591 Bitumens and bituminous binders. Specifications for paving grade bitumens.
- BS 3690-3 Bitumens for Building and Civil Engineering

16.10.10.3 Car Parks

All materials, workmanship and testing shall be in accordance with the Department for Transport 'Specification for Highway Works, Part 3'. All areas of roads or hardstanding that could be subjected to a fuel, oil or chemical spillage shall be constructed in concrete.

A minimum capacity of 10 No vehicles shall be provided.

16.10.10.3 Road Drainage

Access roads shall be constructed with an elevated grade above the level of water that ponds on the surface during the rainy season. The roads shall be graded to drainage gullies which shall discharge into the main drainage system.

Culverts should be installed through the elevated roadway to allow the free movement of the water and to avoid ponding adjacent to the roadway.

Where pipes pass under the road they shall be surrounded by concrete or laid in concrete ducts and the road shall be bridged over them if necessary.

16.10.10.4 Kerbs

The roads shall be constrained between kerbs.

Kerbs shall conform to BS EN 1340:2003 Concrete Kerb Units – Requirements and test methods.

They shall be cast to the required radii for all curves less than 12 metres. Paving slabs will be to BS EN 1339.

Concrete bedding and backing to kerbs shall be cast in-situ to the dimensions shown on the drawings. Bedding mortar shall consist of freshly mixed moist 1:3 cement sand mortar using sand complying with BS 882 grading M. Kerbs shall be backed with concrete with a grade of not less than C15.

Flush kerbs shall be similarly laid or may be cast in-situ. The outside corner of the kerbs shall be chamfered.

Marginal strips and kerbs shall be protected against covering or splashing with bitumen or cement. Kerbs and manhole frames shall be primed before bituminous macadam is laid.

16.10.10.5 Fencing and Gates

This section specifies fixed chain link fencing. This type of fencing shall be used for the entire substation site boundary of 3 meters high.

This shall also apply to the fencing of the Switchyard land and staff housings of 2 meters high.

The provisions and installation of the chain link fence shall be in accordance with the requirements of BS 1722 Part 10 "Specification for anti-intruder fences in chain link and welded mesh" except where varied by this Specification.

16.10.10.5 Chain link fabric

Chain link fabric shall be galvanized wire (Grade A) and PVC (plastics) coated and have a diamond mesh pattern size of 50mm in accordance with Clause 3.2 of BS 1722 Part 10. The width of the mesh roll shall be 2.4m. The external diameter of the mesh coated wire shall be 6.4mm conforming to Table 1 of BS 1722-10.

All wire shall conform to the relevant parts of BS EN 10223 or BS 4102.

The fabric shall be furnished on the top and bottom edges with a twisted and barbed selvage. Chain link mesh shall be joined by interweaving a spiral and restoring the knuckle or barb.

A continuous concrete sill 300mm wide x 300mm deep shall be cast in the ground over the full length between posts, with the top approximately 25mm below the bottom of the chain link mesh. Concrete shall conform with requirements specified herein for unreinforced structural concrete. Hair pin staples 4mm diameter shall be threaded over the bottom row of mesh and line wire, at 500 mm centres and set in the sill to a depth of 150mm.

16.10.10.6 Line wire

Line wire shall be galvanized wire (Grade A) and plastics coated conforming to BS 4102 and Clause 3.3 of BS 1722: Part 10. The external diameter of the wire shall be 6.4mm, conforming to Table 1 of BS 1722-10.

Chain link fence shall have a minimum of five rows of line wires. The top row of wires shall be double and secured not more than 50mm below the top of the chain link mesh, excluding the barb. The bottom row of line wire shall be close to the ground.

16.10.10.7 Stirrup wire

Stirrup wire for securing line wires to intermediate posts shall be galvanized and plastics coated conforming to BS 4102 and Clause 3.4 of BS 1722: Part 10. The external diameter of the wire shall be 3.55mm, conforming to Table 1 of BS 1722-10.

16.10.10.8 Tying wire

Tying wire for securing mesh to line wires shall be galvanized and plastics coated conforming to BS 4102 and Clause 3.5 of BS 1722-10. The external diameter of the wire shall be 2.0mm, conforming to Table 1 of BS 1722-10.

16.10.10.9 Posts

Intermediate posts for chain link fencing shall be circular hollow sections in accordance with Table 2 of BS 1722 Part 10. The post size shall be 60.3 mm o.d x 4 mm for supporting 'heavy duty' mesh. Material properties, protective treatments tolerances on size etc. shall conform with the recommendations of BS 1722-10 Section 5.

Straining posts for chain link fencing shall be circular hollow sections in accordance with Table 2 of BS 1722-Part 10. The post size shall be 89.2mm o.d x 4mm x 3.2m length for supporting 'heavy duty' mesh panels. Material properties, protective treatments, tolerances on size etc. shall conform with the recommendations of BS 1722-Part 10, Section 5.

Struts for chain link fencing shall comprise circular hollow sections in accordance with Table 2 of BS 1722-Part 10. The strut size shall be 48.3mm o.d x 3.2mm x 3.2m lengths for supporting 'heavy duty' mesh panels. Material properties, protective treatments, tolerances on size etc. shall conform with the recommendations of BS 1722-Part 10, Section 5.

16.10.10.10 Barbed wire

Barbed wire with electric shock security for use on substation site chain link fence (as well as on all boundary walls) shall only be provided as follows:

- a. Barbed wire for chain link fence shall comprise 3 Nos straight strings, equally spaced, shall be fixed on each supporting arm.
- b. Barbed wire for gates shall consist of 5 rows of "straight" strings, equally spaced.
- c. Each string of barbed wire shall consist of two strands of 2.5mm dia (12 gauge) wire with 2.0 mm dia (14 gauge) four pointed barbs spaced approximately 125 mm apart along the wire. The wire shall be galvanized in accordance with ASTM A121 to produce a minimum zinc coating of 0.244kg/m² of surface area on 2.5mm dia (12 gauge) wire and 0.198kg/m² of surface area on 2.0mm dia (14 gauge) wire.

Barbed wire shall conform to BS EN 10223-1.

16.10.10.11 Fittings for chain link fences

Fittings required for chain link fences, typically comprising: fixing and straining devices, eye bolt strainers and cleats, winding brackets, stretcher bars, staples, droppers for barbed wire, bolts, nuts and washers, extension arms, etc. shall conform with the requirements detailed in Section 5 of BS 1722-10.

16.10.10.12 Concrete sills

Where chain link fences are used in unpaved areas a concrete sill shall be constructed as specified in the "Chain link fabric" section above. The top surface of the sill shall be 50mm above grade, or as otherwise shown on the approved drawings.

16.10.10.13 Foundations

Foundations shall be designed and constructed of cast-in-place concrete in accordance with this specification, comprising a pad base, adequately sized, to support the fence, and loading criteria (including wind) imposed by the works and satisfying the geotechnical parameters of the subsoil at the location of the fence.

Any damage to the fencing caused by the construction operations shall be rectified promptly by the Contractor at his own expense.

16.11 Miscellaneous**16.11.1 Attendance on Other Trades**

Each trade shall attend upon, cut away for, and make good after, the electrical engineers and all other trades as described and directed.

16.11.1.1 Cleaning up at Completion

On completion of the works all floors shall be scrubbed, all work touched up after all trades, and the whole left clean and ready for use. All rubbish and debris shall be removed from site.

16.11.1.2 Raised Floor

Raised access floors shall be carried out in accordance with DIN EN 12825.

The raised access floor system shall be capable of withstanding the following loads:

- concentrated load: not less than 4.5 KN over 25 mm²
- uniformly distributed load: not less than 12 KN/m²

The factor of safety for the uniformly distributed load shall be „3“. The system when subjected to the test loads shall not deflect or deviate more than 1:250 of the shortest span or 2.5 mm whichever is less. The system shall be capable to carry the specified concentrated loads at any position, such as around the perimeter, centre of panel, cut panel, perforated panel or at any point which considered a point of weakness.

The steel base plate shall be fixed to the floor by epoxy adhesive as well as by bolts.

Application of raised floor according to the attached drawing of the Control Building.

16.11.1.3 Temporary fencing and barricading

The Contractor shall be responsible for all necessary temporary fencing and barricading during the construction works including access control to prevent unauthorized access to the construction site. Stringent measures are to be taken to prevent access to substation parts that are alive.

16.11.2 Building Services

16.11.2.1 Electrical Building Services

16.11.2.1.1 Scope of Works

The scope of works for the Electrical Building Services shall include, but not be limited to, the following:

- Lighting systems;
- Small power installation including cables/wiring and distribution systems;
- Lightning protection system.
- Control wiring, etc.

The Contractor shall be responsible for the complete design, detailed design calculations, equipment selection, installation, testing and commissioning and testing of the complete electrical building services systems.

Design calculations, system diagrams and construction drawings shall be submitted for approval. The Contractor shall ensure that the equipment is provided suitable for the location it is to be installed in taking into account temperature and environmental conditions expected on site.

The Contractor shall include for providing all as constructed drawings, which shall be prepared as the works proceed. Completed sets of Operational and Maintenance Instructions including all test, commissioning and any other documentation required to maintain the works.

16.11.2.1.2 Lighting Systems – Normal, Emergency and External

Lighting systems shall be provided throughout the station for all areas, outbuildings and external areas to the levels required, with considering energy saving through LED type luminaries as per KETRACO requirements.

The lighting system provided shall be in compliance with the Regulations, Codes and Standards and comprise normal, emergency (including security lighting) and external lighting systems that will include a fence security lighting system.

The design and installation of lighting and small power systems shall be based on the following Regulations/Standards or equivalent international (e.g. IEC) standards:

- Requirements for Electrical Installations, IEE wiring regulations BS 7671 as issued by the Institution of Electrical Project Managers, London and British Standards, UK.
- The Code for Lighting, Lighting Guides, as issued by the Chartered Institution of Building Services Project Managers (CIBSE) London, UK.

All interior and exterior lighting designs shall be undertaken using computerized calculation.

The lighting systems will consist of the following systems:

- The normal lighting installation shall cover approximately 75 per cent of the total lighting in a given area;
- The emergency lighting system serving 25 per cent of the total load in a given area and its power shall be from the 110V batteries. The emergency lighting system shall also be capable of illuminating all exit signs, doors, stairways, corridors, other routes of exit and outside each fire exit together with other areas of specific risk.
- Operational (high risk task area) lighting system connected via distribution boards for control rooms and walkways. Basic source of power shall be from the 110V batteries.

Circuit design shall ensure that operation of a circuit protective device or failure of a circuit component shall result only in limited loss of illumination in a room or area.

The lighting installation, under normal operating conditions and throughout the Plant's operational life, shall be capable of providing the minimum service levels of illumination as listed below: These levels shall be based on measurements being taken after the lamps have operated for not less than 100 hours. The method of measurement

is to be carried out in accordance with the International Commission of Illumination (CIE) Publication No 29. Measurements shall generally be taken at floor level.

Areas typically	Description of activity	Standard maintained illuminance (lux)
Substations Emergency Diesel generator building Control and administration building Workshop and stores Firefighting pump house	Control areas/room	250-500
	Data printers	300
	Project Managers/offices	300
	Monitoring room	300
	Telecoms room	300
	Mess room	200
	Metering room	200
	Switch room	200
	Toilets	150
	Access corridors	150
	HV equipment floors	150
	Marshalling room/stairwells	150
	Cable floor/cable risers	50
	Battery room	150
	Entrance	150
	Fuel oil plant room	150
	Stairwells/corridors	150
	Station unit switch room	200
	Workshop/store	300
	C&I equipment	300
	Electronics room	300
	Switchgear room	200
	Prayer room	250
	Stores	200-300
	Kitchens	500
	Conference rooms	300-500
	Locker rooms	200
	Cable tunnels	50
	Transformer compounds	30

If there are areas that are not included in the above, BS ISO 8995 (or equivalent international (e.g. IEC) standards) shall be used for guidance.

The Contractor shall take into account the expected wall, floor and ceiling reflectance values when undertaking the design calculations. The lighting designs shall also take into account the proposed equipment locations.

The Contractor shall base his design calculations on fluorescent lamps of a white colour and a colour-rendering index of typically 95. Lamps shall be triphosphour or multi-phosphour type. High frequency ballasts shall be provided in all fluorescent luminaries and shall be cool daylight with a minimum life of 7500 hours.

High-pressure sodium discharge lamps shall be colour corrected deluxe white with a minimum lamp life of 24 000 hours operation with the required ballasts. All normal lighting shall have uniformity levels (ratio of average to minimum) no less than 0.8. The selection of luminaries and requirements of illumination for various areas shall be in accordance with the recommendations published by the Society of Light and Lighting with consideration of the safety and working conditions on the Project.

All emergency lighting schemes shall be arranged to provide the required illumination on interruption or failure of normal lighting supply, operation of a circuit breaker or fuse or manual acts such as accidental opening of a switch controlling normal lighting facilities. The Contractor shall design, supply, install, wire and connect up a complete emergency lighting installation for a minimum of 3-hour operation, in accordance with the following or equivalent international (e.g. IEC) standards:

- BS 5266, Part 1, 2011 (Code of Practice for the Emergency Escape Lighting of Premises);
- BS EN 1838, Lighting Application – Emergency Lighting.

Emergency lighting including operational (high risk task area) lighting system shall be supplied to all normally occupied spaces and escape routes including coverage to all fire doors.

Emergency lighting on paths of egress at floor level shall have a maximum-to-minimum illumination uniformity ratio of 40 to 1 the emergency lighting for stairs and escalators shall emphasize illumination on the top and bottom landings and at all intermediate landings

The Contractor shall design supply, install wire and connect up a complete external lighting system for all areas of the development.

All external lighting shall be designed to meet the requirements of lighting guide LG06: 1992 for the outdoor environment issued by the Chartered Institution of Building Services Project Managers. Illumination levels shall also be in accordance with the lux levels indicated below. Where a range of average illuminances are recommended in the guide for a particular application, the Contractor shall design his lighting scheme to provide an illuminance not less than midway between the recommended upper and lower values.

- Transformer area 30 lux
- Operating plant areas:

- | | |
|--------------------------------------|---------|
| ○ Machinery areas | 200 lux |
| ○ Platforms/ladders (active) | 50 lux |
| ○ Walkways | 50 lux |
| ○ Road, platform/ladders (inactive), | 30 lux |

The security fence shall be continuously illuminated during hours of darkness to provide an even vertical illuminance of 25 lux on the face of the fence.

In terms of luminaries and switches, all areas shall be individually switched with two way and intermediate switching provided where necessary if there is more than one method of access and for walkways and stairways. Luminaires installed on different floor levels or at different task locations to be controlled by their own switches.

Luminaires used indoors shall be minimum IP21 protection and for external use IP65

Excluding cable tunnels and other underground spaces, the mounting height of luminaires shall not be lower than 2.4m unless restricted by the available mounting height or if otherwise approved.

In the central control room the fluorescent lighting (excluding emergency lighting) shall be provided with "dimming" control to give a graded reduction in lighting levels

In large areas luminaries for access and inspection lighting shall be switched by contactors controlled by a switch adjacent to the plant covered by a specific load centre.

Emergency lighting shall be automatically energized on failure of the electrical supply to normal lighting in the relevant area.

All switches shall be mounted at 1.5 metres above finished floor or platform levels. The switches shall be positioned such that they can be easily located and accessed for use.

The external lighting installation shall be contractor controlled using photoelectric cells.

16.11.2.1.3 Small Power Installations

The Plant and any ancillary areas shall be provided equipped with socket outlets, connection units and isolators to suit the purpose of each building or area. These outlets will be suitable for providing power supplies to all portable equipment, hand tools, portable lamps and fixed equipment required for operating and maintaining the systems

For office areas, equipment and control rooms, maintenance and testing areas or similar, the socket outlet layout shall be designed so as to effectively cover work areas with a 3 metre flexible cable.

Socket layout design for all other areas shall give effective cover with a 15 metre portable extension. 240V socket outlets shall be provided in plant areas to supply power for hand tools etc. used for maintenance.

Power socket outlets shall be rated at either 16A, 32A, 63A or 200A and shall have 4 pole connections and two earth connections. They shall be provided as required by the design to all areas where equipment is to be maintained.

The Contractor shall also supply and install 63A welding socket outlets complete with plugs at strategic points located on a nominal 50-metre grid so that all parts of the Plant can be reached using a maximum cable length of 35 metres.

The mounting height of general-purpose socket outlets and power socket outlets for general-purpose socket outlets mounted in walls of rooms such as offices and control room areas shall be 300mm above finished floor. In all other maintenance type areas, equipment or station areas the mounting height shall be 600mm above finished floor.

Power socket outlets shall be mounted 1.2 metres above finished floor.

16.11.2.1.4 Distribution System

Sub distribution boards shall be provided for the lighting and small power supplies throughout the Substation.

The 415/240V ac power socket boards shall be fed from transformers, the capacity of which will be varied by design, for each group of 240V ac socket outlets.

Enclosures shall have a degree of protection to IP21 for office type rooms (indoor locations) IP44 for indoor locations in plant areas and IP65 for outdoors and damp situations.

16.11.2.1.5 Lightning Protection System

The Contractor shall provide and install a lightning protection system to provide the necessary protection to each building. Each building shall have its own air terminal network, down coming tapes and earth points.

The Contractor shall connect together with a perimeter conductor all earth rods of each individual lightning system. From the nearest point of the perimeter conductor the Contractor shall provide a link to the Plant earthing system.

16.11.2.2 Mechanical Building Services

16.11.2.2.1 Scope of Works

For piped services, the Service Water and Compressed Air Installations shall be extended into each building as required to provide wash down/maintenance facilities. The site Potable Water distribution system shall be extended into each building as required for domestic hot and cold water supplies. The domestic hot and cold water services shall comply with the latest ASHRAE and EN standards. Plant areas and emergency washing/shower facilities are also to be supplied with Potable Water.

The heating, ventilation and air-conditioning (HVAC) systems shall be installed to provide the required inside conditions as indicated in the Specification below, based on the external design conditions applicable to the site location as published by ASHRAE. Design, installation, testing and commissioning of systems shall comply with the latest applicable Codes and Standards, e.g. ASHRAE, NFPA, SMACNA, ARI.

The contractor shall also make reference to local regulations, standards and approval processes, to ensure the designs are fully compliant with local and international standards.

The Contractor shall be responsible for the complete design, detailed calculations, detailed design and construction drawings, equipment selection, construction, metering, controls, testing and commissioning of the whole of the Mechanical Building Services, subject to approval. The above systems shall comply with the relevant sections of both Part A and B of the Contractors MFS. These shall include, but not be limited to, the following:

- Potable water;
- HVAC;
- Service water;
- Service (compressed) air;
- General mechanical plant;
- Public Health (including sanitary ware);
- Thermal insulation;
- Fire detection;
- Fire suppression;
- Earthing and lightning protection
- Testing and commissioning;
- Handover, O&M manuals, record drawings.

16.11.2.2.2 Design Information

Design calculations, system diagrams, detailed design and construction drawings for all services and systems shall be submitted for approval, before procurement/construction is commenced. Design information shall be submitted with descriptions and calculations under the following headings. Sufficient time shall be allowed within the construction programme for the review/approval period, including any required rework.

- Objective;
- Concept of system, including control and metering strategies;
- Method of calculation;
- Design criteria;
- Calculations;

- Detailed Design and Construction Drawings;
- Appendices.

16.11.2.2.3 Quality Control

All equipment for the Mechanical Building Services shall be obtained from member firms of the relevant Trade Association(s). All equipment shall be new and suitable for the specific application. Equipment shall be suitably protected against damage during transit, site storage and installation. Equipment stored on site shall be done so in line with manufacturer's recommendations. An item which is damaged or incorrectly stored will be rejected and replaced at the contractor's expense.

The Contractor shall submit full details for approval, including samples where necessary, of the following components that they propose to use:

- Refrigeration plant and accessories;
- Outdoor and indoor parts of split units and their pipes and fittings
- Fans (all types);
- Energy meters;
- Fire/Smoke dampers;
- Control systems and BMS;
- Water storage tanks;
- Pipes and fittings for all systems.

16.11.2.2.4 Domestic Hot and Cold Water Services

The domestic hot and cold water services within the buildings shall comply with the latest ASHRAE and EN standards.

The Administration and Control Building, Guard House, Technical Staff Housings, and Security Staff Housings and Storage Warehouse shall be provided with a cold-water storage tank of sufficient capacity to meet one day's consumption for the building or area served. The pipes shall be of Polyethylene and the tanks shall be of GRP insulated construction, shall be located so as to prevent water damage or consequential losses in the event of a tank leakage for any reason and shall feature condensation drip trays to prevent nuisance damage. All tanks which are located above water sensitive areas should be surrounded by a bund wall with adequate evacuation ducts. Consideration shall be given to the location of the tanks in relation to localised heat gain and storage temperatures shall be maintained within recommended limits, to prevent the potential for legionella growth.

The elevated cold water storage tank shall be of sectional GRP modules to the size as shown on drawing and shall be mounted on purpose made concrete upstands to suit the manufacturers details. The tank shall consist of access hole and hinged lockable cover, drain connection, overflow main water supply connection via ball valve and bowser feed connection. All internal tie rods, and fixtures shall be of stainless steel. All panel joints shall be made externally and be made with galvanized structural steel nuts and bolts.

All pipework, fittings and valves and the installation of services shall conform to the relevant clauses of the pipework specification. Pipework shall be fixed or supported at appropriate intervals.

The hot water systems shall be served from local electrical water heaters, with central storage systems being provided only for large buildings with heavy demand for hot water. Suitable measures shall be taken to limit pipe losses and to maintain circulating temperatures within recommended limits, to prevent the potential for legionella growth. Systems shall be adequately sized to reflect the anticipated demand within each building or individual area.

Pipe sleeves shall be fitted where pipes pass through walls, floors and ceilings. Sleeves shall be of PVC, shall be of sufficient diameter to permit free movement of the pipe and shall be fixed in a manner that will ensure that they do not become detached from the building fabric.

At the end of each sleeve the approved set screw pattern CP cover plates shall be fitted. Pipework insulation/vapour seal shall be installed through the annular spaces between sleeves and pipes.

HWS-s and CWS-s shall be run directly to taps on sanitary fittings etc. The hot tap shall be on the left when facing the fitting.

The Contractor shall connect up the appropriate service to all bib taps, sinks, showers, basins and closets where required and shown on the drawings, and fit valves for isolating purposes on each individual draw-off.

The Contractor shall also include for Potable Water supplies to emergency wash-down and shower facilities in battery rooms and chemical areas, and to HVAC humidifiers.

The Contractor shall include for all necessary inspection, testing and commissioning, including disinfection, of the complete hot and cold water services installations.

The test pressure to be applied to the various services shall be as follows, and the pressure gauge readings for these tests shall be taken at the lowest points in the respective systems:

1. Domestic hot water flow and return lines - 7 bars
2. CWS and cold feed lines - 7 bars
3. Drinking water lines - 7 bars
4. Cold water rising mains - 13.5 bars

All plugs, caps, tees, drain fittings etc. required to enable the tests to be carried out shall be supplied by the Contractor.

The Contractor shall arrange for the domestic hot water service, cold water down service and mains water systems to be chemically cleaned immediately after the completion of the required flushing out, following the pressure tests. The systems shall be first treated to remove corrosion products, followed by a further treatment to inhibit corrosion.

The Contractor shall allow for the provision of suitable tapping points for introduction of chemicals and all the necessary drain/flushing connections. To provide a base treatment (after flushing procedures) the Contractor shall

introduce an approved chemical treatment for scale and corrosion prevention obtained from specialist suppliers into the cold water storage tanks at the rate of approximately 1 l per 4,000 l of water and agitate the tanks to distribute the chemical evenly.

The Contractor shall carry out the chlorination of all main water and drinking water services.

All necessary charging and raining down points shall be provided on the pipework as required to allow the chlorination and flushing out to be completed throughout. The chlorination of the services shall be carried out in accordance with the method described in BS EN 806 and the requirements of the Water Supply Authority.

16.11.2.2.5 HVAC Systems and Design Conditions

The HVAC system will be provided for the following purposes:

- To provide a comfortable working environment within the building for personnel and equipment.
- To warm up the incoming outside air during winter to prevent freeze-up problems.
- To maintain sufficient air circulation within the building to ensure that heat losses from the equipment do not result in an excessively uneven temperature distribution.
- To remove fumes and gases from the areas where undesirable build-up of these could otherwise occur.

The design parameters and necessary requirements to meet the design intent must be read in conjunction with other appropriate sections.

HVAC systems shall be designed, installed and commissioned in accordance with the latest applicable codes of the following:

- ASHRAE American Society of Heating, Refrigerating and Air Conditioning Project Managers.
- SMACNA Sheet Metal and Air Conditioning Contractors National Association.
- NFPA National Fire Protection Association.
- ARI American Refrigeration Institute.
- ANSI American National Standards Institute.
- AABC Associated Air Balance Council.

Calculation of heat loads and losses, cooling loads, ventilation and air flow requirements shall be made in accordance with the ASHRAE Standard for Cooling Load Calculation.

Commercially available latest version cooling load and duct system design programs (hourly analysis program (HAP)) shall be used for load calculation and the results of the calculation process shall be submitted along with a hard and a soft copy of the calculations for review and approval.

The Contractor is obliged to co-ordinate the design, installation and integration of the air-conditioning and ventilation system at the building with the related design and construction requirements of the architectural, civil, electrical and mechanical works.

All systems shall be designed and installed to provide acceptable environmental conditions for each area. The conditions of temperature, humidity, air movement and air filtration shall be controlled as required in the respective areas in summer and winter.

Main plant, equipment and distribution systems shall be provided with a 20% spare capacity allowance for future expansion.

HVAC systems serving critical areas such as Control Rooms shall be provided with duty/standby air handling and mechanical cooling plant to ensure continuity of operation.

HVAC systems shall be arranged to shut down in the event of a fire alarm, seal supply and extract ducts as required for the application of clean agent fire suppression systems, and start up smoke control pressurization systems. Provision shall be made in all plant areas for the venting and clearance of smoke and fumes in the event of fire, by means of roof vents or extract fans.

All systems and components shall be suitable for the design life of the Plant, and be designed for minimum life cycle cost and complexity, consistent with functionality, ease of maintenance and reliability.

For all general cases the HVAC system's ambient design conditions shall be as ASHRAE recommendations to suite the site conditions.

The HVAC systems shall be designed to obtain the internal conditions and system redundancy as indicated in the table below.

Area (s)	Internal Condition	Comment
Control rooms Offices Electronic rooms Laboratories Relay rooms	Summer: 25°C db \pm 1.5°C 50% r.h \pm 5% Winter: 22°C db \pm 1.5°C 40% r.h minimum.	Central air conditioning systems with 2 x 100% air handling units and standby mechanical cooling.
Workshop/stores Lecture rooms Prayer rooms.	Summer:- 25°C db \pm 1.5°C 50% r.h \pm 5% Winter: 22°C db \pm 1.5°C No humidity control.	Central air conditioning systems 2 x 50% air handling units. No standby mechanical cooling.
Corridors. Stairs.	28°C db max. 20°C db min.	Pressurization systems for smoke control may be required in these areas.

Area (s)	Internal Condition	Comment
Toilets	28°C db max. 18°C db min.	Extract ventilation (10 AC/h min.) Rooms under negative pressure.
Mess rooms.	25°C db max. 18°C db min.	Extract ventilation (6 AC/h min.) Rooms under negative pressure.
Excitation Switchgear Rectifier/inverter	42°C db max. 25°C db min 40°C db max No humidity control	AC systems with 100% fresh air facility for free cooling. 2 x 50% air handling units. Contractor to ensure Maximum and minimum temperatures (as specified by the equipment manufacturers) are not exceeded under maximum site conditions
Battery rooms	27°C db max. 22°C db min.	100% exhaust with duty/standby fans. Max 1% hydrogen concentration. Rooms under negative pressure. Contractor to ensure Maximum and minimum temperatures (as specified by the equipment manufacturers) are not exceeded under maximum site conditions
Standby diesel generator room	5°C above ambient db max. No winter heating.	Supply/extract ventilation for "normal" operation (DG off) plus boost ventilation (DG running) to DG. Contractor to ensure Maximum and minimum temperatures (as specified by the equipment manufacturers) are not exceeded under maximum site conditions

All HVAC units and systems shall be provided with local control panels for local manual/automatic control. The operation status such as alarms, humidity, temperature, fault indication, status indication of each air conditioning system shall be indicated and available at the local control panel and any individual fault signal results in a group signal, which shall be transmitted to the central control room.

In addition, the following criteria shall be considered in the design of the HVAC system:

- i. A general lighting level dissipation of 20 watts/m²
- ii. Sensible and latent heat gains for occupancy should be allowed on the basis of one person per 10m².
- iii. A minimum quantity of fresh air should be provided at the rate of 0.00125m³/s per m² of floor area or 12 l/s/person, whichever is the greater and this should be shown in the

calculations. Actual equipment gains within each room should be allowed for in determining Plant capacities. Determination of these values should be identified within the calculations.

- iv. Re-circulated air should be filtered. Air from areas where pungent fumes are likely to be present should not be re-circulated.

Battery rooms should be air conditioned by self-contained air conditioning units, where appropriate, or alternatively a centralized air conditioning system. The design of the air conditioning system shall avoid recirculation of air back into the battery room. These units should be of the non-recirculation type and sized to provide the internal conditions previously specified with a minimum of five air changes per hour. Duplicate extract fans should be provided, mounted at high level and positioned such that accumulations of hydrogen cannot occur. The fan units should be suitable for long life in the acidic environment

16.11.2.2.6 Fresh Air Requirements

Fresh air shall be supplied for the following purposes:

- Fresh air for occupied areas, minimum 12 litres/second/per person;
- Free cooling during periods of low ambient temperatures;
- Make-up air for exhaust ventilation systems;
- Building pressurization to exclude dust. Minimum fresh air supply shall not be less than 5 per cent of supply air volume.

Fresh air supplies shall be obtained from areas not subject to contamination from fumes. Air intakes shall be located at maximum available height, to reduce dust load.

Fresh air intakes on large systems shall have inertial sand filters with bleed fans and access sections. Small systems with fixed amounts of fresh air shall be provided with sand louvres.

All supply systems shall have two-stage air filtration, comprising washable primary panel filters and secondary bag filters, efficiency as required for the areas served.

16.11.2.2.7 Mechanical Cooling

Complete cooling systems shall be provided. The units and complete installation shall comply with (but not be limited to) the latest ASHRAE 15 & 34 – Safety Code for Mechanical Refrigeration – and ASHRAE Guideline 3 for Refrigerant Leaks, Recovery, Handling and Storage Requirements.

Air-cooled air conditioning systems shall be provided for each Plant building.

Critical air-conditioning systems shall be provided with 100 per cent standby plant. Critical air conditioning systems are those which are essential for the continued operation of the buildings and allow continued occupancy of essential working areas.

HCFC refrigerants shall not be used.

16.11.2.2.8 Power Supplies

The Contractor shall include for all power and control cabling and containment, MCC and controls for the complete HVAC systems.

Dual redundant power supplies (normal ac and safe ac) shall be provided for systems requiring 100 per cent standby plant, including mechanical cooling. The control system for HVAC will be powered by safe AC however the HVAC's motors, heaters etc., with the exception of the control system will be powered by emergency DG power.

16.11.3 Ventilation

All rooms, except toilets and battery rooms shall be kept under positive pressure to reduce dust penetration, by providing proper fresh air to air conditioned areas

Toilets shall be kept under negative pressure by exhaust ventilation, with spill air from the cooled supply air system to corridors or adjacent areas.

Battery rooms shall be provided with dedicated exhaust ventilation, and kept under slight negative pressure. Exhaust ventilation rate shall be sufficient to maintain hydrogen level at below 1% under maximum charge conditions, but be not less than minimum AC/h which defined at data sheet Duplicate (duty/standby) bifurcated exhaust fans shall be provided. Re-circulation of the air from the Battery Room will not be permitted.

16.11.3.1 Axial Fans

General exhaust fans shall be of the axial-flow type, single stage long casing with adjustable pitch air foil blades.

Each fan and motor shall be completely housed in a heavy galvanized mild steel casing with flanged ends for duct connections. Fan casings shall be complete with access door, extended lubricators and terminal block. Casings shall be truly circular to maintain throughout a maximum blade to casing mean tip clearance. Adjustable pitch impellers shall be galvanized, and fixed to the extended shaft of the drive motor.

16.11.3.2 Battery Room Exhaust Fans

Battery rooms shall be ventilated to give a maximum residual hydrogen concentration in the room air of one percent by volume under battery boost charge conditions.

Proper explosion proof bifurcated fans shall be installed complete with exhaust insulated ductwork, grilles and louvers. The fans shall be with the additional fitting of a spark minimizing impeller track and suitable for Group II gases (Battery room applications). The entire system shall be proofed against corrosive gases. The fans shall be interlocked with the battery charger systems so that during normal trickle charge a single fan will operate at slow speed and at high speed during boost charge. During boost charge the additional air supply requirements will be met by wall mounted electrically powered ON-OFF damper with external/sand louver all mounted at semi-low level in an external wall. Damper actuator shall be interlocked with the battery charger system.

Air flow/pressure switches shall be provided across the battery room exhaust fans to monitor their performance and provide automatic changeover in the event of supply fan failure.

16.11.3.3 Toilet Exhaust Fan

Toilets shall be provided with exhaust ventilation to provide minimum air change based on standards. Fans for toilets within the main building shall be packaged duty/standby units within a common casing, with back draught shutters and automatic changeover in the event of failure of the duty fan. Units shall be provided with a wall mounting control box, with facility for fault indication to the central control panel.

16.11.3.4 Wind driven roof top ventilation

A wind driven, roof mounted ventilator designed to exhaust heat & moisture from the roof space without the use of electrical energy. It Operates when the wind hits the turbine fins and causes the vent to rotate. It can also be driven by the expanding air in the roof space due to rising temperatures. This rotation creates a vacuum that sucks out air from the roof space. Most them are made of galvanized steel or aluminium. This type of ventilation system is used for storage warehouse.

16.11.4 Solar Water Heating System

16.11.4.1 General

This specification addresses the installation solar heated hot water systems for use within KETRACO's facilities. It includes specifications for hot water to be used both in buildings and swimming pools.

The contractor shall ensure that all material used in the construction, assembly and installation of the hot water system shall be of high quality, ensuring a life of 20 years for hot water systems installed in buildings, and 12 years for hot water systems installed in swimming pools. Furthermore, solar water heating system shall be equipped with an electric heating element as back up.

Design and installation work to be done according to the professional standards. This specification indicates guiding standards. The contractor shall comply with at least, but is not limited to these standards.

The contractor shall adhere to the specifications and guidelines provided by the equipment manufacturer.

16.11.4.2 Design Specifications

The products, design and installation shall comply with at least, but not limited to, the following industry standards wherever applicable:

- IEEE – The Institute of Electrical and Electronics Engineering
- NCA – National Construction Authority
- KEBS – Kenya Bureau of Standards
- IAPMO – International Association of Plumbing and Mechanical Officials
- IBC – International Building Code

SRCC – Solar Rating and Certification Cooperation

16.11.4.3 Solar Collectors

The contractor shall ensure that his design incorporates, but is not limited to the following:

- SRCC OG-100 for Solar Thermal Collectors
- SRCC OG-300 for Solar Water Heating System
- Mounting Instructions to be provided by the manufacturer
- In the event the collectors contain hazardous material, this shall be disclosed to the client, and any special maintenance and proper disposal/recycling practices provided.
- The collectors transmission shall be at least 95%

16.11.4.4 Collector Array

All collectors shall be arranged in such a manner that they face the same direction

The collectors shall be arranged such no shadow from a collector falls on another at any given time

In case of several collectors, the piping should be done such that they are interconnected in a reverse return configuration.

Each collector bank to be provided with isolation valves. The banks should also have a pressure release and it should be possible to drain them

The existing support structure is to be used for the collector array. In case a separate support system is to be used, the contractor is to provide this in the design.

16.11.4.5 Transport System

The system should be able to handle 150 psi for systems including heat exchangers.

The heat exchanger should be made out of a non-corrosive material

The heat exchanger should be able to handle 115 °C

For active systems involving pumps, the contractor shall ensure the pumps shaft is made of non-corrosive material. The pump should be solidly mounted on a concrete surface. The pump shall be controlled by the solar thermal temperature regulation system. Isolation valves shall be provided to enable the pump get serviced without draining the system

Any heat transfer fluid used in the system shall be compatible with all materials in the system. It shall be non-toxic and purposed for use in portable systems.

16.11.4.6 Plumbing Works

The contractor shall provide appropriate pipes, pipe fittings, valves, strainers, expansion loops, pipe hangers, inserts, supports, anchors, guides, sleeves and any other accessories deemed necessary for the proper installation of the hot water heating system.

All material used in the installation shall adhere to the appropriate codes and standards in its category.

All exposed sections carrying hot water must be insulated.

Supply thermometers with wells and appropriate bronze sockets

Provide pressure gauges with throttle type needle valve, or a pulsating dampener and shut off valve.

Piping shall be supported and firmly hung to ensure no sagging. The supporting shall be done in such a manner as to ensure the piping does not provide weight to other building or equipment members.

16.11.4.7 Electrical Works

All wiring and electrical installations to be done in accordance with IEEE and other relevant standards.

Motor starters to be provided with overload protection.

16.11.4.8 Mounting System

The mounting system shall be designed to ensure the panels are properly fixed. The mounting should be able to handle dead load, live load, winds, UV degradation, corrosion, seismic loads for a period of 25 years.

The mounting shall not compromise the structural dignity of the building/structure it is assembled on.

The contractor shall ensure that the thermal load fluctuations of the system shall not bring out fatigue on the mounting.

The final paint coat of the mounting shall be approved by the client. The paint shall not interfere with the grounding and bonding of the array.

The mounting shall be designed in such a manner as to allow for ease of operation and maintenance.

16.11.4.9 Corrosion

The whole system must be designed to handle the environmental conditions of the particular site.

Unprotected steel shall not be used in any part of the system

Fasteners shall be made of corrosive resistant material, or be anodized sufficiently to protect them from the elements.

16.11.4.10 Roof Installation

The installation shall be done in such a manner as to provide enough spacing to allow for access and maintenance. If other equipment is installed on the roof, a minimum of 900mm shall be maintained between the solar system equipment and the other installation.

The solar water heating system shall not be installed in such a manner as to obstruct the air flow into the building.

The installed equipment shall not exceed the ability of the existing structure to support. The contractor's design shall ensure the existing structure can handle the weight and installation process of the solar water heating system.

The installation process of the solar water heating system shall not interfere with the integrity of the roof. The works shall not negatively impact existing roof warranties.

All penetrations shall be waterproofed. Any chemicals/material used shall be chemically compatible with the existing structure.

Any damages arising during installation shall be borne by the contractor

The assembly design to be approved by the client.

16.11.4.11 Warranties

All solar collectors must have a minimum of a 10 year manufacturer's performance warranty to protect against defects and a 15% performance degradation. Additionally, the contractor shall provide a 20-year warranty option if commercially available.

All systems must have a minimum 10 year performance warranty to protect the host against more than a 15% degradation of system performance over the 10 year period that may occur as a result of faulty installation.

All systems must have a minimum 1 year warranty on installation labour and workmanship not otherwise covered by the manufacturer's performance warranty.

The mounting system shall have a 20-year warranty covering at least structural integrity and corrosion.

The contractor shall provide a comprehensive ten (10) year warranty on all system components against defects in materials and workmanship under normal application, installation, and use and service conditions.

All warranties must be documented in advance and be fully transferable to the client.

All work performed by the contractor must not render void, violate, or otherwise jeopardize any pre-existing Purchaser-Owner facility or building warranties or the warranties of system components.

16.11.4.12 Acceptance Testing

The contractor shall conduct comprehensive tests on each system. The acceptance test procedures shall be shared with the client for approval. All testing shall be conducted according to the manufacturers' specifications.

After the test have been conducted, the contractor shall provide the client with documented results for approval.

16.11.4.13 System Start Up

Once the client approves the acceptance tests, the contractor shall conduct a 24 hour test on the system. The following parameters shall be observed every 30 minutes:

- Thermal output (Btu)
- In-plane irradiance
- Ambient temperature
- Collector inlet temperature
- Thermal energy storage temperatures

The results of this shall be properly documented and given to the client for approval.

16.11.4.14 Monitoring period

Once acceptance testing and start-up has been undertaken, the contractor shall monitor the system for a period of thirty (30) days.

- During this period, data on the following parameters shall be collected on an hourly basis:
- Date and Time of data points
- Thermal output (Btu)
- Total Btu's delivered (per tank if system has multiple tanks)
- In-plane irradiance
- Ambient temperature
- Collector inlet temperature
- Thermal energy storage temperatures
- Quantity of back-up fuel consumption
- System availability

The system shall be deemed fit once the data collected throughout the monitoring this 30 day period is considered acceptable, and approved by the client.

16.11.4.15 Training

The contractor shall provide on-site training on operational and maintenance practices of the solar water heating system. The client shall provide members of a team to attend the training.

16.11.4.16 Automatic Controls

The automatic controls, controllers, cubicles and panels shall be designed, equipment selected, installed, tested and commissioned in line with ASHRAE and EN standards.

The Automatic Controls installation shall comprise the following:

- Outstation controllers within each building
- Central monitoring station located within the central control room
- All detectors, sensors etc.
- All valves, meters and actuators
- Control panel within each building c/w local user interface
- Local Area Network
- Testing and commissioning
- Graphics and user instructions

The contractor shall install all motorised valves, dampers, actuators, linkage kits to be supplied by the BEMS specialist and allow for all necessary pipework, ductwork, pockets for pressure switches / temperature detectors etc.

Control and monitoring of the plant will be via a central monitoring station, located within the central control room and provided as part of the works.

The controls shall be set to effect maximum fuel economy and interconnections to and between the various items of equipment will be carried out by the BEMS specialist under the supervision of the mechanical contractor.

All electrical equipment and apparatus shall be in accordance with the Institute of Electrical Project Managers Wiring Regulations (latest edition).

The control manufacturers (via the mechanical contractor) shall supply all wiring connection diagrams and all other similar relevant information necessary to carry out all wiring and interconnections. Wiring connection diagrams shall be submitted for review.

It is essential that wiring connection diagrams are made available at the beginning of the contract so that no delays are incurred.

All elements of the control system shall be designed to be high reliability and be replaceable for up to 15 years after the installation.

16.11.4.17 Metering

Energy metering shall be provided within each building to ensure all energy utilised is identified and assessed. The following measures shall be incorporated to ensure adequate metering is included:

- Metering and sub-metering to be provide in line with ASHRAE, EN, local and international standards
- At least 90% of the estimated annual energy consumption of each fuel shall be accounted for within each building

In addition to metering required by the above standards, energy meters and sub-metering shall be provided to the following:

- All incoming services to each building
- Metering of any heating or cooling services within each building when provided from a central system
- Sub-metering for large usage areas
- Sub-metering of all electrical final distribution boards to meter lighting usage
- Sub-metering of all central domestic hot water plant

A metering data collection system in parallel with the BEMS shall be provided ensuring quality real time data is available to the proposed monitoring and targeting system to identify avoidable wastage.

17.Fire fighting

The complete fire protection system shall be designed, installed, tested and taken into operation in accordance with the latest state of the art in the field of fire protection engineering and shall comply basically with the codes

and standards of NFPA (National Fire Protection Association, USA) and associated international recognised standards.

Fire detection and alarm system, fire protection and firefighting system for Substation including water storage tanks, firefighting room with fire pumps and associated piping and valves, all pertaining equipment, external pipelines, hydrants and fire hose cabinets to cover entire site.

All buildings and structures shall be made of non-combustible or fire resistant materials.

In order to avoid an uncontrolled fire spread inside a building, which would result in a considerable or total loss of the building and equipment, and to provide safe escape routes for the personnel, the buildings shall be subdivided into various fire areas, also called fire zones, separated by approved fire resistant barriers and elements, such as fire walls, fire resistant ceilings, doors, dampers and fire partitions.

Fire walls, ceilings and partitions shall have in general a fire resistance rate of not less than 2 hours, except for oil-insulated transformers installed indoors, for which the fire barriers shall have a fire resistance rate of not less than 3 hours.

Fire doors, dampers and shutters installed in 2-hour rated fire barriers shall have a fire resistance rate of not less than 1½ hours.

In principle, the following plants and rooms shall be designed as independent fire areas:

- Staircases
- Transformer rooms
- Switchgear rooms
- Control, electronic and computer rooms
- Battery rooms
- Cable floors, shafts and tunnels
- Air conditioning rooms
- Storage rooms

All ventilation and air conditioning ducts penetrating fire resistant walls or ceilings shall be provided with approved fire and/or smoke dampers, which shall be released via the fire detection and alarms. All control and power cables penetrating openings in walls or ceilings of fire rated walls or boundaries shall be sealed with an approved sealing system, consisting of fire resistant constructions and materials, providing a fire resistance rate consistent with the rating of the fire barrier system, providing a fire resistance rate consistent with the rating of the fire barrier.

A digital and intelligent, centralized or modular fire detection and alarm system shall be designed, installed, tested and commissioned in accordance with NFPA 72.

A reliable central fire alarm control panel shall be supplied including all necessary electronic cards and equipment to receive, operate, supervise and display all detection and alarm installations and to release and initiate all other functions as applicable.

The central fire alarm control panel shall be located inside the control room.

Portable and mobile (trolley-mounted) fire extinguishers shall be provided for the various areas, rooms, components and equipment. Numbers and locations of extinguishers shall be satisfactory to local authorities and are subject to approval. The fire extinguishers shall be in accordance with the requirements of NFPA 10, latest edition, and shall be installed at locations approved by the Employer/ Engineer.

Firefighting water shall be taken from a firefighting water tank, automatically filled with potable / non-saline public network water line for firefighting purposes and where public network water line is not available Contractor shall fill using water tankers until contract final acceptance . Independent fault signal shall be initiated to LDC (Load dispatch center) for low water level at $\frac{3}{4}$ tank level.

The fire water tanks reservoir shall be capable of providing 2 hour supply to fire protection system.

External hydrant shall be designed with a flow rate not less than 1890 l/m.

The capacity and pump head of each Electric Main Pump and diesel Main Pump shall be the equal to simultaneous operation of one largest single hazard system and one external hydrant for 2 hrs

The firefighting water tanks shall be designed, constructed and tested in accordance with NFPA 22, latest edition

Next to each outdoor hydrant, a weather resistant hose cabinet properly ventilated and painted red shall be provided.

Design, installation and tests shall be accomplished in accordance with the latest edition of NFPA.

17.1 Fire Zones and Required Considerations

The fire protection system shall mainly consist of the following installations and equipment as per KETRACO, KEBS, IEEE 979 and NFPA 850 requirements:

- Linear heat detection system for cable spreading rooms and cable shafts
- Nitrogen injection and oil evacuation system (NIFPS)
- Sprinkler systems
- Clean agent gas extinguishing systems (as per NFPA 2001)
- Standpipes and hose systems
- Fixed water spray systems (as per NFPA 15)
- Fire detection and fire alarm system
- Passive fire protection system (Fire resistant/retardant coatings for cables)
- Firefighting water tank
- Fire water service main ring surrounding substation complex
- Firefighting water pump station (containing NFPA-listed and jockey pumps)
- Hydrants and hose cabinets
- Wheeled and portable fire extinguishers

- Spare parts and special tools

The fire detection and protection systems for each fire zone are recommended as following table:

Fire Zones	Protection system	Detection system
Switchyard area	Outdoor hydrants and hose cabinets as per scope of work, Dry Powder/ Carbon Dioxide Extinguishers.	Outdoor point type heat detectors, Manual fire alarm stations
General areas, offices, lobbies, kitchens, small stores, guard room, etc.	Dry Powder / Foam Fire Extinguishers, in addition to Carbon Dioxide Extinguishers.	Smoke and/or heat detectors, Manual fire alarm stations
Staff housings	Water Extinguishers, Dry Powder /Foam Fire Extinguishers/ Carbon Dioxide Extinguishers and fire blankets.	Smoke and/or heat detectors, Manual fire alarm stations
Oil filled transformers, reactors	Nitrogen injection and oil evacuation system (NIFPS), for equal and above 100MVA or 100MVar	NIFPS detection, Heat detectors for Fire Alarm, Manual fire alarm stations
	Note: Protection & detection requirements of Transformers shall be based on Fire Protection Design Basis.	
Dry-type transformers	Portable dry Powder/Carbon Dioxide extinguisher	Outdoor heat detectors, Manual fire alarm stations
Cable basements, cable spreading rooms and cable tunnels within substation premises	fire resistant/ retardant coating of cable penetrations, portable dry chemical and CO2 fire extinguishers	Linear heat detection system, Smoke detectors, Manual fire alarm stations
Cables in reinforced concrete trenches within substation premises	Fire barriers with fire stopping at the cable penetrations	Detection not required
Cable Shafts	Fire barriers at every floor level. Fire barriers and fire stopping at cable penetrations.	Linear Heat detection system
Relay, computer and telecommunication rooms, Control rooms, SAS, LVAC, DC charger room, BCRs, indoor capacitor/reactor, HVAC control panel room	Portable dry chemical and CO2 fire extinguishers	Smoke detectors, Manual fire alarm stations

Fire Zones	Protection system	Detection system
Service shafts for HVAC ducts etc.	Fire barriers at each floor level	Smoke detectors at each floor level
Battery rooms	Portable dry chemical and CO2 fire extinguishers	Smoke and H2 detectors in every beam pocket, Manual fire alarm stations
Fire pump house as per scope of work	Portable dry chemical and CO2 fire extinguishers	Manual fire alarm stations, smoke detectors
All other buildings and areas including A/c condensing unit yards, outdoor capacitor banks/reactors	Outdoor hydrants and hose cabinets, Portable dry chemical fire extinguishers	Outdoor point type heat detectors, Manual fire alarm stations
Guard house and Telecom room	Portable dry chemical and CO2 fire extinguishers and fire blankets.	Smoke detectors, Manual fire alarm stations
Diesel Generator house	Portable Dry Powder/Foam and CO2 fire extinguishers	Heat detectors, Manual fire alarm stations

Note: No Automatic Water Extinguisher shall be used in the control room or yard.

17.2 Separation Distance & Fire Walls between Transformers

- For transformers using mineral based dielectric fluid, the method of separation shall be in accordance with NFPA-850.
- Transformers containing more than 500gal (1.9m³) of oil shall be provided with 2 hour rated fire wall or spatial separation between transformers and/or between transformers & structures. Where a fire wall is provided to protect from a transformer fire, it shall be extended in accordance with NFPA 850.
- For transformers using less-flammable dielectric fluid, the method of separation shall be in accordance with NFPA-850, Section 5.1.4 and 5.1.5.

17.3 Fire Hydrants

- The Hydrant system requirements shall be determined in accordance with Local Code.
- Hydrant system shall be installed, tested & commissioned in accordance with NFPA-24.
- Pressure at the remotest hydrant shall be accordance with Local code.
- Pipe size of hydrant network shall not be less than 150mm. (NFPA14)
- Hydrants shall be located not less than 40 ft (12 m) from the spaces to be protected. (NFPA24)

17.4 Portable and Trolley-Mounted Fire Extinguishers

17.4.1 Portable fire extinguishers

The following types of portable extinguishers shall be provided:

- Powder BC fire extinguishers
- Carbon dioxide fire extinguisher

Where extinguishers are provided externally, or in other areas where they may be subjected to the weather, they are contained inside a protective cabinet.

The extinguishers are of the type operated by means of a lever provided with a safety pin, which allows for the partial discharge.

17.4.2 Trolley-mounted fire extinguishers

The following types of wheeled extinguishers shall be provided:

- Powder ABC fire extinguisher
- Carbon dioxide fire extinguisher

Each powder unit consists of a powder container to which a carbon dioxide cylinder operating as propellant gas is attached; it is provided with a 15 m hose with controlled nozzle. The powder unit is mounted on a metal frame with two wheels and a driving handle.

Each carbon dioxide unit consists of a carbon dioxide cylinder, a hose, a control valve and a discharge nozzle. The cylinder and discharging devices are mounted on a metal frame with two wheels and a driving handle.

17.4.3 Fire Alarm

- Automatic fire detectors shall be designed, installed, tested & commissioned in accordance with NFPA 72.
- The type of protective signaling system for each installation and area should be determined by the Fire Protection Design Basis in consideration of hazards, arrangement, and fire suppression systems.
- Fire detection and automatic fixed fire suppression systems shall be equipped with local audible and visual signals with annunciation in a constantly attended location, such as the main control room.
- Audible fire alarms shall be distinctive from other plant system alarms and shall comply with NFPA-72.
- The fire-signaling system or plant communication system shall consist of the following:
 - 1) Manual fire alarm devices (e.g., manual pull station) shall be provided in all occupied buildings and for yard hazards.
 - 2) Plant-wide audible fire alarm or voice communication systems, or both, for purposes of personnel evacuation and alerting of plant emergency organization shall be provided. The plant public address system, if provided, should be available on a priority basis.
 - 3) Two-way communications for the plant emergency organization during emergency operations.
 - 4) Means to notify the public fire department shall be provided.

17.5 Nitrogen Injection system

Nitrogen Injection system should be a dedicated system for each oil immersed transformers (equal to and above 100 MVA) / reactors (equal to and above 100 MVAR). It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the firewall (if firefighting wall exists). The FEC shall be connected to the top of transformer / reactor oil tank for depressurization of tank and to the oil pit (steel tank) (capacity is approximately equal to 10% of total volume of oil in transformer / reactor tank / or existing oil pit) from its bottom through oil pipes. The FEC should house a pressurized nitrogen cylinder (s) which is connected to the oil tank of transformer / reactor oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to FEC and from TCIV to signal box. Detectors placed on the top of transformer / reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

17.5.1 System components

Nitrogen Injection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable and effective working of the system shall deemed to be included in the scope of supply.

- Fire Extinguishing Cubicle (FEC)
- Control box
- Detectors
- Signal box
- Fire survival cables and Fire Retardant Low Smoke (FRLS) Armoured Cables,
- Electrical Resistance Welded pipes with support & fitting as per standard norms for connection between transformer & FEC,
- Transformer Conservator Isolation Valve (TCIV) and oil drain pipe suitable for transformer oil quantity,
- Power supply
 - For Control Box
 - For FEC Auxiliary

17.5.2 Tests

Contractor has to submit valid type test reports as per relevant NFPA/IEC. including IP 55 on FEC, control box etc., from a reputed authority nationally or internationally and must be valid till expiry of validity of offer. Reports of all routine test conducted as per relevant NFPA/IEC standards in respect of various bought out items including test reports for degree of protection for FEC / control box / signal box shall be submitted by the supplier. The supplier shall demonstrate the entire functional test associated with the following as Factory Acceptance Tests:

- FEC, Control Box
- Fire Detector
- Transformer Conservator Isolation Valve

The performance test of the complete system shall be carried out after erection of the system with transformer at site.

18. Earthing and Lightning Protection

All buildings shall be connected to the earthing grid of the substation.

Wherever required a lightning protection system shall be provided under strict observation of the local regulations and relevant Standards (e.g. IEC62305). The system shall consist but not be limited to the following:

- Each super-structure shall be provided with the necessary lightning catching rods of stainless steel, with a minimum diameter of 10 mm, roof and down conductors of tinned copper or galvanised steel.

Steel constructions or down conductors of a civil construction shall be connected at ground elevation to a ring main equipped with an adequate number of earthing electrodes of sufficient length to obtain an earthing resistance of approx. 0.1 Ω . Such ring main shall not be directly connected to the sub-grade earthing system or the protective earthing system.

18.1 Support Structure Earthing

(1) Earthing Angle Set

Each leg of foundations shall be earthed by earthing angle. A set of earthing angle consists of a galvanized steel angle of 45 mm wide and 5 mm thick and 1 m long, stranded copper conductor of 38 mm² and compression terminals at both ends. The steel angle shall be driven into ground underneath the concrete block before concreting and electrically connected to tower stub member or cleat by means of copper conductor.

(2) Counterpoise

Counterpoise shall be 7/4.0mm stranded galvanized steel wire. It shall be electro-galvanized to provide a coating of at least 520 grams of Zinc per square meter of surface.

The counterpoise shall be buried not less than 600 mm in the ground. Normally two counterpoise sets will be installed per tower connecting to individual leg members in an approved manner and shall run an opposite direction each other underneath the lines where possible.

The electrical resistance to earth of all structures shall be measured.

Wherever possible individual tower footing resistance shall be reduced to a value not exceeding 10Ω (ohms), or as agreed by the Employer following resistance measurements.

18.2 Steel work detailing and manufacture

18.2.1 Detailing and fabrication

All towers shall be of self-supporting construction.

The towers shall be of approved design and construction. Unless otherwise approved, tension members, such as crossarm ties, which are liable to be set in vibration, shall consist of rolled steel sections and not flats.

The material used for main leg angles and stubs shall not be less than 6 mm thick and the material used for all other tower steelwork shall have a minimum thickness of 4 mm.

Welding shall not be used in the fabrication of any component used to form the tower structure.

Stub steelwork used to connect the tower to the foundation shall be at least the same section and steel thickness used for the lower tower leg which is attached to the stub.

The stub is considered as part of the foundation, therefore the safety factor of the foundation shall apply to the stub and cleats calculation

Tension only members shall be detailed with a 1 mm 'draw' per metre length of member with an additional 1 mm for each joint in the member.

Horizontal members shall be detailed wherever possible, in such a way, as to place the horizontal flange on top.

No bolt hole shall, before galvanizing, be more than 1.5 mm larger than the corresponding bolt diameter. As far as possible, bolt heads, rather than nuts, shall be on the outer or upper faces of tower joints.

The distance between the centre line of any hole and the member end shall be in excess of 1.5 times the hole diameter. The distance between the centre line of any hole and the edge of the member shall be in excess of 1.25 times the hole diameter. Hole to hole distance shall not be less than 2.5 times the bolt diameter

The design shall be such as to keep the number of different parts as small as possible and to facilitate transport, erection and inspection. Pockets and depressions likely to hold water, if not avoidable, shall be properly drained.

The holes necessary for accommodating the specified earthing counterpoise connections shall be provided on each leg of every tower and extension and the earthwire peak.

Suspension insulator sets and earth conductor suspension assemblies shall be attached to the tower such that the point of transverse rotation is on a full bearing surface.

All attachments shall be of 'hinge' type. Ubolt/shackle attachment type shall not be allowed

Provision shall be made on all tower types for the attachment of stringing and maintenance equipment to the cross-arms.

Approved means shall be provided on all towers and extensions to avoid risk of livestock being caught and injured in the angles between tower members.

Towers shall be equipped with approved devices immediately above each suspension insulator attachment point to prevent birds perching above the insulators.

18.2.2 Material

All rolled steel sections, flats, plates and bolt and nut bars used shall consist of steel manufactured by an approved process and shall be to the requirements of BS EN 10025 for grades S235JR and S355J0 steel or equivalent from other approved standards, the provisions of which in respect of tests and analyses shall be extended to include steel less than 6 mm thick. The steel shall be free from blisters, scales, laminations or other defects. Steel sections shall preferably be ISO Standard sections chosen with a view to avoiding delays in obtaining material.

High tensile steel when stored in the fabricator's stock-yard prior to fabrication and galvanising shall be marked continuously throughout its length with a light blue water paint line. In addition the grade of steel shall be painted on and ringed round with paint.

18.2.3 Bolts and nuts

All metal parts shall be secured by means of bolts and nuts and single washers. The minimum diameter shall be 12 mm.

All bolts and nuts shall comply with BS 4190, BS EN 20898 or other approved standard and screw threads shall be to metric standards. Bolts and nuts shall be of steel, with hexagonal heads. Screw threads shall not form part of the shearing plane between members, any thread in the bearing plane shall be to the approval of the Engineer. Bolts of any given diameter shall be of one grade of steel and marked for identification.

The nuts of all bolts for attaching to the tower, plates, brackets or angles supporting insulator sets or earth conductor fittings shall be locked by means of locknuts.

All bolts and screwed rods shall be galvanised, including the threaded portions; all nuts shall be galvanised with the exception of the threads, which shall be oiled. Galvanising shall be in accordance with this Technical Specification.

When in position all bolts or screwed rods shall project through the corresponding nuts, for a minimum of two full turns but such projection shall not exceed 10 mm. Suitable bolt grip tables shall be provided to demonstrate compliance with the above requirements.

All bolts shall be supplied with nuts and flat washers.

18.2.4 Workmanship

All members shall be cut to jig and all holes shall be drilled or punched to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite to each other before being bolted up. Drifting of holes will not be allowed.

The drilling, punching, cutting and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulty in the erection of the towers on the Site.

All bends in high tensile steel shall be formed hot.

Built members shall, when finished, be true and free from all kinks, twists and open joints, and the material shall not be defective or strained in any way.

In order to check the workmanship, not less than 1 per cent of the members corresponding to each type of tower shall be selected at random and assembled to form complete towers in the presence of the Engineer at the Manufacturer's Works.

If the towers are fabricated or galvanized by Sub-contractors, the Contractor shall, if required by the Engineer, provide a resident inspector at the works of each Sub-Contractor during the time that the steelwork is being fabricated or galvanized.

18.2.5 Erection marks

Before leaving the Manufacturer's Works all tower members shall be hard stamped with distinguishing numbers and/or letters corresponding to distinguishing numbers and/or letters on approved drawings or material lists to be submitted by the Contractor. The erection marks shall be located on the member so that, after assembly and erection, all members can be individually identified.

The erection marks shall be stamped before galvanizing and shall be clearly legible after galvanizing. Care shall be taken to distinguish between various grades of steel.

The erection marks shall incorporate the standard tower nomenclature as given in this Technical Specification.

18.3 Galvanizing

18.3.1 General

Except where specified to the contrary, all iron and steel used in the construction of the Contract Works shall be galvanized after all sawing, shearing, drilling, punching, filing, bending and machining are completed.

Galvanizing of all material, except core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with BS EN ISO 1461 and BS 7371 Part 6 and shall be applied by the hot dip process to provide thickness of zinc coating of not less than 610 gm. of zinc per square metre of surface on steel bars, plates, sections and fittings. Threaded work shall have a coating weight of 305 gm. of zinc per square metre.

Galvanizing of steel core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with IEC 61089 and BS EN 10244-2 or other approved standard and shall be applied by either the hot dip or electrolytic process. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

All steel tower materials shall be treated with a sodium dichromate solution immediately after galvanizing.

The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. Tests shall be carried out as specified elsewhere in this Technical Specification.

Sherardizing or other similar process shall not be used.

The Contractor shall keep available on site an instrument suitable to determine the thickness of galvanized coatings on steel members.

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19.Low Voltage Power and Control Cables (LV Cables)

19.1 General

This part of the specifications covers the design, manufacture, testing, marking and packing, transport, delivery, unloading and storage at site, installation, commissioning, handing over in satisfactory operating condition and defects liability of low voltage power and control cables and their accessories.

Standard designs and models from the Bidder's/ Contractor's manufacturing program are preferred, provided they meet the requirements of this Specification, and serve the intended purpose.

It is not the intent to specify completely herein all the details of design and manufacturing of the above cables and accessories. It may be noted that norms, standards specified are the bare minimum that is required. The cables and accessories shall conform in all respects to high standards of engineering design and workmanship and shall be capable of performing continuous commercial operation within the parameters guaranteed by the supplier in a manner acceptable to KETRACO. Any temporary arrangements that might be necessary shall be included.

The cables shall meet, as a minimum requirement, the latest versions of IEC and VDE/ DIN Standards. They shall be designed, manufactured, installed and tested in full compliance with all applicable sections, articles and drawings of these Tender Documents.

19.2 Applicable Standards

The latest issues of Recommendations of the International Electrotechnical Commission (IEC-Standards, etc.) shall apply.

The delivered equipment shall conform to the latest relevant directives of the European Community.

Supplementary standards are the international standards ISO, the German standards DIN and VDE, the European standards EN (CENELEC), the British standards BS, the American standards or specific national standards in the above mentioned sequence, if there are no relevant IEC-standards existing or if there is no sufficient information available in the IEC standards and/ or if explicitly asked for in these Tender Documents.

19.3 Technical Description

19.3.1 General

All cables shall fulfil the following characteristics:

- Halogen free according to IEC 60754-1 and EN 50267-2-1
- No emission of corrosive gases according to IEC 60754-2 and EN 50267-2-2
- Low smoke density according to IEC 61034-1/-2
- Flame retardant according to IEC 60332-1
- Minimal fire propagation according to IEC 60332-3-24 (type of test according to category C)

Outer sheath of LV cables shall be of uniform colour, even and free of outlines to achieve the appropriate tightness for the required IP degree together with the cable glands. The stranding must not become apparent.

Outer sheath of the cables shall be widely resistant to oils, greases, acids and bases.

Shore hardness of outer sheath shall be as follows:

- Halogen free material: Shore-D, 40
- Polyurethane (outdoor): Shore-A, 85

Shore hardness of core insulation shall be as follows:

- Halogen free material: Shore-D, 48
- Outdoor material: Shore-A, 89

All cables to be supplied shall be connected to the relevant equipment in an approved manner, including all necessary wiring. Their spare conductors shall be terminated and marked for future extensions. The conductors shall be connected to terminals as such that crossovers are avoided.

The dimensions of the cables shall meet the required operating currents, considering also that the permissible voltage drops are not exceeding the limit. Furthermore, the cables shall resist the expected thermic and dynamic short-circuit currents trouble-free.

The cable length of delivery shall be selected in that way that cable joints are not needed.

Minimum cross section of cable cores except telecommunication shall be 1.5 sqmm.

The maximum permissible voltage drops for all auxiliary power supply and control cable circuits up to the consumer shall be less than 5 %.

19.3.2 Power Cables

Power cables shall have copper conductor, XLPE insulation, inner covering and a flame retardant sheath.

In selecting the number of cables as well as the cable cross sections, due regard shall be paid to the appropriate de-rating factors in relation to the climatic conditions at site. All cables and wires shall continuously carry their rated currents under the worst temperature conditions, which prevail in summer, and shall also withstand maximum fault currents without damage or deterioration.

All Power cables shall have one separate conductor (TN-S system) of adequate size for protective earth. At the equipment to be supplied the protective earth is connected to the PE terminal.

The cross-section of the neutral conductor shall be the same like that of the respective phase conductors.

All appropriate cable racks, pipes, supporting structures, cable terminals, ferrules, and auxiliary equipment as necessary for proper installation, connection and operation shall be included to the satisfaction of KETRACO.

Conductor colours shall be selected according to KETRACO standard.

19.3.3 Control Cables

Multicore armoured and shielded control cables shall have standard cross section copper cores. The outer covering shall be preferably high density polyethylene, termite resistant, vermin proof, and suitable for the prevailing service conditions at site.

The printing on the cable sheath shall be repeated in intervals of at least 0.5 m and shall contain

- manufacturers name or trade mark
- cable type designation
- number and cross sectional area of the cable cores
- mark of conformity to RoHS

Control/ signalling cables shall have an overall screen with an optical covering $\geq 85\%$ and with the screen suitably earthed. In normal cases screens are earthed on both sides. For that reason they shall have the necessary ampacity. In special cases only earthing on one side might be needed, but this shall be agreed during design phase with KETRACO.

Cables running outside of a building shall be additionally armoured.

Control/ signalling cables shall be of bare copper wires, multi stranded acc. to IEC 60228 Class 5 and with standardised conductivity in accordance with IEC 60228. Cable cores shall be stranded concentrically; each cable core layer shall run in the opposite direction to the subjacent one.

The cable core insulation shall be either colour coded (cables to current transformers and voltage transformers) or black with white numbering acc. to EN 50334, consecutive and starting with #1 from the inner core. Repetition of the numbering shall be in intervals of at least 0.3 m.

The cables shall be designed for nominal voltage of (U0/U) of 300/500 V, the test voltage (50 Hz, 1 min) shall be 3 kV.

Individual cables shall be used for current transformer secondary circuits, voltage transformer secondary circuits, control and signalling circuits and communication circuits.

Cables for telephone and data links shall be of the twisted pair wire type with an appropriate screen. The screen shall be connected to earth.

19.3.4 Battery Cables

The cables for connection of the batteries to the fuse boxes shall be single core, halogen free insulated, short-circuit safe and inherently earth-fault-proof.

19.3.5 Voltage Transformer Cables

The cable connections from the voltage transformer secondary terminals up to the mini circuit breakers shall be short-circuit safe and inherently earth-fault-proof. This unprotected cable length shall be as short as possible.

19.3.6 Temperature Resistant Cables

Control cables that are exposed to high temperatures like on transformers shall conform to an increased maximum permissible temperature (for fixed installation operation temperature up to 145 °C and temperature under short-circuit conditions up to 280 °C). For use in outdoor applications and if applicable due to the climatic conditions the cables shall additionally allow a minimum ambient temperature of -55 °C for fixed installation and they shall have good resistance to weathering, ozone and UV-rays. In areas with possible oil contact (e.g. on oil insulated transformers) the cables shall also be oil resistant. In other respects requirements specified for control cables shall apply.

19.3.7 Fire Resistant Cables

Fire resistant cables shall be used wherever personal safety has to be considered e.g. for the following applications:

- Fire protection and fire alarm systems
- Emergency and safety lighting
- Systems for emergency evacuation

The cables shall fulfil:

- Circuit integrity (FE180) in accordance with IEC 60331, VDE 0472-814
- System Circuit Integrity E90 in accordance with DIN 4102-12.

The system circuit integrity can only be reached together with appropriate cable support systems.

19.4 Cable Installation

19.4.1 General

The cable routes shall be designed/ planned by the Contractor in close coordination with KETRACO. All cables shall be laid according to a cable schedule to be prepared by the Contractor. In the cable schedule all cables will be identified by numbers, their route and length will be indicated and the points of termination will be specified. At either end of a cable and before and after each firewall a metallic legend plate or other permanent identification label shall be affixed bearing the same identification number as in the cable schedule. The identification number shall be consecutive.

Power cables shall be strictly segregated from control cables and instrument transformer cables.

All types of cable glands required for the termination of the various sizes of cables shall be part of cable supply.

Cable glands shall be made of non-corrosive material (e.g. nickel-plated brass or stainless steel) and shall be of metric size. They shall provide protection class of at least IP67 at 5 bar. Cable screens and armours shall be contacted in a circumferential manner for earthing purpose. Gasket material shall not be exposed to sunlight radiation.

Cable routes shall consider redundancy requirements like for example in case of trip circuits. Redundant cables shall be laid on different routes as far as possible.

To resist the short-circuit forces spacers shall be used as far as needed.

19.4.2 Consideration of Induced Voltage Requirements

Control, signalling and communication cables laid in the vicinity of power cables have to be protected against damage by induced high voltages occurring in case of asymmetrical power cable operation, e.g. during short circuits.

Thus the Contractor must prove by calculation on the induced voltages whether the sheaths and insulations of the offered cables are sufficient for the given network configuration.

19.4.3 Sealing and Drumming

Immediately after tests at the Contractor's premises, both ends of every length of cable shall be sealed with a metal cap (with pulling eye for power cables) which shall be plumbed to the sheath.

All cables and conductors shall have the inner ends brought out and suitably fixed to the drum to avoid any damage during handling or pulling operations.

The cables shall be rolled on strong wooden or steel drums provided with suitable wooden battens to protect the cables from damage. They shall also be suitable for storage in the open air without additional protection by casing or shutters for a period of at least two years.

The drums shall be marked in English to indicate the direction of rolling, and also as stipulated in the Special Conditions of Contract, Shipping Marks, plus the following:

SIZE AND TYPE OF CABLE, VOLTAGE, CABLE LENGTH

For all spare cut lengths of cable which are to be delivered to the Employer's stock, approved sealing caps of correct sizes shall be supplied and properly mounted immediately after the respective cable length is cut.

19.5 Documentation

As a minimum requirement the following documentation shall be handed over with the Bid.

- Brochures and data sheets of the typical cables Bidder intends to use.
- Brochures and data sheets of the typical cable supporting systems Bidder intends to use.

As a minimum requirement the following documentation shall be handed over during the design phase.

- Cable calculation in regard to maximum permissible voltage drop (cable length), load current (cable diameter under consideration of the de-rating factors to be applied) and the disconnection condition of the protective elements (minimum required short-circuit current).
- Layout drawings for the cable supports (plan views and sectional views)
- Cable Lists
- Cable routing diagrams

19.6 Tests

19.6.1 Type Tests

The Supplier shall carry out all type tests called for in this Specification and such tests in the Standard in accordance with criteria and to the extent specified in the Specification and on custom manufactured items as called for by the Employer to obtain required performance data.

19.6.2 Routine Tests

Routine and sample tests according to the IEC standards shall monitor the ongoing manufacturing process.

Before leaving the factory each completed cable shall undergo the following tests:

- Voltage Test
- Measurement of insulation resistance

19.6.3 Site Tests

Before energising a cable circuit, including all accessories, tests according to the IEC standards shall be performed on the complete installation. The tests shall include amongst others:

- Measurement of insulation resistance
- Measurement of loop resistance.

20. Earthing And Lightning Protection

20.1 Introduction

This Specification covers the ratings, design, equipment requirements, erection, inspection and testing of complete earthing system and lightning protection system.

Earthing system shall mean a complete copper conductor ground grid system, which includes all conductors, earthing rods, connectors, equipotential mats, equipment and other measures required to complete earthing of switchyards, indoor switchgears and buildings.

This is basically a performance specification and covers only those aspects that are required to define a minimum standard of quality and performance. Other details and specific data are contained in the Contract drawings, Technical Schedules and other documents that form part of the Tender Documents.

The Contractor is deemed to have visited the site and the area where the substation is to be located prior to submitting his Tender, making observations in order that he can assess the quantities required for earth electrodes to satisfy the specification requirements.

All materials and equipment shall be provided as required to make a complete, properly, functioning installation and shall conform to the highest standards of engineering design and workmanship.

The Contractor shall at an early stage of the Project and before the Site works commence undertake a survey of the ground all over the site in order to establish general characteristics and ascertain values of soil resistivity at various depths to a minimum of 20 m and measure the aggressiveness of soil. If a plot will be filled with a soil layer > 1 m to rise the level, two soil resistivity measurements – one before and one after the filling – shall be carried out. A report of the resistivity values measured, the effective earth resistivity, the expected resistance of the proposed grid and aggressiveness of soil shall be submitted to KETRACO/Engineer for approval.

Based on the above survey the Contractor shall prepare a detail design of the earthing system and lightning protection system for approval by Ketraco/Engineer. Thereafter the Contractor shall supply, excavate, install, erect, backfill and test the installation to the satisfaction of KETRACO /Engineer.

Calculations and designs shall be made using a latest version of earthing calculation and design software. Prior to any Earthing System calculation, the Contractor shall agree with KETRACO /Engineer what type of computer programme shall be applied for the Earthing System calculation. On completion of the work the complete datasets and outputs including drawings and designs from the software shall be provided to Ketraco for future use.

20.2 Applicable Codes and Standards

The design and installation of the earthing and lightning protection systems shall be based on the following standards:

IEEE 80	Guide for safety in AC Substation Grounding
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface potentials for Ground system

IEC 60364-5-54	Earthing arrangements and protective conductors for indoor installations up to 1000 V a.c. and 1500 V d.c.
NFPA 780	Lightning Protection Code
BS 6651	Protection of Structures against Lightning
BS 7430	Code of Practice for Earthing

The electrical equipment shall be in accordance with the requirements of IEC recommendations.

20.3 Scope of Works

The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KETRACO's personnel and warranty of the works.

20.4 Main Technical Data

The 400, 220, 132, 66 and 33 kV Systems' Neutrals are solidly earthed.

20.4.1 Electrical Parameters for Earthing Calculation:

Parameter for	400 kV	220 kV	132 kV	33 kV
Fault current (kA)	40kA	40kA	31.5kA	25kA
Frequency (Hz)	50	50	50	50
Duration fault current for earthing conductor sizing (s)	1	1	1	3
Duration of shock for body current (s)	0.5	0.5	0.5	0.5

To ensure the lowest possible resistance to earth and to lower the surge impedance for lightning protection, buried electrodes shall be provided to bring the overall resistance to earth to less than 0.2 Ω . A value higher than 0.2 Ω shall be subject to the approval of the KETRACO/Engineer.

20.5 Earthing System

The earthing system shall mainly comprise a meshed earthing grid directly buried at a minimum depth of 0.5 m below final ground level, set of primary earth electrodes and down leads to all electrical equipment and all metallic frames to form an equi-potential bonding system capable of carrying the fault currents resulting from short circuits. Where there are other services like trenches, then the grid shall be laid below them.

The earthing system shall fulfill the following requirements:

- Maintain acceptable earth resistance to limit the ground potential rise (in accordance with IEEE 80) with respect to true earth and ensure protective relay operation in the event of an external fault. The GPR shall be less than the allowable touch voltage for 70 kg body weight.
- Provide earth connections to all electrical apparatus enclosures and structural steel works adequate to carry prospective earth faults without excessive heating or fire risk. To ensure, every structure must be connected via two different risers to two different parts of the grounding grid. Steel structures and fence shall not be used as parts of the protective earth connection of apparatus.
- Limit potential differences within the substation site in the event of earth current, originating from within or outside the station.
- Ensure the safety of personnel by limiting step and touch voltages within the building, outside building, within the perimeter fence and outside perimeter fence. In addition, within the building the transfer voltage is a key aspect which needs to be ascertained to values well within acceptable levels and eliminate interference or damage to sensitive electronic circuits.

The split factor may be considered in the design calculations however the worst case scenarios such as one power cable or transmission line with earth wires supplying the substation shall be used. Split factor calculation shall be subject to approval of KETRACO/Engineer. Split factor shall be confirmed during commissioning and this shall be carried out by earthing the remote end of the feeder and connecting the source at the new substation. The required source capacity shall be established prior to commissioning.

20.5.1 Outdoor Earthing System

Underneath the substation site a meshed earthing grid shall be installed to provide a common main earthing grid for the connection of equipment and structures. The mesh conductors shall be spaced in such a manner to prevent the occurrence of excessive step potentials and touch potentials on conducting parts of the installation which are not part of the main electrical circuits. Maximum mesh potential shall not be greater than the maximum tolerable touch potential, considering clearance time equal to the back-up protection earth fault clearance.

Main earth grid shall utilize fully the available site area.

The location of the main earthing electrodes shall be such to enable all items of equipment

to be connected to the earth system via the shortest practicable route.

In addition to the above, the following is considered as part of earthing grid:

- Earth ring electrodes around each individual building in the substation area,
- Reinforcing steel mesh of building foundation,
- Earth electrodes for outdoor lighting pole earthing,
- Substation fence earth electrodes,
- All interconnections,
- Vertically driven rods, etc

A continuous conductor shall be laid outside the periphery of substation site typically at a distance of 1.5 m to 2 m from the boundary fence, and at a minimum depth of 0.5 m below final ground level. The exact positioning of the perimeter conductor and the depth of burial shall be determined by the Contractor during the design process taking into account external

step and touch potentials.

The substation wall reinforcing shall be connected to the main earth system minimum once per wall panel section.

Where overhead lines enter the substation passing over the wall additional earthing shall be provided to ensure an effective earth path.

A meshed earthing grid shall be formed by interconnection of various points of the earth electrode perimeter.

Where appropriate, the earthing system shall be designed so as to include all overhead line terminal towers, which shall be earthed by extending the system so as to envelope all towers within the earthing system.

If the event of the substation resistance obtained with the foregoing installation being of a magnitude unacceptable to KETRACO/Engineer, then where practicable, the earth area enclosed by the earth system may have to be increased by installing directly in the ground earth electrodes in the form of a ring outside the site at a significant distance from the substation boundary.

Alternatively, earth rods may be approved if the earth resistivity survey indicates that their use is warranted.

In all cases the Contractor shall demonstrate by calculation that extensions of the grid outside the substation perimeter do not create a hazard for humans or animals under all conditions of operation.

Items of equipment and structures which are most likely to contribute high earth fault currents, such as AIS switchgear, instrument transformers, power transformers, towers, arrester pads etc. shall always be connected to the grid with a minimum of two fully rated spur connections. The down leads connections shall preferably run in opposite directions to eliminate common mode failure.

The lighting poles of the outdoor lighting system shall be connected with separate earth electrodes at the meshed earthing grid.

Two interconnections, if not specified otherwise in the remaining sections of document, between each of the building earthing sub-systems and the main earthing grid shall be provided, each having an accessible isolating point to enable measurement of the earthing resistance.

The lightning installations for all the buildings, structures, etc., must also be connected to the main earthing grid.

The effects of lightning strikes on the control and monitoring systems vary from faulty pulses in control and measurement to the destruction of electronic sub-assemblies and cables and must therefore be prevented by the earthing of screens. To this end the screens of the control cables leading from the signal transmitters, actuators etc. must be taken to the dedicated earthing points and from there to the indoor earthing installation. They must be insulated and terminated via the screen bars in subsidiary distribution boxes, intermediate terminal boxes, marshalling racks, control cabinets and DC main distribution boards.

As an additional safety measure, a closed mesh shall be provided below all operating positions for outdoor HV equipment manual operating mechanism boxes and local electrical control cubicles to ensure the safety of the operator. The mat shall be directly bonded to the cubicle and the conductors forming the mat and the bonding connection shall have a minimum copper cross-section area of 70 mm².

At locations with high surface resistance, where applicable, the Contractor shall install deep bore hole earthing. A hole shall be drilled into the ground, to a depth reaching permanently moist soil layers. The depth required shall be determined by KETRACO/Engineer on the basis of the soil investigation results.

At locations with rocky high surface resistance where it is proven by calculation that it will not be possible to achieve the desired earthing grid resistance to earth the Contractor may utilize the materials such as bentonite, marconite or modern earthing concrete materials however selection of materials and locations of utilization are subject to approval of KETRACO/Engineer. In no case charcoal and salt shall be used for improvement of earthing grid resistance to earth. In case of utilization of materials for reduction of the earthing grid resistance to earth, before warranty expiring, Contractor shall verify the integrity of the earthing grid by performing measurements of the earthing grid resistance to earth. In case of evident discrepancy between the first installation measurement and pre-warranty expiring measurement any required works to remedy the earthing grid resistance to earth to the desired value will be included in the supply of the contract.

Rods shall be used for the perimeter grounding mesh, in distances about 30 meters.

Gates shall be earthed by proper riser and Flexible conductors.

Each surge arrester, capacitive voltage transformer, grounding switch, power transformer neutral, auxiliary transformer neutral, shunt reactor neutral shall be connected to ground via a copper clad steel rod.

At least 15 cm gravel shall be considered in the outdoor switchyard area.

20.5.2 Indoor Earthing System

Flat bare copper sized to carry the fault current shall be installed to form one ring inside the building on the walls of each story. From the ring conductor the connections to the, cable trays, conduits, doors, steelworks, buried floor screens etc., shall be made using PVC sheathed copper stranded conductor or bare copper tape.

Connection to panels and other sensitive electrical apparatus shall be made independently to the indoor ring to minimize conducted interference. All of the electrical equipment, frames and mechanical apparatus shall be provided with designated earthing points.

An earth ring connected to the main earth grid at two or more points shall surround each item of large plant situated in the buildings.

Provision shall be made for the connection of power cable sheath bonding systems and cable accessories to the indoor earthing sub-system.

Copper conductors shall be laid and fixed at the cable trays. Where this is not possible supports for earthing conductor shall be provided and fixed in concrete or masonry.

The bare copper tape shall be also fixed and supported on walls. Care shall be taken to avoid the creation of tripping hazards due to surface mounted earthing conductors.

Cable trays and vertical runs shall be connected to earth at least 15 m intervals.

At maximum intervals of 10 m, the main earthing bus inside buildings shall be connected to the outdoor earthing system using lead-sheathed single core copper conductor.

20.5.3 Cable Trenches

A lead sheathed copper main earthing conductor shall be provided for each cable route within substation to which all steelworks shall be bonded. Metallic cable trays and conduits shall be electrically bonded at all mechanical joints and connect at intervals to main ground grid.

20.5.4 Pipelines

Where pipelines enter the site (fence / boundaries) they shall be fitted with a length of electrical insulation over the pipe on each side of the wall, and an insulating flange at the boundary. This prevents dangerous potentials occurring between the pipe and earth, both within and outside the site.

20.5.5 Earthing system materials

- **Earthing grid:**

Lead-sheathed stranded copper conductor shall be used for main grid conductors and down leads connected to them. The lead sheath shall be at least 2 mm thick. . If especially there is problem of theft in the substation so the Copper-clad steel wire with equivalent cross section can be used only by the client approval.

The cross-section of earth grid conductors shall be confirmed by calculation in accordance with the main technical data. All down leads shall be with redundant connections.

The size of lead-sheathed stranded copper conductors shall be uniform throughout the area under the Contract.

Alternatively, when the ground conditions are not chemical corrosive (Ph value greater than six (6) and less than nine (9)) copper conductors may be used (instead of Lead-sheathed).

The selection shall only be finalized after site investigation and is subject to KETRACO/Engineer approval.

The current density for lead sheathed stranded copper conductor shall not be greater than 140 A/mm² for 1 s duration.

- **Indoor earthing conductor:**

Bare copper tape shall be used for the ring inside the building on the walls at each operational level.

PVC sheathed stranded copper conductor or bare copper tape shall be used for connection of the equipment to the ring inside building.

Each connection between the equipment and the earthing system (spur connection) shall carry the total fault current, but the cross-section area of branch connections may be reduced to 60 percent of corresponding single conductor to provide for the current distribution in two or more conductors.

The current density for copper earthing conductors shall not be greater than 190 A/mm² for 1 s duration.

All earthing copper conductors for indoor installation shall be PVC sheathed, colored green and yellow.

- **Earth Leads**

All equipment within the station area shall be connected to the main grid including but not limited to the following: steel structures, hoist and motors, transformers neutral points, transformer tanks, shunt reactor, reactor tank, fences, cables armour, cable trays and conduits, AC switchboards, DC switchboards, control panels, control desks, relay panels, motor frames, lighting fixtures, lighting poles, housing of small equipment, ladders, steel reinforcing bars where it is applicable or where it is used in earth slabs for equi-potential grading, etc

Branch connections of the non-current carrying metal parts of equipment shall have a minimum conductor size as designed to carry maximum earth fault current for the fault clearance time or 1s (3 s for 33 kV) whichever is the longer time.

Jointing of conductor-to-conductor under the ground shall be performed by an exothermic welding process of cad weld type.

Exothermic welding shall be used to connect grounding grid conductors for switchyard and fence grids.

Equipment and metal structures may be connected to the ground grid by using bolted connectors.

Surge arrester ground connections must be short as possible, straight and shall not be used as ground connections for any other equipment.

Disconnect switch frames shall be directly connected to main ground grid. Hinge end of ground switch shall be directly connected to main ground grid.

Connection of the risers to steel structures shall be ended by cable lugs and the connection shall be endured forces by tension and short circuit.

All lighting poles shall be connected to ground grid by copper conductors that sectional area not less than 35 mm².

Earth bonds shall be used to bond all steel platforms operating floors, ladders, hand rails, cable tray, structural steel work, etc. which does not have a solidly welded path to the main structure/or earthing grid.

Whenever dissimilar materials are to be joined the necessary bi-metallic plates shall be inserted as required to ensure that electrolytic action is avoided.

- **Inspection Pits and Earth Rods**

Earth Rods shall be 20 mm diameter extendible type of solid copper or stainless steel, each driven into undisturbed soil as required by the calculation with minimum depth of 3 m. Each rod electrode shall be complete with approved non-ferrous clamps for the connections of earthing conductors and with a hardened steel tip and cap for driving by means of a power hammer.

The connections from earth rods to the main earth grid shall be made in a concrete inspection pit with cover, using bolted clamps. Clamping arrangements and terminations shall be submitted for review and approval.

20.6 Lightning Protection

The following lightning protection material shall be used:

lead sheathed copper tape at least 70 mm² for roof conductor and down conductor, copper or stainless steel earth rods of 20 mm in diameter driven into undisturbed soil with minimum depth of 3 m, air terminators with copper strip or tape of not less than 120 mm² cross section, etc.

20.6.1 Lightning Protection Material

Lightning protection shall be provided to give effective shielding against a lightning strike to the structures and all outdoor equipment.

Lightning protection shall be provided for all buildings & switchyard area and shall be in accordance with BS 6651.

Contractor shall prove by calculation and drawings of all constructional details and protective zones showing that all structures and equipment are properly protected from lightning.

The main components of a lightning protection system are as follows:

- Shield wire,
- Air terminations,
- Down conductors,
- Earth terminations and earth rods,
- Joints, bonds, test joints, etc.

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

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

Down conductors shall be distributed on the surface of the outside walls of the buildings with a spacing distance of not more than 20 m and all main metal parts near the down conductors shall be connected thereto.

Each down conductor shall be provided with earth solid copper or stainless steel rod of 20 mm in diameter driven into undisturbed soil with minimum depth of 3 m with test joints placed in a position that results in easy testing. Each earth rod shall be interconnected with the main station earth grid.

The ring around a building installed as a part of main earth grid shall be used for connecting the air termination network. The connection points should be stripped of the lead sheath. The connection points are to be bitumen

protected against corrosion Nuts and bolts at the test joint or other joints, which are to remain detachable, shall be made of copper-nickel-silicon-bronze.

20.6.2 Inspection and Tests

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties.

All tests on material and equipment shall be made in accordance with IEC Standards if not otherwise specified.

The testing of earthing system shall be in accordance with IEEE 81.

Upon completion of earthing system, the following measurement shall be effected:

- Measurement of resistance to earth,
- Measurement of touch voltage inside and outside perimeter fence
- Measurement of step voltage inside and outside perimeter fence,
- Determination of Grid Potential Rise.
- Contact resistance measurement to check the Integrity of welded/bolted joints in the internal as well as external earthing system.

All tests shall be carried out to the satisfaction of KETRACO/Engineer and in his presence, at such reasonable times as he may require, unless agreed otherwise.

Not less than one (1) week notice of all tests shall be given to KETRACO/Engineer.

20.6.3 Special Equipment and Tools

Works to be done under this section include the delivery of special equipment and tools for erection, installation, maintenance, setting to work and other purposes.

20.7 Documentation

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals and other information in accordance with requirements listed in above section.

the contractor after award must submit the below documents:

Calculation, layout drawings, materials and manufacturer documents as stipulated in Sections above shall be provided. The earthing systems shall not be accepted as complete until the required information has been provided to the satisfaction of KETRACO/Engineer.

D.**Drawings**

E-Schedules of Technical Information

E -TECHNICAL DATA SCHEDULES

1. 132KV OPEN TERMINAL SWITCHGEAR

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
	132KV Circuit Breaker				
	General				
1.1	Manufacturer				
1.2	Place of manufacturing				
1.3	Type designation for breaker				
1.4	Type designation for operating mechanism				
1.5	Type of operation mechanism			Spring Charge motor operated	
1.6	Type of interrupting chamber				
1.7	Applicable standard			IEC 62271-100, 62271-101, 62271-110, 62271-302,	
1.8	Rated voltage		kV	145	
1.9	System Voltage		kV	132	
1.10	Rated current at maximum site temperature		A		
1.10.1	For line feeder			Acc. to SLD	
1.10.2	For Transformer feeder			Acc. to SLD	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.10.3	For Bus Coupler feeder			Acc. to SLD	
1.10.4	For Bus Coupler feeder			Acc. to SLD	
1.10.5	For Bus Section			N.A.	
1.10.6	For reactor feeder			N.A.	
1.11	Rated frequency		Hz	50	
1.12	Media of breaking chamber			SF6	
1.13	Single pressure, low pressure or others				
1.14	Quantity of poles per breaker			3 Poles	
1.15	Rated operating sequence			O -0.3 sec- CO - 3 min - CO	
1.16	Single pole or three pole operation				
1.16.1	For line feeder			1 pole operated	
1.16.2	For Transformer feeder			3 pole operated	
1.16.3	For Bus Coupler feeder			3 pole operated	
1.16.5	For Bus Section			N.A	
1.16.6	For reactor feeder			N.A	
Note	All 132 kV circuit breakers should be capable of both Single pole and three pole operation				
1.17	Number of interrupting chambers per pole				
1.18	Class (indoor / outdoor)			Outdoor	
1.19	Circuit breaker type (live tank / dead tank)			Live tank	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.20	Type of system earthing			Non-Effective	
1.21	Withstanding in load combinations of earthquake, wind , short circuit , etc as mentioned in Technical Specification		(Yes/ No)	Yes	
1.22	Maximum and Minimum ambient temperature for design		°C	Acc. to section 1	
1.23	Design altitude above sea level		m	Acc. to section 1	
1.24	Pollution level		mm/kV	Acc. to section 1	
1.25	Design seismic acceleration		g	Acc. to section 1	
	Insulation Rating				
1.26	Type of Insulator (porcelain/silicon rubber)			porcelain	
1.27	Basic Insulation level (at site condition)		kV peak		
1.27.1	Common value (Phase-phase, Phase-ground)			750	
1.27.2	Across the isolating distance			860	
1.28	One minute power frequency withstand voltage (at IEC condition)		kV rms		
1.28.1	Common value (Phase-phase, Phase-ground)			325	
1.28.2	Across isolating distance			375	
1.29	Switching Impulse Withstand Voltage at IEC conditions		kV peak	N.A.	
1.29.1	Phase to ground and across open switching device				
1.29.2	Phase to phase				
1.29.3	Across isolating distance				
1.30	Rated transient recovery voltage for terminal faults		kV peak	215	
1.31	Rated recovery voltage		kV peak	As per IEC 62271-110	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.31.1	Amplitude factor			As per IEC 62271-110	
1.31.2	Rate of rise		kV/μs	As per IEC 62271-110	
1.32	Rate of rise of restriking voltage			As per IEC 62271-110	
1.32.1	For 30% breaking capacity		kV/μs		
1.32.2	For 60% breaking capacity		kV/μs		
1.32.3	For 100% breaking capacity		kV/μs		
1.33	Maximum recovery voltage on breaking a synchronous system		kV		
1.34	Rated characteristics for short line faults		kV rms		
1.35	First pole to clear factor			1.5	
1.36	Whether circuit breaker is restrike free?			Yes	
1.37	Maximum overvoltage factor on any switching duty		pu	2.3	
1.38	Maximum overvoltage factor when interrupting rated line/cable/capacitor		pu	2.3	
1.39	Maximum overvoltage factor when switching small inductive/reactor currents		pu	2.3	
1.40	Maximum total break time (trip initiation to final arc extinction)		ms		
	Current Ratings				
1.41	Rated short time withstand current & duration		kA rms/sec	31.5/1	
1.42	Rated short circuit making current		kA peak	2.5*31.5	
1.43	Rated out of phase breaking current		kA rms	10	
1.44	Rated small inductive breaking current		A rms	Acc. To IEC	
1.45	Rated capacitive breaking current				
1.45.1	Rated line-charging breaking current		A rms	Acc. To IEC	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.45.2	Rated cable charging breaking current		A rms	Acc. To IEC	
1.45.3	Rated Single/Back to Back Capacitor bank breaking current		A rms	Acc. To IEC	
1.46	Rated short circuit breaking current				
1.46.1	AC component		kA rms	31.5	
1.46.2	DC component		%	Acc. To IEC	
1.47	Maximum current on breaking asynchronous system		kA peak		
1.48	180° out of phase switching duty as a percentage of rated breaking current		%		
	Other Characteristics				
1.49	Voltage drop across HV terminals of one pole at 100 A dc		mV		
1.50	Maximum temperature rise at normal current over maximum		°C		
1.51	Opening time (from trip contact closing to the primary contacts separation in all				
1.51.1	Without current		ms		
1.51.2	With 100% rated breaking current		ms		
1.52	Opening time from trip contact closing to primary contact separation		μs		
1.53	Closing time (from energization of close coil to latching of circuit breaker in fully		μs		
1.54	Rated break or interrupting time (opening time plus arcing time)		μs		
1.55	Making time (energization of close coil to contact touch)				
1.55.1	Without current		ms		
1.55.2	100% making current		ms		
1.56	Maximum break time		ms	40	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.57	Maximum close time		ms	< 70	
1.58	Dead time (during auto-reclosing)		ms		
1.59	Reclosing		ms		
1.60	Arcing time		ms		
1.61	Maximum time interval between opening of first and last phase of three phase circuit		ms		
1.62	Maximum time interval between opening of interrupters of one phase		μs		
1.63	Maximum time interval between closure of interrupters of one phase		μs		
1.64	Minimum time from extinction of main arc to contact make during auto-reclosing		ms		
1.65	Closing time from energisation of close coil to latching of circuit breaker in fully		ms		
1.66	Making time (energisation of close coil to contact touch)				
1.66.1	Without current		ms		
1.66.2	100% making current		ms		
	Operating Mechanism				
1.67	Type of spring			spring operated	
1.68	Motor type			DC Motor charged,	
1.69	Motor				
1.69.1	Rated voltage		V	110 VDC	
1.69.2	Power demand		W		
1.69.3	Full-load current		A		
1.69.4	Maximum starting current		A		
1.69.5	Speed		rpm		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.69.6	Required time by motor to charge the spring completely		s		
1.69.7	Type of protection of motor				
1.70	Hand operating facility		Yes/No	Yes	
1.70.1	Manual spring charging facility to be accessible from ground respectively platform to be provided		Yes/No	Yes	
1.70.2	Manual spring release (suitably positioned to avoid accidental operation)		Yes/No	Yes	
1.70.3	Manual mechanism charging torque		Nm		
1.71	Mechanical on/off indicator		Yes/No	Yes	
1.72	Mechanical spring charge/discharge indication		Yes/No	Yes	
1.73	Charging time		S	≤12	
1.74	Number of trip coils per phase			2	
1.75	Number of close coils per phase			1	
1.76	Reclosing suitable for 1 pole and/or 3 pole			3pole and 1pole	
1.77	Whether circuit breaker is trip free or others?			Yes	
1.78	Number and type of spare auxiliary reversible contacts			12NO+12NC	
1.79	Opening and closing nominal control voltage		V dc		
1.80	Control cabinet				
1.80.1	Power Socket in Control cabinet			British Standard	
1.80.2	cabinet Light (Compact LED)		Yes/No	Yes	
1.80.3	Number, type & power of cabinet heater				
1.80.4	cabinet space heaters (thermostat Controlled)		Yes/No	Yes	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.80.5	Degree of protection (IP) of control cabinet			IP55	
1.80.6	Minimum thickness of steel control cabinet		mm	2	
1.81	Tripping and closing coils				
1.81.1	Number of closing coils			1	
1.81.2	Number of tripping coils			2	
1.81.3	Tripping coil current		A, DC		
1.81.4	Closing coil current		A, DC		
1.81.5	Rated power of trip coil		W		
1.81.6	Rated power of close coil		W		
1.81.7	Tripping and closing coils' nominal control voltage		V, DC	110	
1.81.8	Variation of closing / opening coils' operating voltage		%	85-110 / 70-110	
1.81.9	Minimum voltage for proper operation of trip & close coils		%	40	
1.81.10	- Pick up range of control voltage				
1.82	Whether antipumping device is provided?		Yes/No	Yes	
1.83	Whether operating counter is provided?		Yes/No	Yes	
1.84	Whether emergency trip is provided?		Yes/No	Yes	
1.85	Whether circuit breaker is equipped with Local/ remote/ maintenance change over		Yes/No	Yes	
1.86	Whether circuit breaker is equipped with manually spring charge facilities?		Yes/No	Yes	
1.87	Whether Pre-insertion resistor is provided?		Yes/No	No	
1.87.1	Closing resistor value		Ω		
1.87.2	Insertion time		ms		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.88	Whether Switching Control Relay is provided?		Yes/No	No	
1.89	Pole discrepancy feature		Yes/No	Yes	
	Insulating Medium				
1.90	Insulating medium			SF6 gas	
1.91	Rated pressure SF6 at 20°C		Absolut e		
1.92	Limits of gas pressure for correct operation of breaker		Absolut e		
1.93	Signal loss of SF6 at 20°C		Absolut e		
1.94	General lockout at 20°C		Absolut e		
1.95	Leakage rate of SF6 at rated pressure per annum		%	< 0.1	
1.96	Type and material of gasket used to gas tightening the joints				
1.96.1	Metal to metal joints				
1.96.2	Metal to porcelain joints				
1.97	Supplier of SF6 gas				
1.98	Supplier of Density meter				
1.99	Toxicological test				
1.100	Storage capacity of each gas cylinder		m³		
1.101	Whether sufficient gas plus 20% supplied for first filling?		Yes / No		
1.102	Mass of gas stored cylinder		kg		
1.103	Time required to fill the circuit breaker with SF6 gas ready for operation		hour		
1.104	Time required to empty gas of the circuit breaker		hour		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.105	Total mass of transportable gas handling equipment		kg		
1.106	Whether SF6 is stored as gas or liquid?				
	Insulator Columns				
1.107	Manufacturer				
1.108	Type				
1.109	Color				
1.110	Creepage distance phase to ground		mm	4495	
1.111	Creepage distance between terminals of one pole		mm		
1.112	Protected creepage distance (90° shadow)		mm		
1.113	Clearance (phase to phase)		mm		
1.114	External striking distance				
1.114.1	Phase to ground		mm		
1.114.2	Phase to phase		mm		
1.115	Ultimate strength of columns				
1.115.1	Cantilever		N		
1.115.2	Tension		N		
1.115.3	Torsion		N.m		
1.115.4	Compression		N		
1.116	Permissible force at HV terminals				
1.116.1	Static at any direction		N		
1.116.2	Dynamic at any direction		N		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.117	Washable in service		Yes / No	Yes	
	Miscellaneous				
1.118	Mechanical life of CB and mechanism in No. of operations		time	10000	
1.119	Electrical contact life in number of operations at:				
1.119.1	Rated current		time	10000	
1.119.2	Breaking current		time	≥ 30	
1.119.3	Cumulative ampere rating		time		
1.120	Whether a lock out device for preventing circuit breaker to close is provided?		Yes / No		
1.121	Whether Switching Control Relay is provided?		Yes/No		
1.122	Number and type of free auxiliary contacts for main contact monitoring			>10NO+ >10NC	
1.123	Number and type of free auxiliary contacts for SF6 gas pressure monitoring			>10NO+ >10NC	
1.124	Number and type of free auxiliary contacts for local/remote selector switch			>10NO+ >10NC	
1.125	Whether circuit breaker is equipped with rings?		Yes/No		
1.126	Whether circuit breaker is equipped with grading capacitors?		(Yes/ No)	Yes	
1.127	Mechanical on/off indicator		Yes/No	Yes	
1.128	Gas supervision		Yes/No	Yes	
1.129	Circuit breaker Operating platform (from ground level)		Yes/No	Yes	
1.130	Type and material for main contacts				
1.131	Material of HV conductor			Aluminum	
1.132	Whether contacts are silver plated?		Yes / No	Yes	
1.133	Un-galvanized metal parts shall primed, undercoated and finished with outdoor		Yes/No	Yes	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
1.134	Galvanizing parts accordance with ISO 1461 standards			As per ISO-1461	
1.135	CB weight				
1.135.1	Weight of single pole breaker		kg		
1.135.2	Total weight of complete circuit breaker		kg		
1.135.3	Maximum weight of pakage ready for shipment		kg		
1.136	CB main dimensions				
1.136.1	Overall height of assembled circuit breaker		mm		
1.136.2	Phase spacing		mm		
1.136.3	Minimum vertical distance between upper and lower terminal of the circuit breaker		mm		
1.136.4	Minimum vertical distance between lower side of the circuit breaker and metallic		mm		
1.137	Mechanical endurance class			M2	
1.138	Electrical endurance class			E2	
1.139	Restrike probability class due to capacitive current breaking			C2	
	132KV ISOLATOR				
	General				
2.1	Manufacturer				
2.2	Place of manufacturing				
2.3	Type designation for Isolator				
2.4	Type designation for grounding switch				
2.5	Type of Isolator			Horizontal Double Break/Centre	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.6	Applicable standard			IEC 62271-102	
2.7	Quantity of poles			Single pole op.	
2.8	Rated voltage		kV	145	
2.9	System Voltage		kV	132	
2.10	Rated current at maximum site temperature		A		
2.9.1	At maximum site temperature				
2.9.1.1	For line feeder			Acc. to SLD	
2.9.1.2	For Transformer feeder			Acc. to SLD	
2.9.1.3	For Diameter			N.A.	
2.9.1.4	For Bus Coupler feeder			Acc. to SLD	
2.9.1.5	For Bus Section			N.A.	
2.9.1.6	For reactor feeder			N.A.	
2.9.2	At IEC condition				
2.9.2.1	For line feeder			Acc. to SLD	
2.9.2.2	For Transformer feeder			Acc. to SLD	
2.9.2.3	For Bus Coupler feeder			Acc. to SLD	
2.9.2.4	For Bus Coupler feeder			Acc. to SLD	
2.9.2.5	For Bus Section			N.A.	
2.9.2.6	For reactor feeder			N.A.	
2.10	Rated frequency		Hz	50	
2.11	Class (outdoor / indoor)			Outdoor	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.12	Withstanding in load combinations of earthquake, wind, short circuit and etc.? (Yes / No)		Yes / No	Yes	
2.13	Hand operating facility is provided? (Yes / No)		Yes / No	Yes	
2.14	Accessibility to operating mechanism from ground level		Yes / No	Yes	
2.15	Mechanical Endurance Class			M2	
2.16.1	Electrical Endurance Class			E2	
2.16.2	Capacitive switching at maximum temporary			C2	
2.17	Manufacturer quality system in accordance with ISO 9000		Yes / No	Yes	
2.17.1	Date of issue			Latest	
2.17.2	Validity				
2.17.3	Certificate attached to the offer		Yes / No	Yes	
2.18	Type test certificate to be issued by independent laboratory or independently witnessed type test		Yes / No	Yes	
2.18.1	Certificate to be attached to the offer			Yes	
2.18.2	Report to be attached to the offer			Yes	
	Insulation Rating				
2.19	Basic Insulation level (at site condition)				
2.19.1	Common value		kV peak	750	
2.19.2	Across the isolating distance		kV peak	860	
2.20	One minute power frequency withstand voltage (at site condition)				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.20.1	Common value		kV rms	325	
2.20.2	Across the isolating distance		kV rms	375	
2.21	Switching impulse withstand voltage (at site condition)				
2.21.1	Common value		kV peak	N.A.	
2.21.2	Across the isolating distance		kV peak	N.A.	
2.22	Type of Insulation(porcelain/silicon rubber)			porcelain	
	Current Rating				
2.23	Rated short time withstand current				
2.23.1	For Isolator		kA rms/sec	31.5/1	
2.23.2	For grounding switch		kA rms/sec	31.5/1	
2.24	Rated short circuit making current for grounding switches		kA rms	2.5*31.5	
2.25	Rated peak short circuit withstand current		kA peak		
2.26	Maximum inductive current breaking capacity for grounding switch (acc.to IEC 62271/102)		kVA		
2.27	Maximum capacitive current breaking capacity for grounding switch (acc. to IEC 62271/102)		kVA		
	Other Characteristic				
2.28	Rated Supply Voltage				
2.28.1	For motor, control and interlock		Vdc	110	
2.28.2	For AC auxiliaries		Vac	240	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.29	Voltage drop across terminals of one pole at 100 A.dc for Isolator and ground switches		mV		
2.30	Maximum temperature rise at normal current over Maximum ambient temperature		°C		
2.31	Maximum and minimum ambient temperature for design		°C	Acc. to section 1	
2.32	Altitude above sea level		m	Acc. to section 1	
	Operating Mechanism				
2.33	Type of operating mechanism				
2.33.1	For Isolator			DC Motor	
2.33.2	For grounding switch			DC Motor	
2.34	Motor type				
2.35	Motor		V	110 VDC	
2.35.1	Rated voltage		W		
2.35.2	Power demand		A		
2.35.3	Full load current		rpm		
2.35.4	Speed				
2.36	Type of motor protection				
2.37	Total time from initiation of opening operation to Isolator in fully open position		sec	≤15	
2.38	Time from contact separation to extinct of capacitive arc		sec		
2.39	Total time from initiation of opening operation to time when Isolator gap can withstand phase voltage				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.40	Breaking and closing of:				
2.40.1	Magnetizing current of power transformers		Yes / No	Yes	
2.40.2	Mutual inductive/capacitive current of parallel circuit in double circuit line		Yes / No	Yes	
2.40.3	Charging current of unloaded lines and/or cables		Yes / No	Yes	
2.41	Minimum guaranteed no. of operations for Isolators or grounding switches before maintenance		N		
2.42	Maximum required force for hand operation with supplied handle				
2.43	Thickness of steel control cabinet		mm	Min (2)	
2.44	Degree of protection (IP) of mechanism housing			IP55	
2.45	Cubicle space heaters (thermostat Controlled)		Yes / No	Yes	
2.46	Cabinet heater				
2.46.1	Power		W		
2.46.2	Nominal Voltage		V	240AC	
2.47	Whether local/ remote/ disconnect selector switch is provided? (Yes / No)		Yes / No		
2.48	Whether open/neutral /close control switch is provided? (Yes / No)		Yes / No		
2.49	Whether under voltage relay is provided for motor supply?		Yes / No	Yes	
2.50	Whether all of the heaters are equipped with a M.C.B ?		Yes / No	Yes	
2.51	Rated power of operation coil		W		
2.52	Total load of heaters for Isolator		W		
	Insulators				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.53	Manufacturer				
2.54	Place of manufacturing				
2.55	Type (porcelain /composite)			porcelain	
2.56	Color				
2.57	Creepage distance		mm	4495	
2.58	Protected creepage distance		mm		
2.59	Permissible cantilever working load		N	C8	
2.60	Operating handle or lever mounting height above ground		m	1.2	
2.61	Permissible tensional strength		N.m		
	Minimum clearance		mm		
2.61.1	Between poles when Isolator is closed				
2.61.2	Between poles when Isolator is open				
2.61.3	Between phase and ground				
2.61.4	Between one pole terminals at open condition				
	Interlocks				
2.62	Type of interlock between Isolator and associated ground switch			Electrical and Mechanical	
2.63	Type of interlock between ground switch and related circuit breakers			Electrical	
2.64	Type of interlock between Isolator and related circuit breaker			Electrical	
2.65	Locking arrangement in on/off position		Yes / No	Yes	
2.66	Automatic isolation of control supplies when lock off		Yes / No	Yes	
	Miscellaneous				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.67	Type of main contacts				
2.67.1	For Isolator				
2.67.2	For grounding switch				
2.68	Material of main contacts				
2.68.1	For Isolator			Copper	
2.68.2	For grounding switch			Copper	
2.69	Material of blades				
2.69.1	For Isolator				
2.69.2	For grounding switch				
2.70	Whether main contacts are silver plated				
2.70.1	For Isolators			Yes	
2.70.2	For grounding switches			Yes	
2.71	Quantity and type of free auxiliary contacts				
2.71.1	For Isolators			10NO+10NC	
2.71.2	For grounding switches			10NO+10NC	
2.72	Permissible force on HV terminals				
2.72.1	Static in any direction		N		
2.72.2	Dynamic in any direction		N		
2.73	Weight of maximum package ready for shipment		kg		
2.74	Weight of complete				
2.74.1	Isolator		kg		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
2.74.2	Isolator with associated grounding switch		kg		
2.74.3	Single phase		kg		
2.75	Cubicle Light (Compact LED)		Yes / No	Yes	
2.76	Number of grounding switch			1/2	
		Note: The table should be filled and submitted for each of the following equipment separately: 1. Isolator with 2 Ground Switches 2. Isolator with 1 Ground Switches			
	132KV EARTHING SWITCH				
	General				
3.1	Manufacturer				
3.2	Place of manufacturing				
3.3	Type designation				
3.4	Type of operating mechanism			DC Motor	
3.5	Applicable standard			IEC 62271-102	
3.6	Rated voltage		kV	145	
3.7	System Voltage		kV	132	
3.8	Rated current		A		
3.8.1	At maximum site temperature			Acc. to SLD	
3.8.2	At IEC condition			Acc. to SLD	
3.9	Rated frequency		Hz	50	
3.10	Class (outdoor / indoor)			Outdoor	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.11	Withstanding in load combinations of earthquake, wind, short circuit and etc.? (Yes / No)		Yes / No	Yes	
3.12	Hand operating facility is provided. (Yes / No)		Yes / No	Yes	
3.13	Accessibility to operating mechanism from ground level		Yes / No	Yes	
3.14	Manufacturer quality system in accordance with ISO 9000		Yes / No	Yes	
3.15	Date of issue			Latest	
3.16	Validity				
3.17	Certificate attached to the offer		Yes / No	Yes	
3.18	Type test certificate to be issued by independent laboratory or independently		Yes / No	Yes	
3.18.1	Certificate to be attached to the offer			Yes	
3.18.2	Report to be attached to the offer			Yes	
	Insulation Rating				
3.19	Basic Insulation level (at site condition)				
3.19.1	Common value		kV peak	750	
3.19.2	Across the isolating distance		kV peak	850	
3.20	One minute power frequency withstand voltage (at site condition)				
3.20.1	Common value		kV rms	325	
3.20.2	Across the isolating distance		kV rms	375	
3.21	Switching impulse withstand voltage (at site condition)				
3.21.1	Common value		kV peak	N.A.	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.21.2	Across the isolating distance		kV peak	N.A.	
3.22	Type of Insulation(porcelain/silicon rubber)			porcelain	
	Current Rating				
3.23	Rated short time withstand current				
3.23.1	For grounding switch		kA rms/sec	31.5/1	
3.23.2	Rated short circuit making current for grounding switches		kA rms	2.5*31.5	
3.24	Rated peak short circuit withstand current		kA peak		
3.25	Maximum inductive current breaking capacity for grounding switch (acc.to IEC 62271/102)		kVA		
3.26	Maximum capacitive current breaking capacity for grounding switch (acc. to IEC 62271/102)		kVA		
	Other Characteristic				
3.27	Rated Supply Voltage				
3.27.1	For motor, control and interlock		Vdc	110	
3.27.2	For AC auxiliaries		Vac	240	
3.28	Voltage drop across terminals of one pole at 100 A.dc for ground switches		mV		
3.29	Maximum temperature rise at normal current over Maximum ambient temperature		°C		
3.30	Maximum and minimum ambient temperature for design		°C	Acc. to section 1	
	Altitude above sea level		m	Acc. to section 1	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.31	Operating Mechanism				
3.32	Type of operating mechanism			DC Motor	
3.32.1	Motor type				
3.32.2	Motor		V		
3.33	Rated voltage		W		
3.34	Power demand		A		
3.34.1	Full load current		rpm		
3.34.2	Speed				
3.35	Type of motor protection				
3.36	Total time from initiation of opening operation in fully open position		sec	≤15	
3.37	Breaking and closing of:				
3.37.1	Magnetizing current of power transformers		Yes / No	Yes	
3.37.2	Mutual inductive/capacitive current of parallel circuit in double circuit line		Yes / No	Yes	
3.37.3	Charging current of unloaded lines and/or cables		Yes / No	Yes	
3.38	Minimum guaranteed no. of operations for grounding switches before maintenance		N		
3.39	Maximum required force for hand operation with supplied handle				
3.40	Thickness of steel control cabinet		mm	Min (2)	
3.41	Degree of protection (IP) of mechanism housing			IP55	
3.42	Cubicle space heaters (thermostat Controlled)		Yes / No	Yes	
3.43	Cabinet heater				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.43.1	Power		W		
3.43.2	Nominal Voltage		V	240 AC	
3.44	Whether local/ remote/ disconnect selector switch is provided? (Yes / No)		Yes / No		
3.45	Whether open/neutral /close control switch is provided? (Yes / No)		Yes / No		
3.46	Whether under voltage relay is provided for motor supply?		Yes / No	Yes	
3.47	Whether all of the heaters are equipped with a M.C.B ?		Yes / No	Yes	
3.48	Rated power of operation coil		W		
3.49	Total load of heaters		W		
	Insulators				
3.50	Manufacturer				
3.51	Place of manufacturing				
3.52	Type (porcelain /composite)			porcelain	
3.53	Color				
3.54	Creepage distance		mm	4495	
3.55	Protected creepage distance		mm		
3.56	Permissible cantilever working load		N	C8	
3.57	Operating handle or lever mounting height above ground		m	1.2	
3.58	Permissible tensional strength		N.m		
3.59	Minimum clearance		mm		
3.59.1	Between poles when earth switch is closed				
3.59.2	Between poles when earth switch is open				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.59.3	Between phase and ground				
3.59.4	Between one pole terminals at open condition				
	Interlocks				
3.60	Type of interlocking			Electrical and Mechanical	
3.61	Locking arrangement in on/off position		Yes / No	Yes	
3.62	Automatic isolation of control supplies when lock off		Yes / No	Yes	
	Miscellaneous				
3.63	Type of main contacts				
3.64	For grounding switch				
6.65	Material of main contacts				
3.65.1	For grounding switch				
3.66	Material of blades				
3.66.1	For grounding switch				
3.67	Whether main contacts are silver plated				
3.67.1	For grounding switches			Yes	
3.68	Quantity and type of free auxiliary contacts				
3.67.1	For grounding switches			>10NO+ >10NC	
3.69	Permissible force on HV terminals				
3.69.1	Static in any direction		N		
3.69.2	Dynamic in any direction		N		
3.70	Weight of maximum package ready for shipment		kg		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
3.71	Weight of complete earth switch		kg		
3.72	Cubicle Light (Compact LED)		Yes / No	Yes	
	132kV CURRENT TRANSFOMERS				
	General				
4.1	Manufacturer				
4.2	Place of manufacturing				
4.3	Type designation			Post	
4.4	Number of phases			3 phase	
4.5	Type of neutral grounding			Non-Effective	
4.6	Applicable standard			IEC 61869-1/-2	
4.7	Class (indoor / outdoor)			Outdoor	
4.8	Type (Oil-immersed / dry)			Oil-immersed Oil impregnated	
4.9	Construction (tank / inverted)			Tank	
4.10	Rated voltage		kV rms	145	
4.11	System Voltage		kV	132	
4.12	Rated current at max. site temperature :		A		
4.12.1	For line feeders			Acc. to SLD	
4.12.2	For transformer feeders			Acc. to SLD	
4.12.3	For bus coupler feeders			Acc. to SLD	
4.12.4	For bus coupler feeders			Acc. to SLD	
4.12.5	Power transformer neutral			N.A	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
4.12.6	For Reactor feeder			N.A	
4.13	Rated frequency		Hz	50	
4.14	Max. and min. ambient temperatures used for design		°C	Acc. to section 1	
4.15	Rated short time withstand current		kA rms	31.5/1sec	
4.16	Rated short time dynamic current		kA peak	2.5*31.5	
4.17	Whether withstanding in load combinations of earthquake, wind, short circuit? (Yes / No)		(Yes / No)	Yes	
4.18	Altitude above sea level		m	Acc. to section 1	
4.19	Manufacturer quality system in accordance with ISO 9000		Yes/No	Yes	
4.19.1	Date of issue			Latest	
4.19.2	Validity				
4.19.3	Certificate attached to the offer		Yes/No	Yes	
4.20	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be		Yes/No	Yes	
4.20.1	Certificate to be attached to the offer		Yes/No	Yes	
4.20.2	Report to be attached to the offer		Yes/No	Yes	
	Insulation				
4.21	Maximum continuous line to line operating voltage		kV rms	145	
4.22	Basic Insulation level (at site condition)		kV peak	750	
4.23	Switching impulse withstand level (at site condition)		kV peak	-NA	
4.24	One minute power frequency withstand voltage (at site condition)		kV rms		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
4.24.1	Dry			325	
4.24.2	Wet				
4.25	One minute power frequency withstand voltage for secondary winding		kV rms		
4.26	Highest value of partial discharge when tested acc. to IEC		pc	5	
4.27	Voltage at secondary winding terminals with normal primary load current , and secondary open circuit		kV		
4.28	Time permitted with open circuit secondary		sec		
4.29	Dielectric dissipation factor				
	Ratings and Accuracies				
4.30	Rated primary current		A	Acc. to SLD	
4.31	Rated extended primary current			120%	
4.32	Rated secondary current		A	1	
4.33	Change of CT ratio shall be possible at the secondary circuit only		Yes/No	Yes	
4.34	specification of CTs on: Line feeders, Transformer feeders,Bus couple, Tie coupler, Auxiliary transformer, Power transformer neutral. Core balance				
4.34.1	Number of cores			Acc. to SLD	
4.34.2	Ratio (TR – turns ratio)		A	Acc. to SLD	
4.34.3	Class			Acc. to SLD	
4.34.4	Knee point voltage (Ek)		V	Acc. to SLD	
4.34.5	Exciting current (IE) at Ek		mA	Acc. to SLD	
4.34.6	Rated output (burden to be 25-100% rated burden)		VA	Acc. to SLD	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
	External Insulation				
4.35	Material				
4.36	Manufacturer				
4.37	Place of manufacturing				
4.38	Type designation				
4.39	Minimum creepage distance		mm	4495	
4.40	Color			Brown	
4.41	Protected creepage distance (90 shadow)		mm		
4.42	Shortest flash-over distance		mm		
4.43	Whether washable in service ? (Yes / No)		(Yes / No)	Yes	
	Miscellaneous				
4.44	Maximum R.I.V. level at 1.2 max. rated voltage at 1 MHz according to NEMA 107		μv	2500	
4.45	Whether oil level indicator/oil sampling valve/oil filling valve are provided ? (Yes			Yes	
4.46	Means for compensation of oil expansion				
4.47	Temperature rise at rated continuous thermal current		°C		
4.48	Rated continuous thermal current (% of rated primary current)			Rated extended primary current	
4.49	Electrostatic capacity of complete current transformer. PF				
4.50	Loss angle at rated voltage				
4.51	Permissible force at HV terminals				
4.51.1	Static at any direction		N		
4.51.2	Dynamic at any direction		N		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
4.52	Type , grade and manufacturer of oil				
4.53	Weight of oil		kg		
4.54	Primary conductor material				
4.55	Secondary conductor material				
4.56	Overall height		mm		
4.57	Overall width		mm		
4.58	Overall length		mm		
4.59	Total weight of complete current transformer		Kg		
4.60	Max. package weight ready for shipment		Kg		
4.61	ting up of CT are provided? (Yes / No)			Yes	
4.62	Permitted inclination refer to vertical axis during transport or storage		Degree		
4.63	Degree protection of Terminal box			IP55	
	132kV CAPACITIVE VOLTAGE TRANSFORMERS				
	General				
5.1	Manufacturer				
5.2	Place of manufacturing				
5.3	Type of CVT			Single-phase/self-Cooled	
5.4	Applicable standard			IEC 61869-1/-5	
5.5	Rated voltage		kV rms	145	
5.6	System Voltage		kV	132	
5.7	Rated frequency		Hz	50	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
5.8	Max. and min. ambient temperatures used for design		°C	Acc. to Section1	
5.9	Class (indoor/ outdoor)			Outdoor	
5.8	Type (Oil-immersed / dry)			Oil-immensed/ Oil-impregnated	
5.9	Maximum permissible partial discharge level at Um		pC	10	
5.10	Maximum permissible partial discharge level at 1.2Um /Ö3		pC	5	
5.11	Whether withstanding in load combinations of earthquake , wind , short		(Yes / No)	Yes	
5.12	Altitude above sea level		m	Acc. to Section1	
5.13	Manufacturer quality system in accordance with ISO 9000		Yes/No	Yes	
5.13.1	Date of issue			Latest	
5.13.2	Validity				
5.13.3	Certificate attached to the offer		Yes/No	Yes	
	Insulation ratings				
5.14	Basic insulation level (at site condition)		kV peak	750	
5.15	Switching impulse withstand voltage (at site condition)		kV peak	-	
5.16	One minute power frequency withstand voltage (at site condition)		kV rms	325	
5.17	Power frequency withstand voltage between secondaries and secondary to		kV rms		
5.18	Rated voltage factor				
5.18.1	Continuous			1.2	
5.18.2	30 seconds			1.5	
5.19	Minimum HV terminal withstand				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
5.19.1	Static terminal load			1000	
5.19.2	Dynamic terminal load			2000	
5.20	Max. RIV measured at 1.2 highest system voltage , 1 Mega-Hz acc. to CISPR		μV		
	Burdens and accuracies				
	3-Winding CVT			3	
5.21	Number of secondary windings				
5.22	Accuracy class for			Acc. to SLD	
5.22.1	Winding 1			Acc. to SLD	
5.22.2	Winding 2			Acc. to SLD	
5.22.3	Winding 3				
5.23	Rated primary voltage		KVrms	$132/\sqrt{3}$	
5.24	Rated secondary voltage		KVrms	$0.11/\sqrt{3}$	
5.25	Rated burden for				
5.25.1	Winding 1		VA	Acc. to SLD	
5.25.2	Winding 2		VA	Acc. to SLD	
5.25.3	Winding 3		VA	Acc. to SLD	
5.26	Continuous thermal burden of				
5.26.1	Winding 1 alone		VA		
5.26.2	Winding 2 alone		VA	2	
	2-Winding CVT				
5.27	Number of secondary windings			Acc. to SLD	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
5.28	Accuracy class for				
5.28.1	Winding 1			Acc. to SLD	
5.28.2	Winding 2			Acc. to SLD	
5.29	Rated primary voltage		KVrms	132/√3	
5.2.30	Rated secondary voltage		KVrms	0.11/√3	
5.31	Rated burden for				
5.31.1	Winding 1		VA	Acc. to SLD	
5.31.2	Winding 2		VA	Acc. to SLD	
5.32	Continuous thermal burden of				
5.32.1	Winding 1 alone		VA	Effective	
5.32.2	Winding 2 alone		VA	phase to ground	
5.33	Type of system grounding				
5.34	Type of connection			Stud type	
5.35	Connections			Standard terminal block (screw and	
5.35.1	Primary			MCB with auxiliary contact	
5.35.2	Secondary			MCB with auxiliary contact	
5.36	Type of protection device in secondary side			Stud type	
5.37	Total continuous thermal burden of secondary windings		VA	Standard terminal block (screw and	
5.37.1	Primary				
5.37.2	Secondary			60K Wind. 50K Oil	
	Other Characteristics			1	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
5.38	Temperature rise at rated burden and at 1.2 times rated primary voltage and ambient		K	Max(0.25)	
5.39	Permissible secondary short circuit time with rated primary voltage		sec	RLC Dumping	
5.40	Short circuit impedance		Ohm		
5.41	Method of suppressing for ferro-resonance			Max (10000)	
5.42	Available ranges of high voltage capacitor		pF	35*10-4	
5.43	Coupling capacitor *		pF		
5.44	Loss angle at rated voltage			Max(40)	
5.45	Frequency range for PLC use		KHz		
5.46	Equipment series resistance for 35-450 KHz		Ohm		
5.47	Natural frequency		MHz		
5.48	Intermediate stage voltage		kV		
5.49	Attenuation of intermediate voltage transformer within 35-450 KHz		dB		
5.50	Max. insertion loss when used for PLC		dB		
5.51	Whether intermediate tap is brought out? (Yes / No)				
	* Min. coupling capacitance of CVT could be changed by manufacture				
	Insulator columns				
5.52	Manufacturer				
5.53	Place of manufacturing				
5.54	Type designation				
5.55	Material			Porcelin	
5.56	Min. creepage distance		mm	4495	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
5.57	Protected creepage distance		mm		
5.58	Color			Brown	
	Miscellaneous				
5.59	Type and manufacturer of oil for capacitor section				
5.60	Type and manufacturer of oil for intermediate section				
5.61	Whether oil level indicator is provided? (Yes / No)		(Yes / No)	Yes	
5.62	Class and grade of insulation material used in capacitors				
5.63	Permitted inclination during transport/storage		Degree		
5.64	Material of windings				
5.65	Whether CVT is designed to mount line trap on top? (Yes / No)				
5.66	Permissible force at HV terminals				
5.66.1	Static at any direction		N		
5.66.2	Dynamic at any direction		N		
5.67	Total weight		kg		
5.68	Total oil weight		kg		
5.69	Overall height		mm		
5.70	Overall width		mm		
5.71	Max. package dimensions ready for shipment		m3		
5.72	Washable in service? (Yes / No)				
	132KV Conductors				
	General				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
6.1	Rated current		A		
6.1.1	Line feeders			Acc. to SLD	
6.1.2	Trans feeders			Acc. to SLD	
6.1.3	Busbars			Acc. to SLD	
6.1.4	Busbar coupler			Acc. to SLD	
6.2	Rated frequency		Hz	50	
6.3	Rated voltage		kV	145	
6.3.1	Basic insulation level of equipment at site condition		kV peak	750	
6.3.2	Rated one minute power frequency withstand voltage at site condition		kV rms	325	
6.3.3	Rated short circuit withstand current and its duration		kA/sec	31.5/3	
6.4	Withstanding in load combinations of earthquake, wind, short circuit, as mentioned in Technical Specification? (Yes / No)		(Yes / No)	Yes	
6.5	Maximum permissible temperature of conductors at rated current and Max. ambient temperature		°C	80 Max	
6.6	Minimum assumed tension for each stranded conductor at E.D.S condition		% of UTS	3	
6.7	Minimum assumed tension for each stranded conductor of incoming and outgoing overhead lines (per phase)		% of UTS	20	
6.8	Minimum tension of incoming and outgoing shield wires		% of UTS	10	
6.9	Maximum permissible surface gradient		kV/cm	16	
6.10	Maximum permissible angle for incoming and outgoing overhead lines			±30	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
6.11	Ambient condition				
6.11.1	Minimum ambient temperature			Acc. to section 1	
6.11.2	Maximum ambient temperature			Acc. to section 1	
6.11.3	Solar radiation			Acc. to section 1	
6.11.4	Seismic acceleration			Acc. to section 1	
6.11.5	Wind speed			Acc. to section 1	
6.10.6	Ice thickness			Acc. to section 1	
6.12	Solar radiation absorption coefficient (Y)			Acc. to section 1	
6.13	Emissivity coefficient in respect to black body (Ke)			0.5	
6.14	Altitude above sea level		m	Acc. to section 1	
	Stranded Conductors				
6.15	Manufacturer				
6.16	Place of manufacturing				
6.17	Material and alloy type			AAAC/AAC (IEC 61089)	
6.18	Nominal cross section		mm²	460 (AAAC 400) / Existing	
6.19	Number of strands			37	
6.20	Overall diameter of conductor		mm	27.86	
6.21	Ultimate strength of conductor		kN		
6.22	Continuous current rating of conductor at max. ambient temperature and 80° conductor Temperature		A	543 @ 75 deg and 689 @ 85 deg	
	Note: The stranded conductor size adequacy shall be determined by				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
	Tubular Conductors				
6.23	Manufacturer				
6.24	Place of manufacturing				
6.25	Material and alloy type			Aluminum alloy	
6.26	Outside diameter		mm		
6.27	Thickness		mm		
6.28	Weight		kg/m		
6.29	Max. deflection after installation		mm		
6.30	Continuous current rating of conductor at max. ambient temperature at and tube Temperature 80 °C		A		
6.31	Moment of inertia		cm		
6.32	Minimum yield strength		kg/cm²		
	Note: The tubular conductor size adequacy shall be determined by calculation.				
	Shield wires				
6.33	Manufacturer				
6.34	Place of manufacturing				
6.35	Material			Al clad steel	
6.36	Cross section		mm²	58.56	
6.37	Diameter		mm	9.78	
6.38	Number of strands			7 no.8	
6.39	Resistance (at 20 °C)		ohm/km	1.463	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
6.40	Ultimate strength		kN	70.76	
6.41	Modulus of elasticity		kg/mm2	16000	
6.42	Coefficient of linier expansion		1/°C	13* 10 ^(−6)	
6.43	Aluminium coating thickness		μm		
	Connectors and Hardware				
6.44	Manufacturer				
6.45	Place of manufacturing				
6.46	Material of connectors				
6.47	Material of bolts and nuts				
6.48	Material of washers				
6.49	Applicable standard for connectors				
6.50	Type of contact paste				
	Minimum Clearances (Not applicable for equipment subject to impulse voltage tests \				
6.51	Clearance between live parts and ground (Basic value)		mm	1500	
6.52	Clearance between different phases in bays		mm	2500	
6.53	Minimum Spacing between phases of rigid buses		mm	2500	
6.54	Minimum height of energized parts above ground		mm	4000	
6.55	Height of energized parts above access roads		mm	9000	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
6.56	Minimum Distance between over-span phases		mm	3500	
6.57	Shield wire clearance over bus conductors		mm	3000	
	132KV Insulators				
	General				
7.1	Rated current		A		
7.1.1	Line feeders			Acc. to SLD	
7.1.2	Trans feeders			Acc. to SLD	
7.1.3	Busbars			Acc. to SLD	
7.1.4	Coupler			Acc. to SLD	
7.1.5	Reactor feeders			N.A	
7.2	Rated frequency		Hz	50	
7.3	Rated voltage		kV	145	
7.2.1	Basic insulation level of equipment at site condition		kV peak	750	
7.2.2	Rated one minute power frequency withstand voltage at site condition		kV rms	325	
7.2.3	Rated short circuit withstand current and its duration		kA/sec	31.5/3	
7.4	Withstanding in load combinations of earthquake, wind, short circuit, as mentioned in Technical Specification? (Yes / No)		(Yes / No)	Yes	
7.5	Maximum permissible temperature of conductors at rated current and Max. ambient temperature		°C	80	
7.6	Maximum permissible surface gradient		kV/cm	16	
7.7	Maximum permissible angle for incoming and outgoing overhead lines			±30	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.8	Ambient condition				
7.8.1	Minimum ambient temperature			Acc. to section 1	
7.8.2	Maximum ambient temperature			Acc. to section 1	
7.8.3	Solar radiation			Acc. to section 1	
7.8.4	Seismic acceleration			Acc. to section 1	
7.8.5	Wind speed			Acc. to section 1	
7.8.6	Ice thickness			Acc. to section 1	
7.8.7	Solar radiation absorption coefficient (Y)			Acc. to section 1	
7.8.8	Emissivity coefficient in respect to black body (Ke)			0.5	
7.9	Altitude above sea level		m	Acc. to section 1	
7.10	Manufacturer quality system in accordance with ISO 9000		Yes / No	Yes	
7.10.1	Date of issue			Latest	
7.10.2	Validity				
7.10.3	Certificate attached to the offer		Yes / No	Yes	
7.11	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be submitted		Yes / No	Yes	
7.11.1	Certificate to be attached to the offer			Yes	
	String Insulators				
7.12	Manufacturer				
7.13	Place of manufacturing				
7.14	Type designation			ball & socket	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.15	Applicable standard			IEC	
7.16	Insulator material			Glazed porcelain	
7.17	Color			Brown	
7.18	Wet power frequency withstand voltage of each unit		kV	47	
7.19	Lightning impulse withstand voltage of each unit		kV	110	
7.20	Electromechanical failing load of each unit		kN	120	
7.21	Puncture voltage of each unit		kV	130	
7.22	Minimum creepage distance of each unit		mm	295	
7.23	Total creepage distance of string		mm	4459	
7.24	Nominal spacing		mm	146	
7.25	Protected (90) creepage distance		mm		
7.26	Size of ball and socket		mm		
7.27	IEC coupling ball				
7.28	Material of fittings				
7.29	Minimum quantity of disks per string			16	
7.30	Power frequency withstand voltage of complete String		kV rms		
7.30.1	Dry			325	
7.30.2	Wet				
7.31	Basic Insulation level of complete string		KV peak		
7.31.1	Positive			750	
7.31.2	Negative				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.32	Max. R.I.V. at 1MHz as per CISPR no.1		μ V		
7.33	Overall length of string with accessories		mm		
7.34	Ultimate tensile strength of string		kN		
7.35	Total weight of string		kg		
7.36	Whether arcing ring at ground side Provided? (Yes / No)		(Yes / No)	Yes	
7.37	Whether corona ring at live side Provided? (Yes / No)		(Yes / No)	Yes	
7.38	Arcing distance		mm		
7.39	Whether washable in service? (Yes / No)		(Yes / No)	Yes	
	Note: The string insulator and each insulator size adequacy shall be determined by calculation.				
	String Insulator Accessories				
7.40	Manufacturer				
7.41	Place of manufacturing				
7.42	Material				
7.43	Applicable standard				
7.44	Rated ultimate tensile strength		kN		
	Post Insulators				
7.45	Manufacturer				
7.46	Place of manufacturing				
7.47	Type designation			Post type	
7.48	Applicable standard				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.49	One minute power frequency withstand Voltage (at IEC condition)		kV rms		
7.49.1	Dry			325	
7.49.2	Wet				
7.48	Basic Insulation level (at IEC condition)		kV peak	750	
7.49	Basic Insulation level (at site condition)		kV peak		
7.50	Switching impulse withstand voltage		kV peak	-	
7.51	Color				
7.52	Insulator material			Ceramic Polymer	/
7.53	Top metal fitting material				
7.54	Bottom metal fitting material				
7.55	Bonding material				
7.56	Minimum creepage distance		mm	4495	
7.57	Protected (90) creepage distance		mm		
7.58	Maximum cantilever working load (complete post insulator)		kN		
7.59	Minimum cantilever breaking load, upright (complete post insulator)		kN		
7.60	Minimum torsion strength		kNm		
7.61	Minimum compression strength		kN		
7.62	Total height		mm		
7.63	Arcing distance		mm		
7.64	Fixing bolts				
7.64.1	Quantity per post insulator				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.64.2	Diameter				
7.65	Bolt circle diameter (Top / Bottom)		mm		
7.66	Total weight		kg		
7.67	Maximum R.I.V. at 100 KHz		μv	500	
7.68	Whether washable in service? (Yes / No)				
7.69	Maximum weight of one package ready for Shipment		kg		
7.70	Whether corona ring at live side Provided? (Yes / No)			Yes	
7.71	Number of units in complete post insulator				
7.72	Length of each unit		mm		
	Note: The post insulator size adequacy shall be determined by calculation.				
	Connectors and Hardware				
7.73	Manufacturer				
7.74	Place of manufacturing				
7.75	Material of connectors				
7.76	Material of bolts and nuts				
7.77	Material of washers				
7.78	Applicable standard for connectors				
7.79	Type of contact paste				
	Minimum Clearances (Not applicable for equipment subject to impulse voltage tests)				
7.80	Height of base of post insulator from ground		mm	2500	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
7.81	Clearance between live parts and ground (Basic value)		mm	1500	
7.82	Minimum height of energized parts above ground		mm	4000	
7.83	Height of energized parts above access roads		mm	9000	
	132kV SURGE ARRESTERS				
	General				
8.1	Manufacturer of surge arrester:				
8.1.1	Name				
8.1.2	Country				
8.2	Manufacturer of surge counter:				
8.2.1	Name				
8.2.2	Country				
8.3	Type designation for surge arresters			Station metal oxide gapless	
8.4	Type designation for surge counter (equipped with leakage current measuring				
8.5	Applicable standard			IEC 60099-4	
8.6	Rated frequency		Hz	50	
8.7	Nominal line to line voltage rating		kV	145	
8.8	Type			MOA	
8.9	Class of surge arrester			Very Heavy	
8.10	Maximum and Minimum ambient temperature for design		°C	Acc. to section 1	
8.11	Altitude above sea level		m	Acc. to section 1	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
8.12	Design seismic acceleration		g	Acc. to section 1	
8.13	Ice thickness		mm	Acc. to section 1	
8.14	Wind velocity		m/s	Acc. to section 1	
8.15	Maximum overvoltage factor on the system due to any switching duty		pu	2.3	
8.16	Whether withstanding in load combinations of earthquake , wind , short circuit, as mentioned In Technical		(Yes / No)	Yes	
	Surge Arresters				
8.17	Rated voltage		kV rms	145	
8.18	Continuous operating voltage		kV rms	116	
8.19	Long duration discharge class as per IEC 99-1		Class	3	
8.20	Number of phases			3	
8.21	Type of system earthing			Non-Effective	
8.22	Nominal discharge current with 8/20 us wave		kA peak	10	
8.23	Arrester designation			SM	
8.24	Type of housing in the case of utilizing porcelain and its classification acc to Std. 60672			Brown glazed Aluminum porcelain class C130	
8.25	Type of housing in the case of utilizing composite polymer and its resistance classification acc to IEC 60587			Silicon rubber (LSR,HCR or RTV type) class	
8.26	Earth fault factor			1.4	
8.27	Place of installation			Line/Transformer	
8.28	Pressure relief class				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
8.28.1	High current 0.2 sec		kA	50	
8.28.2	Low current 1 sec			600±200	
8.29	Thermal energy rating (Wth)		(kJ / kV) of	> 10	
8.30	Repetitive charge transfer rating (Qrs)		C	> 2.4	
8.31	Reference voltage		kV rms		
8.32	Reference current		mA		
8.33	TOV capability for				
8.33.1	1 sec		kV	Acc. to IEC 60099-4	
8.33.2	10 sec		kV	Acc. to IEC 60099-4	
8.34	Continuous current under ambient temperature		mA		
8.35	Maximum residual voltage for lightning impulse current with 8/20 microsecond wave for following impulse peaks				
8.35.1	Switching surges-1kA/2kA		kV peak	Acc. to IEC 60099-4	
8.35.2	5 KA		kV peak	Acc. to IEC 60099-4	
8.35.3	10 KA		kV peak	Acc. to IEC 60099-4	
8.35.4	20 KA		kV peak	Acc. to IEC 60099-4	
8.36	Maximum residual voltage for switching impulse current with 30/60 microsecond wave for following impulse peaks				
8.36.1	500 A		kV peak	Acc. to IEC 60099-4	
8.36.2	1 KA		kV peak	Acc. to IEC 60099-4	
8.36.3	2 KA		kV peak	Acc. to IEC 60099-4	

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
8.37	Maximum residual voltage for steep current impulse with 1/20 microsecond wave and 10 KA peak		kV peak		
8.38	High current 4/10 microsecond impulse withstand level		kA peak	Acc. to IEC 60099-4	
8.39	Low current 2000 microsecond withstand level		kA peak	Acc. to IEC 60099-4	
8.40	Number of arrester units				
8.41	Rated voltage of each arrester unit		kV rms		
8.42	Number of parallel non linear MO resistance block			1	
8.43	Power frequency voltage versustime characteristics included?		(Yes/No)		
8.44	Maximum internal partial discharge		pC	Acc. to IEC 60099	
8.45	Manufacturer quality system in accordance with ISO 9000		Yes/No	Yes	
8.45.1	Date of issue			Latest	
8.45.2	Validity				
8.45.3	Certificate attached to the offer		Yes/No	Yes	
8.46	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be		Yes/No	Yes	
8.46.1	Certificate to be attached to the offer		Yes/No	Yes	
8.46.2	Report to be attached to the offer		Yes/No	Yes	
	Miscellaneous				
8.47	Insulator				
8.47.1	Manufacturer				
8.47.2	Country				
8.47.3	Type				

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
8.47.4	Material				
8.48	Creepage distance of insulator		mm	4495	
8.49	Basic insulation level of insulator at site condition		kV peak	1.3*LIPL	
8.50	One minute power frequency withstand voltage of insulator at site condition		kV rms	1.06*SIWL/ √2	
8.51	Switching Impulse withstand voltage of insulator at site condition		kV peak	1.25*SIWL	
8.52	Filling medium				
8.53	Method used for sealing test				
8.54	Whether washable in service (Yes/ No)		(Yes/ No)	Yes	
8.55	Permissible force at HV terminals				
8.55.1	Static Horizontal		N		
8.55.2	Static Vertical		N		
8.55.3	Dynamic Horizontal		N		
8.55.4	Dynamic vertical		N		
8.56	Whether isolating pads for surge arresters with surge counter provided? (Yes/No)		(Yes/ No)	Yes, separated	
8.57	Non Linear MO resistor				
8.57.1	Manufacturer				
8.57.2	Country				
8.57.3	Type				
8.58	Dimension of each non-linear MO resistance block				
8.58.1	Diameter		mm		
8.58.2	Height		mm		

132 kV OPEN TERMINAL SWITCHGEAR			UNIT	DATA	
				REQUIRED	OFFERED
8.59	Total weight of single unit		kg		
8.60	Total weight of complete surge arrester		kg		
8.61	Total height of surge arrester		mm		
8.62	Total width of surge arrester		mm		
8.63	Whether grading ring for high voltage terminal required?		(Yes/No)	Yes	
8.64	Maximum Package weight ready for shipment		kg		

2. 33 KV OPEN TERMINAL SWITCHGEAR

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
	33KV Circuit Breaker			
	General			
1.1	Manufacturer			
1.2	Place of manufacturing			
1.3	Type designation for breaker			
1.4	Type designation for operating mechanism			
1.5	Type of operation mechanism		Spring Charge motor operated	
1.6	Type of interrupting chamber			
1.7	Applicable standard		IEC 62271-200, 62271-102, 62271-1, 62155, 61869-1, 61869-5, 60383, 60815	
1.8	Rated voltage	kV	36	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.9	System Voltage	kV	33	
1.10	Rated current at maximum site temperature	A		
1.10.1	For Transformer feeder		Acc. to SLD	
1.10.2	For Bus Section		Acc. to SLD	
1.10.3	For Diameter		N.A.	
1.10.4	For Bus Coupler feeder		N.A.	
1.10.5	For Bus Section		Acc. to SLD	
1.10.6	For reactor feeder		N.A.	
1.11	Rated frequency	Hz	50	
1.12	Media of breaking chamber		SF6	
1.13	Single pressure, low pressure or others			
1.14	Quantity of poles per breaker		3 Poles	
1.15	Rated operating sequence		O -0.3 sec- CO - 3 min - CO	
1.16	Single pole or three pole operation			
1.16.1	For Transformer feeder		3 pole operated	
1.16.2	For Bus Section		3 pole operated	
1.16.3	For Diameter		N.A	
1.16.4	For Bus Coupler feeder		N.A	
1.16.5	For Bus Section		3 pole operated	
1.16.6	For reactor feeder		N.A	
1.17	Number of interrupting chambers per pole			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.18	Class (indoor / outdoor)		Outdoor	
1.19	Circuit breaker type (live tank / dead tank)		Live tank	
1.20	Type of system earthing		Effective	
1.21	Withstanding in load combinations of earthquake, wind , short circuit , etc as mentioned in Technical Specification	(Yes/No)	Yes	
1.22	Maximum and Minimum ambient temperature for design	°C	Acc. to section 1	
1.23	Design altitude above sea level	m	Acc. to section 1	
1.24	Pollution level	mm/kV	Acc. to section 1	
1.25	Design seismic acceleration	g	Acc. to section 1	
	Insulation Rating			
1.26	Type of Insulator (porcelain/silicon rubber)		porcelain	
1.27	Basic Insulation level (at site condition)	kV peak		
1.27.1	Common value (Phase-phase, Phase-ground)		250	
1.27.2	Across the isolating distance		290	
1.28	One minute power frequency withstand voltage (at IEC condition)	kV rms		
1.28.1	Common value (Phase-phase, Phase-ground)		95	
1.28.2	Across isolating distance		110	
1.29	Switching Impulse Withstand Voltage at IEC conditions	kV peak		
1.29.1	Phase to ground and across open switching device		N.A.	
1.29.2	Phase to phase		N.A.	
1.29.3	Across isolating distance		N.A.	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.30	Rated transient recovery voltage for terminal faults	kV peak	62	
1.31	Rated transient recovery voltage	kV peak		
1.31.1	Amplitude factor			
1.31.2	Rate of rise	kV/ μ s		
1.32	Rate of rise of restriking voltage			
1.32.1	For 30% breaking capacity	kV/ μ s		
1.32.2	For 60% breaking capacity	kV/ μ s		
1.32.3	For 100% breaking capacity	kV/ μ s		
1.33	Maximum recovery voltage on breaking a synchronous system	kV		
1.34	Rated characteristics for short line faults	kV rms		
1.35	First pole to clear factor		1.5	
1.36	Whether circuit breaker is restrike free?		Yes	
1.37	Maximum overvoltage factor on any switching duty	pu	2.3	
1.38	Maximum overvoltage factor when interrupting rated line/cable/capacitor	pu	2.3	
1.39	Maximum overvoltage factor when switching small inductive/reactor currents	pu	2.3	
1.40	Maximum total break time (trip initiation to final arc extinction)	ms	<60	
	Current Ratings			
1.41	Rated short time withstand current & duration	kA rms/sec	25/1	
1.42	Rated short circuit making current	kA peak	2.5*25	
1.43	Rated out of phase breaking current	kA rms	10	
1.44	Rated small inductive breaking current	A rms	Acc. To IEC	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.45	Rated capacitive breaking current			
1.45.1	Rated line-charging breaking current	A rms	Acc. To IEC	
1.45.2	Rated cable charging breaking current	A rms	Acc. To IEC	
1.45.3	Rated Single/Back to Back Capacitor bank breaking current	A rms	Acc. To IEC	
1.46	Rated short circuit breaking current			
1.46.1	AC component	kA rms	25	
1.46.2	DC component	%	Acc. To IEC	
1.47	Maximum current on breaking asynchronous system	kA peak		
1.48	180° out of phase switching duty as a percentage of rated breaking current	%		
	Other Characteristics			
1.49	Voltage drop across MV terminals of one pole at 100 A dc	mV		
1.50	Maximum temperature rise at normal current over maximum	°C		
1.51	Opening time (from trip contact closing to the primary contacts separation in all			
1.51.1	Without current	ms		
1.51.2	With 100% rated breaking current	ms		
1.52	Opening time from trip contact closing to primary contact separation	μs		
1.53	Closing time (from energization of close coil to latching of circuit breaker in fully	μs		
1.54	Rated break or interrupting time (opening time plus arcing time)	μs		
1.55	Making time (energization of close coil to contact touch)			
1.55.1	Without current	ms		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.55.2	100% making current	ms		
1.56	Maximum break time	ms	<60	
1.57	Maximum close time	ms	<120	
1.58	Dead time (during auto-reclosing)	ms		
1.59	Reclosing	ms		
1.60	Arcing time	ms		
1.61	Maximum time interval between opening of first and last phase of three phase circuit	ms		
1.62	Maximum time interval between opening of interrupters of one phase	μs		
1.63	Maximum time interval between closure of interrupters of one phase	μs		
1.64	Minimum time from extinction of main arc to contact make during auto-reclosing	ms		
1.65	Closing time from energisation of close coil to latching of circuit breaker in fully	ms		
1.66	Making time (energisation of close coil to contact touch)			
1.66.1	Without current	ms		
1.66.2	100% making current	ms		
	Operating Mechanism			
1.67	Type of spring		spring operated	
1.68	Motor type		DC Motor charged,	
1.69	Motor			
1.69.1	Rated voltage	V	110 VDC	
1.69.2	Power demand	W		
1.69.3	Full-load current	A		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.69.4	Maximum starting current	A		
1.69.5	Speed	rpm		
1.69.6	Required time by motor to charge the spring completely	s		
1.69.7	Type of protection of motor			
1.70	Hand operating facility	Yes/No	Yes	
1.70.1	Manual spring charging facility to be accessible from ground respectively platform to be provided	Yes/No	Yes	
1.70.2	Manual spring release (suitably positioned to avoid accidental operation)	Yes/No	Yes	
1.70.3	Manual mechanism charging torque	Nm		
1.71	Mechanical on/off indicator	Yes/No	Yes	
1.72	Mechanical spring charge/discharge indication	Yes/No	Yes	
1.73	Charging time	S	≤12	
1.74	Number of trip coils per breaker		2	
1.75	Number of close coils per breaker		1	
1.76	Reclosing suitable for 1 pole and/or 3 pole		As protection diagram	
1.77	Whether circuit breaker is trip free or others?		Yes	
1.78	Number and type of spare auxiliary reversible contacts		6NO+6NC (min.)	
1.79	Opening and closing nominal control voltage	V dc		
1.80	Control cabinet			
1.80.1	Power Socket in Control cabinet		British Standard	
1.80.2	cabinet Light (Compact LED)	Yes/No	Yes	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.80.3	Number, type & power of cabinet heater			
1.80.4	cabinet space heaters (thermostat Controlled)	Yes/No	Yes	
1.80.5	Degree of protection (IP) of control cabinet		IP55	
1.80.6	Minimum thickness of steel control cabinet	mm	2	
1.81	Tripping and closing coils			
1.81.1	Number of closing coils		1	
1.81.2	Number of tripping coils		2	
1.81.3	Tripping coil current	A, DC		
1.81.4	Closing coil current	A, DC		
1.81.5	Rated power of trip coil	W		
1.81.6	Rated power of close coil	W		
1.81.7	Tripping and closing coils' nominal control voltage	V, DC	110	
1.81.8	Variation of closing / opening coils' operating voltage	%	85-110 / 70-110	
1.81.9	Minimum voltage for proper operation of trip & close coils	%	40	
1.81.10	- Pick up range of control voltage			
1.82	Whether antipumping device is provided?	Yes/No	Yes	
1.83	Whether operating counter is provided?	Yes/No	Yes	
1.84	Whether emergency trip is provided?	Yes/No	Yes	
1.85	Whether circuit breaker is equipped with Local/ remote/ maintenance change over	Yes/No	Yes	
1.86	Whether circuit breaker is equipped with manually spring charge facilities?	Yes/No	Yes	
1.87	Whether Pre-insertion resistor is provided?	Yes/No	No	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.87.1	Closing resistor value	Ω		
1.87.2	Insertion time	ms		
1.88	Whether Switching Control Relay is provided?	Yes/No	No	
1.89	Pole discrepancy feature	Yes/No	Yes	
	Insulating Medium			
1.90	Insulating medium		SF6	
1.91	Rated pressure SF6 at 20°C	Absolute		
1.92	Limits of gas pressure for correct operation of breaker	Absolute		
1.93	Signal loss of SF6 at 20°C	Absolute		
1.94	General lockout at 20°C	Absolute		
1.95	Leakage rate of SF6 at rated pressure per annum	%	< 0.1	
1.96	Type and material of gasket used to gas tightening the joints			
1.96.1	Metal to metal joints			
1.96.2	Metal to porcelain joints			
1.97	Supplier of SF6 gas			
1.98	Supplier of Density meter			
1.99	Toxicological test			
1.100	Storage capacity of each gas cylinder	m ³		
1.101	Whether sufficient gas plus 20% supplied for first filling?	Yes / No		
1.102	Mass of gas stored cylinder	kg		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.103	Time required to fill the circuit breaker with SF6 gas ready for operation	hour		
1.104	Time required to empty gas of the circuit breaker	hour		
1.105	Total mass of transportable gas handling equipment	kg		
1.106	Whether SF6 is stored as gas or liquid?			
	Insulator Columns			
1.107	Manufacturer			
1.108	Type			
1.109	Color			
1.110	Creepage distance phase to ground	mm	1256	
1.111	Creepage distance between terminals of one pole	mm		
1.112	Protected creepage distance (90° shadow)	mm		
1.113	Clearance (phase to phase)	mm		
1.114	External striking distance			
1.114.1	Phase to ground	mm		
1.114.2	Phase to phase	mm		
1.115	Ultimate strength of columns			
1.115.1	Cantilever	N		
1.115.2	Tension	N		
1.115.3	Torsion	N.m		
1.115.4	Compression	N		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.116	Permissible force at MV terminals			
1.116.1	Static at any direction	N		
1.116.2	Dynamic at any direction	N		
1.117	Washable in service	Yes / No	Yes	
	Miscellaneous			
1.118	Mechanical life of CB and mechanism in No. of operations	time	10000	
1.119	Electrical contact life in number of operations at:			
1.119.1	Rated current	time	10000	
1.119.2	Breaking current	time	≥ 30	
1.119.3	Cumulative ampere rating	time		
1.120	Whether a lock out device for preventing circuit breaker to close is provided?	Yes / No		
1.121	Whether Switching Control Relay is provided?	Yes/No		
1.122	Number and type of free auxiliary contacts for main contact monitoring		>10NO+ >10NC	
1.123	Number and type of free auxiliary contacts for SF6 gas pressure monitoring		>10NO+ >10NC	
1.124	Number and type of free auxiliary contacts for local/remote selector switch		>10NO+ >10NC	
1.125	Whether circuit breaker is equipped with rings?	Yes/No		
1.126	Whether circuit breaker is equipped with grading capacitors?	(Yes/No)	Yes	
1.127	Mechanical on/off indicator	Yes/No	Yes	
1.128	Gas supervision	Yes/No	Yes	
1.129	Circuit breaker Operating platform (from ground level)	Yes/No	Yes	
1.130	Type and material for main contacts			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
1.131	Material of MV conductor		Aluminum	
1.132	Whether contacts are silver plated?	Yes / No	Yes	
1.133	Un-galvanized metal parts shall primed, undercoated and finished with outdoor	Yes/No	Yes	
1.134	Galvanizing parts accordance with ISO 1461 standards		As per ISO-1461	
1.135	CB weight			
1.135.1	Weight of single pole breaker	kg		
1.135.2	Total weight of complete circuit breaker	kg		
1.135.3	Maximum weight of package ready for shipment	kg		
1.136	CB main dimensions			
1.136.1	Overall height of assembled circuit breaker	mm		
1.136.2	Phase spacing	mm		
1.136.3	Minimum vertical distance between upper and lower terminal of the circuit breaker	mm		
1.136.4	Minimum vertical distance between lower side of the circuit breaker and metallic	mm		
1.137	Mechanical endurance class		M2	
1.138	Electrical endurance class		E2	
1.139	Restrike probability class due to capacitive current breaking		C2	
33kV ISOLATOR				
	General			
2.1	Manufacturer			
2.2	Place of manufacturing			
2.3	Type designation for Isolator			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.4	Type designation for grounding switch			
2.5	Type of Isolator		Horizontal Double Break/Centre	
2.6	Applicable standard		IEC 62271-102	
2.7	Quantity of poles		Single pole op.	
2.8	Rated voltage	kV	36	
2.9	System Voltage	kV	33	
2.10	Rated current at maximum site temperature	A		
2.9.1	At maximum site temperature			
2.9.1.1	For Transformer feeder		Acc. to SLD	
2.9.1.2	For Bus Section		Acc. to SLD	
2.9.1.3	At IEC condition			
2.9.1.4	For Transformer feeder		Acc. to SLD	
2.9.1.5	For Bus Section		Acc. to SLD	
2.9.1.6	For reactor feeder		N.A.	
2.9.2	At IEC condition			
2.9.2.1	For line feeder		N.A.	
2.9.2.2	For Transformer feeder		Acc. to SLD	
2.9.2.3	For Diameter		N.A.	
2.9.2.4	For Bus Coupler feeder		N.A.	
2.9.2.5	For Bus Section		Acc. to SLD	
2.9.2.6	For reactor feeder		N.A.	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.10	Rated frequency	Hz	50	
2.11	Class (outdoor / indoor)		Outdoor	
2.12	Withstanding in load combinations of earthquake, wind, short circuit and etc.? (Yes / No)	Yes / No	Yes	
2.13	Hand operating facility is provided? (Yes / No)	Yes / No	Yes	
2.14	Accessibility to operating mechanism from ground level	Yes / No	Yes	
2.15	Mechanical Endurance Class		M2	
2.16.1	Electrical Endurance Class		E2	
2.16.2	Capacitive switching at maximum temporary		C2	
2.17	Manufacturer quality system in accordance with ISO 9000	Yes / No	Yes	
2.17.1	Date of issue		Latest	
2.17.2	Validity			
2.17.3	Certificate attached to the offer	Yes / No	Yes	
2.18	Type test certificate to be issued by independent laboratory or independently witnessed type test	Yes / No	Yes	
2.18.1	Certificate to be attached to the offer		Yes	
2.18.2	Report to be attached to the offer		Yes	
	Insulation Rating			
2.19	Basic Insulation level (at site condition)			
2.19.1	Common value	kV peak	250	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.19.2	Across the isolating distance	kV peak	290	
2.20	One minute power frequency withstand voltage (at site condition)			
2.20.1	Common value	kV rms	95	
2.20.2	Across the isolating distance	kV rms	110	
2.21	Switching impulse withstand voltage (at site condition)			
2.21.1	Common value	kV peak	N.A.	
2.21.2	Across the isolating distance	kV peak	N.A.	
2.22	Type of Insulation(porcelain/silicon rubber)		porcelain	
	Current Rating			
2.23	Rated short time withstand current			
2.23.1	For Isolator	kA rms/sec	25/1	
2.23.2	For grounding switch	kA rms/sec	25/1	
2.24	Rated short circuit making current for grounding switches	kA rms	2.5*25	
2.25	Rated peak short circuit withstand current	kA peak		
2.26	Maximum inductive current breaking capacity for grounding switch (acc.to IEC 62271/102)	kVA		
2.27	Maximum capacitive current breaking capacity for grounding switch (acc. to IEC 62271/102)	kVA		
	Other Characteristic			
2.28	Rated Supply Voltage			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.28.1	For motor, control and interlock	Vdc	110	
2.28.2	For AC auxiliaries	Vac	240	
2.29	Voltage drop across terminals of one pole at 100 A.dc for Isolator and ground switches	mV		
2.30	Maximum temperature rise at normal current over Maximum ambient temperature	°C		
2.31	Maximum and minimum ambient temperature for design	°C	Acc. to section 1	
2.32	Altitude above sea level	m	Acc. to section 1	
	Operating Mechanism			
2.33	Type of operating mechanism			
2.33.1	For Isolator		DC Motor	
2.33.2	For grounding switch		DC Motor	
2.34	Motor type			
2.35	Motor	V	110 VDC	
2.35.1	Rated voltage	W		
2.35.2	Power demand	A		
2.35.3	Full load current	rpm		
2.35.4	Speed			
2.36	Type of motor protection			
2.37	Total time from initiation of opening operation to Isolator in fully open position	sec		
2.38	Time from contact separation to extinct of capacitive arc	sec		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.39	Total time from initiation of opening operation to time when Isolator gap can withstand phase voltage			
2.40	Breaking and closing of:			
2.40.1	Magnetizing current of power transformers	Yes / No	Yes	
2.40.2	Mutual inductive/capacitive current of parallel circuit in double circuit line	Yes / No	Yes	
2.40.3	Charging current of unloaded lines and/or cables	Yes / No	Yes	
2.41	Minimum guaranteed no. of operations for Isolators or grounding switches before maintenance	N		
2.42	Maximum required force for hand operation with supplied handle			
2.43	Thickness of steel control cabinet	mm	Min (2)	
2.44	Degree of protection (IP) of mechanism housing		IP55	
2.45	Cubicle space heaters (thermostat Controlled)	Yes / No	Yes	
2.46	Cabinet heater			
2.46.1	Power	W		
2.46.2	Nominal Voltage	V	240VAC	
2.47	Whether local/ remote/ disconnect selector switch is provided? (Yes / No)	Yes / No		
2.48	Whether open/neutral /close control switch is provided? (Yes / No)	Yes / No		
2.49	Whether under voltage relay is provided for motor supply?	Yes / No	Yes	
2.50	Whether all of the heaters are equipped with a M.C.B ?	Yes / No	Yes	
2.51	Rated power of operation coil	W		
2.52	Total load of heaters for Isolator	W		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
	Insulators			
2.53	Manufacturer			
2.54	Place of manufacturing			
2.55	Type (porcelain /composite)		porcelain	
2.56	Colour			
2.57	Creepage distance	mm	1256	
2.58	Protected creepage distance	mm		
2.59	Permissible cantilever working load	N	C8	
2.60	Operating handle or lever mounting height above ground	m	1.2	
2.61	Permissible tensional strength	N.m		
	Minimum clearance	mm		
2.61.1	Between poles when Isolator is closed			
2.61.2	Between poles when Isolator is open			
2.61.3	Between phase and ground			
2.61.4	Between one pole terminals at open condition			
	Interlocks			
2.62	Type of interlock between Isolator and associated ground switch		Electrical and Mechanical	
2.63	Type of interlock between ground switch and related circuit breakers		Electrical	
2.64	Type of interlock between Isolator and related circuit breaker		Electrical	
2.65	Locking arrangement in on/off position	Yes / No	Yes	
2.66	Automatic isolation of control supplies when lock off	Yes / No	Yes	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
	Miscellaneous			
2.67	Type of main contacts			
2.67.1	For Isolator			
2.67.2	For grounding switch			
2.68	Material of main contacts			
2.68.1	For Isolator		Copper	
2.68.2	For grounding switch		Copper	
2.69	Material of blades			
2.69.1	For Isolator			
2.69.2	For grounding switch			
2.70	Whether main contacts are silver plated			
2.70.1	For Isolators		Yes	
2.70.2	For grounding switches		Yes	
2.71	Quantity and type of free auxiliary contacts			
2.71.1	For Isolators		>10NO+ >10NC	
2.71.2	For grounding switches		>10NO+ >10NC	
2.72	Permissible force on MV terminals			
2.72.1	Static in any direction	N		
2.72.2	Dynamic in any direction	N		
2.73	Weight of maximum package ready for shipment	kg		
2.74	Weight of complete			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
2.74.1	Isolator	kg		
2.74.2	Isolator with associated grounding switch	kg		
2.74.3	Single phase	kg		
2.75	Cubicle Light (Compact LED)	Yes / No	Yes	
2.76	Number of grounding switch		1	
Note: The table should be filled and submitted for each of the following equipment separately: 1. Isolator without Ground Switches 2. Isolator with 1 Ground Switches				
	33kV EARTHING SWITCH			
	General			
3.1	Manufacturer			
3.2	Place of manufacturing			
3.3	Type designation			
3.4	Type of operating mechanism		DC Motor	
3.5	Applicable standard		IEC 62271-102	
3.6	Rated voltage	kV	36	
3.7	System Voltage	kV	33	
3.8	Rated current	A		
3.8.1	At maximum site temperature		Acc. to SLD	
3.8.2	At IEC condition		Acc. to SLD	
3.9	Rated frequency	Hz	50	
3.10	Class (outdoor / indoor)		Outdoor	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.11	Withstanding in load combinations of earthquake, wind, short circuit and etc.? (Yes / No)	Yes / No	Yes	
3.12	Hand operating facility is provided? (Yes / No)	Yes / No	Yes	
3.13	Accessibility to operating mechanism from ground level	Yes / No	Yes	
3.14	Manufacturer quality system in accordance with ISO 9000	Yes / No	Yes	
3.15	Date of issue		Latest	
3.16	Validity			
3.17	Certificate attached to the offer	Yes / No	Yes	
3.18	Type test certificate to be issued by independent laboratory or independently	Yes / No	Yes	
3.18.1	Certificate to be attached to the offer		Yes	
3.18.2	Report to be attached to the offer		Yes	
	Insulation Rating			
3.19	Basic Insulation level (at site condition)			
3.19.1	Common value	kV peak	250	
3.19.2	Across the isolating distance	kV peak	290	
3.20	One minute power frequency withstand voltage (at site condition)			
3.20.1	Common value	kV rms	95	
3.20.2	Across the isolating distance	kV rms	110	
3.21	Switching impulse withstand voltage (at site condition)			
3.21.1	Common value	kV peak	N.A.	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.21.2	Across the isolating distance	kV peak	N.A.	
3.22	Type of Insulation(porcelain/silicon rubber)		porcelain	
	Current Rating			
3.23	Rated short time withstand current			
3.23.1	For grounding switch	kA rms/sec	25/1	
3.23.2	Rated short circuit making current for grounding switches	kA rms	2.5*25	
3.24	Rated peak short circuit withstand current	kA peak		
3.25	Maximum inductive current breaking capacity for grounding switch (acc.to IEC 62271/102)	kVA		
3.26	Maximum capacitive current breaking capacity for grounding switch (acc. to IEC 62271/102)	kVA		
	Other Characteristic			
3.27	Rated Supply Voltage			
3.27.1	For motor, control and interlock	Vdc	110	
3.27.2	For AC auxiliaries	Vac	240	
3.28	Voltage drop across terminals of one pole at 100 A.dc for ground switches	mV		
3.29	Maximum temperature rise at normal current over Maximum ambient temperature	°C		
3.30	Maximum and minimum ambient temperature for design	°C	Acc. to section 1	
	Altitude above sea level	m	Acc. to section 1	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.31	Operating Mechanism			
3.32	Type of operating mechanism		DC Motor	
3.32.1	Motor type			
3.32.2	Motor	V		
3.33	Rated voltage	W		
3.34	Power demand	A		
3.34.1	Full load current	rpm		
3.34.2	Speed			
3.35	Type of motor protection			
3.36	Total time from initiation of opening operation in fully open position	sec	≤15	
3.37	Breaking and closing of:			
3.37.1	Magnetizing current of power transformers	Yes / No	Yes	
3.37.2	Mutual inductive/capacitive current of parallel circuit in double circuit line	Yes / No	Yes	
3.37.3	Charging current of unloaded lines and/or cables	Yes / No	Yes	
3.38	Minimum guaranteed no. of operations for grounding switches before maintenance	N		
3.39	Maximum required force for hand operation with supplied handle			
3.40	Thickness of steel control cabinet	mm	Min (2)	
3.41	Degree of protection (IP) of mechanism housing		IP55	
3.42	Cubicle space heaters (thermostat Controlled)	Yes / No	Yes	
3.43	Cabinet heater			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.43.1	Power	W		
3.43.2	Nominal Voltage	V	240 VAC	
3.44	Whether local/ remote/ disconnect selector switch is provided? (Yes / No)	Yes / No		
3.45	Whether open/neutral /close control switch is provided? (Yes / No)	Yes / No		
3.46	Whether under voltage relay is provided for motor supply?	Yes / No	Yes	
3.47	Whether all of the heaters are equipped with a M.C.B ?	Yes / No	Yes	
3.48	Rated power of operation coil	W		
3.49	Total load of heaters	W		
	Insulators			
3.50	Manufacturer			
3.51	Place of manufacturing			
3.52	Type (porcelain /composite)		porcelain	
3.53	Color			
3.54	Creepage distance	mm	1256	
3.55	Protected creepage distance	mm		
3.56	Permissible cantilever working load	N	C8	
3.57	Operating handle or lever mounting height above ground	m	1.2	
3.58	Permissible tensional strength	N.m		
3.59	Minimum clearance	mm		
3.59.1	Between poles when earth switch is closed			
3.59.2	Between poles when earth switch is open			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.59.3	Between phase and ground			
3.59.4	Between one pole terminals at open condition			
	Interlocks			
3.60	Type of interlocking		Electrical and Mechanical	
3.61	Locking arrangement in on/off position	Yes / No	Yes	
3.62	Automatic isolation of control supplies when lock off	Yes / No	Yes	
	Miscellaneous			
3.63	Type of main contacts			
3.64	For grounding switch			
6.65	Material of main contacts			
3.65.1	For grounding switch			
3.66	Material of blades			
3.66.1	For grounding switch			
3.67	Whether main contacts are silver plated			
3.67.1	For grounding switches		Yes	
3.68	Quantity and type of free auxiliary contacts			
3.67.1	For grounding switches		>10NO+ >10NC	
3.69	Permissible force on MV terminals			
3.69.1	Static in any direction	N		
3.69.2	Dynamic in any direction	N		
3.70	Weight of maximum package ready for shipment	kg		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
3.71	Weight of complete earth switch	kg		
3.72	Cubicle Light (Compact LED)	Yes / No	Yes	
33kV CURRENT TRANSFORMERS				
	General			
4.1	Manufacturer			
4.2	Place of manufacturing			
4.3	Type designation		Post	
4.4	Number of phases		3 phase	
4.5	Type of neutral grounding		Effective	
4.6	Applicable standard		IEC 61869-1/-2	
4.7	Class (indoor / outdoor)		Outdoor	
4.8	Type (Oil-immersed / dry)		Oil-immersed Oil impregnated	
4.9	Construction (tank / inverted)		Tank	
4.10	Rated voltage	kV rms	36	
4.11	System Voltage	kV	33	
4.12	Rated current at max. site temperature :	A		
4.12.1	For transformer feeders		Acc. to SLD	
4.12.2	For bus section feeders		Acc. to SLD	
4.12.3	Power transformer neutral		Acc. to SLD	
4.12.4	For bus section feeders		Acc. to SLD	
4.12.5	Power transformer neutral		Acc. to SLD	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
4.12.6	For Reactor feeder		N.A	
4.13	Rated frequency	Hz	50	
4.14	Max. and min. ambient temperatures used for design	°C	Acc. to section 1	
4.15	Rated short time withstand current	kA rms	25/1sec	
4.16	Rated short time dynamic current	kA peak	2.5*25	
4.17	Whether withstanding in load combinations of earthquake, wind, short circuit? (Yes / No)	(Yes / No)	Yes	
4.18	Altitude above sea level	m	Acc. to section 1	
4.19	Manufacturer quality system in accordance with ISO 9000	Yes/No	Yes	
4.19.1	Date of issue		Latest	
4.19.2	Validity			
4.19.3	Certificate attached to the offer	Yes/No	Yes	
4.20	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be	Yes/No	Yes	
4.20.1	Certificate to be attached to the offer	Yes/No	Yes	
4.20.2	Report to be attached to the offer	Yes/No	Yes	
	Insulation			
4.21	Maximum continuous line to line operating voltage	kV rms	36	
4.22	Basic Insulation level (at site condition)	kV peak	250	
4.23	Switching impulse withstand level (at site condition)	kV peak	-	
4.24	One minute power frequency withstand voltage (at site condition)	kV rms		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
4.24.1	Dry		95	
4.24.2	Wet			
4.25	One minute power frequency withstand voltage for secondary winding	kV rms		
4.26	Highest value of partial discharge when tested acc. to IEC	pc	5	
4.27	Voltage at secondary winding terminals with normal primary load current , and secondary open circuit	kV		
4.28	Time permitted with open circuit secondary	sec		
4.29	Dielectric dissipation factor			
	Ratings and Accuracies			
4.30	Rated primary current	A	Acc. to SLD	
4.31	Rated extended primary current		120%	
4.32	Rated secondary current	A	1	
4.33	Change of CT ratio shall be possible at the secondary circuit only	Yes/No	Yes	
4.34	specification of CTs on: Line feeders, Transformer feeders, Bus couple, Tie coupler, Auxiliary transformer, Power transformer neutral. Core balance			
4.34.1	Number of cores		Acc. to SLD	
4.34.2	Ratio (TR – turns ratio)	A	Acc. to SLD	
4.34.3	Class		Acc. to SLD	
4.34.4	Knee point voltage (Ek)	V	Acc. to SLD	
4.34.5	Exciting current (IE) at Ek	mA	Acc. to SLD	
4.34.6	Rated output (burden to be 25-100% rated burden)	VA	Acc. to SLD	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
	External Insulation			
4.35	Material			
4.36	Manufacturer			
4.37	Place of manufacturing			
4.38	Type designation			
4.39	Minimum creepage distance	mm	1256	
4.40	Color		Brown	
4.41	Protected creepage distance (90 shadow)	mm		
4.42	Shortest flash-over distance	mm		
4.43	Whether washable in service ? (Yes / No)	(Yes / No)	Yes	
	Miscellaneous			
4.44	Maximum R.I.V. level at 1.2 max. rated voltage at 1 MHz according to NEMA 107	μv	500	
4.45	Whether oil level indicator/oil sampling valve/oil filling valve are provided ? (Yes		Yes	
4.46	Means for compensation of oil expansion			
4.47	Temperature rise at rated continuous thermal current	$^{\circ}\text{C}$		
4.48	Rated continuous thermal current (% of rated primary current)		Rated extended primary current	
4.49	Electrostatic capacity of complete current transformer. PF			
4.50	Loss angle at rated voltage			
4.51	Permissible force at MV terminals			
4.51.1	Static at any direction	N		
4.51.2	Dynamic at any direction	N		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
4.52	Type , grade and manufacturer of oil			
4.53	Weight of oil	kg		
4.54	Primary conductor material			
4.55	Secondary conductor material			
4.56	Overall height	mm		
4.57	Overall width	mm		
4.58	Overall length	mm		
4.59	Total weight of complete current transformer	Kg		
4.60	Max. package weight ready for shipment	Kg		
4.61	ting up of CT are provided? (Yes / No)		Yes	
4.62	Permitted inclination refer to vertical axis during transport or storage	Degree		
4.63	Degree protection of Terminal box		IP55	
33kV VOLTAGE TRANSFORMERS				
General				
5.1	Manufacturer			
5.2	Place of manufacturing			
5.3	Type of VT		Single-phase/self-Cooled	
5.4	Applicable standard		IEC 61869-1/-5	
5.5	Rated voltage	kV rms	36	
5.6	System Voltage	kV	33	
5.7	Rated frequency	Hz	50	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
5.8	Max. and min. ambient temperatures used for design	°C	Acc. to Section 1	
5.9	Class (indoor/ outdoor)		Outdoor	
5.8	Type (Oil-immersed / dry)		Oil-immersed/ Oil-impregnated	
5.9	Maximum permissible partial discharge level at Um	pC	10	
5.10	Maximum permissible partial discharge level at 1.2Um /Ö3	pC	5	
5.11	Whether withstanding in load combinations of earthquake , wind , short	(Yes / No)	Yes	
5.12	Altitude above sea level	m	Acc. to Section 1	
5.13	Manufacturer quality system in accordance with ISO 9000	Yes/No	Yes	
5.13.1	Date of issue		Latest	
5.13.2	Validity			
5.13.3	Certificate attached to the offer	Yes/No	Yes	
	Insulation ratings			
5.14	Basic insulation level (at site condition)	kV peak	250	
5.15	Switching impulse withstand voltage (at site condition)	kV peak	-	
5.16	One minute power frequency withstand voltage (at site condition)	kV rms	95	
5.17	Power frequency withstand voltage between secondaries and secondary to	kV rms		
5.18	Rated voltage factor			
5.18.1	Continuous		1.2	
5.18.2	30 seconds		1.5	
5.19	Minimum MV terminal withstand			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
5.19.1	Static terminal load			
5.19.2	Dynamic terminal load			
5.20	Max. RIV measured at 1.2 highest system voltage , 1 Mega-Hz acc. to CISPR	μV		
	Burdens and accuracies			
	3-Winding VT		3	
5.21	Number of secondary windings			
5.22	Accuracy class for			
5.22.1	Winding 1		Acc. to SLD	
5.22.2	Winding 2		Acc. to SLD	
5.22.3	Winding 3		Acc. to SLD	
5.23	Rated primary voltage	KVrms	$33/\sqrt{3}$	
5.24	Rated secondary voltage	KVrms	$0.11/\sqrt{3}$	
5.25	Rated burden for			
5.25.1	Winding 1	VA	Acc. to SLD	
5.25.2	Winding 2	VA	Acc. to SLD	
5.25.3	Winding 3	VA	Acc. to SLD	
5.26	Continuous thermal burden of			
5.26.1	Winding 1 alone	VA		
5.26.2	Winding 2 alone	VA	2	
	2-Winding VT			
5.27	Number of secondary windings		Acc. to SLD	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
5.28	Accuracy class for			
5.28.1	Winding 1		Acc. to SLD	
5.28.2	Winding 2		Acc. to SLD	
5.29	Rated primary voltage	KVrms	$33/\sqrt{3}$	
5.2.30	Rated secondary voltage	KVrms	$0.11/\sqrt{3}$	
5.31	Rated burden for			
5.31.1	Winding 1	VA	Acc. to SLD	
5.31.2	Winding 2	VA	Acc. to SLD	
5.32	Continuous thermal burden of			
5.32.1	Winding 1 alone	VA	Effective	
5.32.2	Winding 2 alone	VA	phase to ground	
5.33	Type of system grounding			
5.34	Type of connection		Stud type	
5.35	Connections		Standard terminal block (screw and bolt)	
5.35.1	Primary		MCB with auxiliary contact	
5.35.2	Secondary		MCB with auxiliary contact	
5.36	Type of protection device in secondary side		Stud type	
5.37	Total continuous thermal burden of secondary windings	VA	Standard terminal block (screw and bolt)	
5.37.1	Primary			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
5.37.2	Secondary			
	Other Characteristics		1	
5.38	Temperature rise at rated burden and at 1.2 times rated primary voltage and ambient	K	Max(0.25)	
5.39	Permissible secondary short circuit time with rated primary voltage	sec	RLC Dumping	
5.40	Short circuit impedance	Ohm		
5.41	Method of suppressing for ferro-resonance		Max (10000)	
5.42	Available ranges of high voltage capacitor	pF	35*10-4	
5.43	Coupling capacitor *	pF		
5.44	Loss angle at rated voltage		Max(40)	
5.45	Frequency range for PLC use	KHz	NA	
5.46	Equipment series resistance for 35-450 KHz	Ohm		
5.47	Natural frequency	MHz		
5.48	Intermediate stage voltage	kV		
5.49	Attenuation of intermediate voltage transformer within 35-450 KHz	dB		
5.50	Max. insertion loss when used for PLC	dB		
5.51	Whether intermediate tap is brought out? (Yes / No)			
	Insulator columns			
5.52	Manufacturer			
5.53	Place of manufacturing			
5.54	Type designation			
5.55	Material			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
5.56	Min. creepage distance	mm	1256	
5.57	Protected creepage distance	mm		
5.58	Color		Brown	
	Miscellaneous			
5.59	Type and manufacturer of oil for capacitor section			
5.60	Type and manufacturer of oil for intermediate section			
5.61	Whether oil level indicator is provided? (Yes / No)	(Yes / No)	Yes	
5.62	Class and grade of insulation material used in capacitors			
5.63	Permitted inclination during transport/storage	Degree		
5.64	Material of windings			
5.66	Permissible force at MV terminals			
5.66.1	Static at any direction	N		
5.66.2	Dynamic at any direction	N		
5.67	Total weight	kg		
5.68	Total oil weight	kg		
5.69	Overall height	mm		
5.70	Overall width	mm		
5.71	Max. package dimensions ready for shipment	m3		
5.72	Washable in service? (Yes / No)			
	33kV Conductors			
	General			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
6.1	Rated current	A		
6.1.1	Trans feeders		Acc. to SLD	
6.1.2	Busbars		Acc. to SLD	
6.1.3	Busbar Section		Acc. to SLD	
6.1.4	Busbar Section		Acc. to SLD	
6.2	Rated frequency	Hz	50	
6.3	Rated voltage	kV	36	
6.3.1	Basic insulation level of equipment at site condition	kV peak	250	
6.3.2	Rated one minute power frequency withstand voltage at site condition	kV rms	95	
6.3.3	Rated short circuit withstand current and its duration	kA/sec	25/1	
6.4	Withstanding in load combinations of earthquake, wind, short circuit, as mentioned in Technical Specification? (Yes / No)	(Yes / No)	Yes	
6.5	Maximum permissible temperature of conductors at rated current and Max. ambient temperature	°C	80 Max	
6.6	Minimum assumed tension for each stranded conductor at E.D.S condition	% of UTS	3	
6.7	Minimum assumed tension for each stranded conductor of incoming and outgoing overhead lines (per phase)	% of UTS	20	
6.8	Minimum tension of incoming and outgoing shield wires	% of UTS	10	
6.9	Maximum permissible surface gradient	kV/cm	16	
6.10	Maximum permissible angle for incoming and outgoing overhead lines		±30	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
6.11	Ambient condition			
6.11.1	Minimum ambient temperature		Acc. to section 1	
6.11.2	Maximum ambient temperature		Acc. to section 1	
6.11.3	Solar radiation		Acc. to section 1	
6.11.4	Seismic acceleration		Acc. to section 1	
6.11.5	Wind speed		Acc. to section 1	
6.10.6	Ice thickness		Acc. to section 1	
6.12	Solar radiation absorption coefficient (γ)		Acc. to section 1	
6.13	Emissivity coefficient in respect to black body (K_e)		0.5	
6.14	Altitude above sea level	m	Acc. to section 1	
	Stranded Conductors			
6.15	Manufacturer			
6.16	Place of manufacturing			
6.17	Material and alloy type		AAAC/AAC (IEC 61089)	
6.18	Nominal cross section	mm ²	921 (AAAC 800)	
6.19	Number of strands		61	
6.20	Overall diameter of conductor	mm	39.42	
6.21	Ultimate strength of conductor	kN		
6.22	Continuous current rating of conductor at max. ambient temperature and 80° conductor Temperature	A	543@75 deg and 689@85 deg	
	Note: The stranded conductor size adequacy shall be determined by			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
	Tubular Conductors			
6.23	Manufacturer			
6.24	Place of manufacturing			
6.25	Material and alloy type		Aluminum alloy	
6.26	Outside diameter	mm		
6.27	Thickness	mm		
6.28	Weight	kg/m		
6.29	Max. deflection after installation	mm		
6.30	Continuous current rating of conductor at max. ambient temperature at and tube Temperature 80 °C	A		
6.31	Moment of inertia	cm		
6.32	Minimum yield strength	kg/cm ²		
	Note: The tubular conductor size adequacy shall be determined by calculation.			
	Shield wires			
6.33	Manufacturer			
6.34	Place of manufacturing			
6.35	Material		Al clad steel	
6.36	Cross section	mm ²	58.56	
6.37	Diameter	mm	9.78	
6.38	Number of strands		7 no.8	
6.39	Resistance (at 20 °C)	ohm/km	1.463	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
6.40	Ultimate strength	kN	70.76	
6.41	Modulus of elasticity	kg/mm ²	16000	
6.42	Coefficient of linear expansion	1/°C	13×10^{-6}	
6.43	Aluminium coating thickness	μm		
	Connectors and Hardware			
6.44	Manufacturer			
6.45	Place of manufacturing			
6.46	Material of connectors			
6.47	Material of bolts and nuts			
6.48	Material of washers			
6.49	Applicable standard for connectors			
6.50	Type of contact paste			
	Minimum Clearances (Not applicable for equipment subject to impulse voltage tests)			
6.51	Clearance between live parts and ground (Basic value)	mm	350	
6.52	Clearance between different phases in bays	mm	1000	
6.53	Minimum Spacing between phases of rigid buses	mm	1000	
6.54	Minimum height of energized parts above ground	mm	2850	
6.55	Height of energized parts above access roads	mm	7500	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
6.56	Minimum Distance between over-span phases	mm	1000	
6.57	Shield wire clearance over bus conductors	mm	2000	
	33kV Insulators			
	General			
7.1	Rated current	A		
7.1.1	Trans feeders		Acc. to SLD	
7.1.2	Busbars		Acc. to SLD	
7.1.3	Diameter		N.A	
7.1.4	Busbars		Acc. to SLD	
7.1.5	Reactor feeders			
7.2	Rated frequency	Hz	50	
7.3	Rated voltage	kV	36	
7.2.1	Basic insulation level of equipment at site condition	kV peak	250	
7.2.2	Rated one minute power frequency withstand voltage at site condition	kV rms	95	
7.2.3	Rated short circuit withstand current and its duration	kA/sec	25/1	
7.4	Withstanding in load combinations of earthquake, wind, short circuit, as mentioned in Technical Specification? (Yes / No)	(Yes / No)	Yes	
7.5	Maximum permissible temperature of conductors at rated current and Max. ambient temperature	°C	80	
7.6	Maximum permissible surface gradient	kV/cm	16	
7.7	Maximum permissible angle for incoming and outgoing overhead lines		±30	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.8	Ambient condition			
7.8.1	Minimum ambient temperature		Acc. to section 1	
7.8.2	Maximum ambient temperature		Acc. to section 1	
7.8.3	Solar radiation		Acc. to section 1	
7.8.4	Seismic acceleration		Acc. to section 1	
7.8.5	Wind speed		Acc. to section 1	
7.8.6	Ice thickness		Acc. to section 1	
7.8.7	Solar radiation absorption coefficient (γ)		Acc. to section 1	
7.8.8	Emissivity coefficient in respect to black body (K_e)		0.5	
7.9	Altitude above sea level	m	Acc. to section 1	
7.10	Manufacturer quality system in accordance with ISO 9000	Yes / No	Yes	
7.10.1	Date of issue		Latest	
7.10.2	Validity			
7.10.3	Certificate attached to the offer	Yes / No	Yes	
7.11	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be submitted	Yes / No	Yes	
7.11.1	Certificate to be attached to the offer		Yes	
	String Insulators			
7.12	Manufacturer			
7.13	Place of manufacturing			
7.14	Type designation		ball & socket	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.15	Applicable standard			
7.16	Insulator material		Glazed porcelain	
7.17	Color			
7.18	Wet power frequency withstand voltage of each unit	kV	95	
7.19	Lightning impulse withstand voltage of each unit	kV	250	
7.20	Electromechanical failing load of each unit	kN	120	
7.21	Puncture voltage of each unit	kV	130	
7.22	Minimum creepage distance of each unit	mm	295	
7.23	Total creepage distance of string	mm	1256	
7.24	Nominal spacing	mm	146	
7.25	Protected (90) creepage distance	mm		
7.26	Size of ball and socket	mm		
7.27	IEC coupling ball			
7.28	Material of fittings			
7.29	Minimum quantity of disks per string		5	
7.30	Power frequency withstand voltage of complete String	kV rms		
7.30.1	Dry		95	
7.30.2	Wet			
7.31	Basic Insulation level of complete string	KV peak		
7.31.1	Positive		250	
7.31.2	Negative			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.32	Max. R.I.V. at 1MHz as per CISPR no.1	μ V		
7.33	Overall length of string with accessories	mm		
7.34	Ultimate tensile strength of string	kN		
7.35	Total weight of string	kg		
7.36	Whether arcing ring at ground side Provided? (Yes / No)	(Yes / No)	Yes	
7.37	Whether corona ring at live side Provided? (Yes / No)	(Yes / No)	Yes	
7.38	Arcing distance	mm		
7.39	Whether washable in service? (Yes / No)	(Yes / No)	Yes	
	Note: The string insulator and each insulator size adequacy shall be determined by calculation.			
	String Insulator Accessories			
7.40	Manufacturer			
7.41	Place of manufacturing			
7.42	Material			
7.43	Applicable standard			
7.44	Rated ultimate tensile strength	kN		
	Post Insulators			
7.45	Manufacturer			
7.46	Place of manufacturing			
7.47	Type designation		Post type	
7.48	Applicable standard			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.49	One minute power frequency withstand Voltage (at IEC condition)	kV rms		
7.49.1	Dry		95	
7.49.2	Wet			
7.48	Basic Insulation level (at IEC condition)	kV peak	250	
7.49	Basic Insulation level (at site condition)	kV peak		
7.50	Switching impulse withstand voltage	kV peak	-	
7.51	Color			
7.52	Insulator material		Ceramic/Polymer	
7.53	Top metal fitting material			
7.54	Bottom metal fitting material			
7.55	Bonding material			
7.56	Minimum creepage distance	mm	1256	
7.57	Protected (90) creepage distance	mm		
7.58	Maximum cantilever working load (complete post insulator)	kN		
7.59	Minimum cantilever breaking load, upright (complete post insulator)	kN		
7.60	Minimum torsion strength	kNm		
7.61	Minimum compression strength	kN		
7.62	Total height	mm		
7.63	Arcing distance	mm		
7.64	Fixing bolts			
7.64.1	Quantity per post insulator			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.64.2	Diameter			
7.65	Bolt circle diameter (Top / Bottom)	mm		
7.66	Total weight	kg		
7.67	Maximum R.I.V. at 100 KHz	μv	500	
7.68	Whether washable in service? (Yes / No)			
7.69	Maximum weight of one package ready for Shipment	kg		
7.70	Whether corona ring at live side Provided? (Yes / No)		Yes	
7.71	Number of units in complete post insulator			
7.72	Length of each unit	mm		
	Note: The post insulator size adequacy shall be determined by calculation.			
	Connectors and Hardware			
7.73	Manufacturer			
7.74	Place of manufacturing			
7.75	Material of connectors			
7.76	Material of bolts and nuts			
7.77	Material of washers			
7.78	Applicable standard for connectors			
7.79	Type of contact paste			
	Minimum Clearances (Not applicable for equipment subject to impulse voltage tests)			
7.80	Height of base of post insulator from ground	mm	2500	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
7.81	Clearance between live parts and ground (Basic value)	mm	350	
7.82	Minimum height of energized parts above ground	mm	2850	
7.83	Height of energized parts above access roads	mm	7500	
33kV SURGE ARRESTERS				
General				
8.1	Manufacturer of surge arrester:			
8.1.1	Name			
8.1.2	Country			
8.2	Manufacturer of surge counter:			
8.2.1	Name			
8.2.2	Country			
8.3	Type designation for surge arresters			
8.4	Type designation for surge counter (equipped with leakage current measuring			
8.5	Applicable standard		IEC 60099-4	
8.6	Rated frequency	Hz	50	
8.7	Nominal line to line voltage rating	kV	36	
8.8	Type		MOA	
8.9	Class of surge arrester		Very Heavy	
8.10	Maximum and Minimum ambient temperature for design	°C	Acc. to section 1	
8.11	Altitude above sea level	m	Acc. to section 1	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
8.12	Design seismic acceleration	g	Acc. to section 1	
8.13	Ice thickness	mm	Acc. to section 1	
8.14	Wind velocity	m/s	Acc. to section 1	
8.15	Maximum overvoltage factor on the system due to any switching duty	pu	2.3	
8.16	Whether withstanding in load combinations of earthquake , wind , short circuit, as mentioned In Technical	(Yes / No)	Yes	
	Surge Arresters			
8.17	Rated voltage	kV rms	30	
8.18	Continuous operating voltage	kV rms	24	
8.19	Long duration discharge class as per IEC 99-1	Class	2	
8.20	Number of phases		3	
8.21	Type of system earthing		Effective	
8.22	Nominal discharge current with 8/20 us wave	kA peak	10	
8.23	Arrester designation		SL	
8.24	Type of housing in the case of utilizing porcelain and its classification acc to Std. 60672		Brown glazed Aluminum porcelain class C130	
8.25	Type of housing in the case of utilizing composite polymer and its resistance classification acc to IEC 60587		Silicon rubber (LSR,HCR or RTV type) class	
8.26	Earth fault factor		1.4	
8.27	Place of installation		Line/Transformer /GIS Feeders	
8.28	Pressure relief class			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
8.28.1	High current 0.2 sec	kA	50	
8.28.2	Low current 1 sec		600±200	
8.29	Thermal energy rating (Wth)	(kJ / kV) of U rated	> 10	
8.30	Repetitive charge transfer rating (Qrs)	C	> 2.4	
8.31	Reference voltage	kV rms		
8.32	Reference current	mA		
8.33	TOV capability for			
8.33.1	1 sec	kV	Acc. to IEC 60099-3	
8.33.2	10 sec	kV	Acc. to IEC 60099-3	
8.34	Continuous current under ambient temperature	mA		
8.35	Maximum residual voltage for lightning impulse current with 8/20 microsecond wave for following impulse peaks			
8.35.1	Switching surges-1kA/2kA	kV peak	Acc. to IEC 60099-3	
8.35.2	5 KA	kV peak	Acc. to IEC 60099-3	
8.35.3	10 KA	kV peak	Acc. to IEC 60099-3	
8.35.4	20 KA	kV peak	Acc. to IEC 60099-3	
8.36	Maximum residual voltage for switching impulse current with 30/60 microsecond wave for following impulse peaks			
8.36.1	500 A	kV peak	Acc. to IEC 60099-3	
8.36.2	1 KA	kV peak	Acc. to IEC 60099-3	
8.36.3	2 KA	kV peak	Acc. to IEC 60099-3	

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
8.37	Maximum residual voltage for steep current impulse with 1/20 microsecond wave and 10 KA peak	kV peak		
8.38	High current 4/10 microsecond impulse withstand level	kA peak	Acc. to IEC 60099-3	
8.39	Low current 2000 microsecond withstand level	kA peak	Acc. to IEC 60099-3	
8.40	Number of arrester units			
8.41	Rated voltage of each arrester unit	kV rms		
8.42	Number of parallel non linear MO resistance block		1	
8.43	Power frequency voltage versus time characteristics included?	(Yes/No)		
8.44	Maximum internal partial discharge	pC	Acc. to IEC 60099	
8.45	Manufacturer quality system in accordance with ISO 9000	Yes/No	Yes	
8.45.1	Date of issue		Latest	
8.45.2	Validity			
8.45.3	Certificate attached to the offer	Yes/No	Yes	
8.46	Type test certificate to be issued by independent laboratory or independently witnessed type test certificate to be	Yes/No	Yes	
8.46.1	Certificate to be attached to the offer	Yes/No	Yes	
8.46.2	Report to be attached to the offer	Yes/No	Yes	
	Miscellaneous			
8.47	Insulator			
8.47.1	Manufacturer			
8.47.2	Country			
8.47.3	Type			

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
8.47.4	Material			
8.48	Creepage distance of insulator	mm	1256	
8.49	Basic insulation level of insulator at site condition	kV peak	1.3*LIPL	
8.50	One minute power frequency withstand voltage of insulator at site condition	kV rms	1.06*SIWL/ $\sqrt{2}$	
8.51	Switching Impulse withstand voltage of insulator at site condition	kV peak	1.25*SIWL	
8.52	Filling medium			
8.53	Method used for sealing test			
8.54	Whether washable in service (Yes/ No)	(Yes/ No)	Yes	
8.55	Permissible force at MV terminals			
8.55.1	Static Horizontal	N		
8.55.2	Static Vertical	N		
8.55.3	Dynamic Horizontal	N		
8.55.4	Dynamic vertical	N		
8.56	Whether isolating pads for surge arresters with surge counter provided? (Yes/No)	(Yes/ No)	Yes, separated	
8.57	Non Linear MO resistor			
8.57.1	Manufacturer			
8.57.2	Country			
8.57.3	Type			
8.58	Dimension of each non-linear MO resistance block			
8.58.1	Diameter	mm		
8.58.2	Height	mm		

33 kV OPEN TERMINAL SWITCHGEAR		UNIT	DATA	
			REQUIRED	OFFERED
8.59	Total weight of single unit	kg		
8.60	Total weight of complete surge arrester	kg		
8.61	Total height of surge arrester	mm		
8.62	Total width of surge arrester	mm		
8.63	Whether grading ring for high voltage terminal required?	(Yes/No)	Yes	
8.64	Maximum Package weight ready for shipment	kg		

3. 132/33kV POWER TRANSFORMER (AIS-AIS)

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
1	Substation name		RUMURUTI/KABARN ET SUBSTATION	
2	Manufacture name & country		Should be Proposed By Tenderer	
3	Type designation		Should be Proposed By Tenderer	
4	Type of transformers		Two Windings	
4.1	Auto or separate windings		Separate	
4.2	Shell or core		Core	
4.3	Indoor or outdoor		Outdoor	
4.4	Three phases or single phases units		Three phase	
5	Type of cooling acc. to IEC			
5.1	First stage		ONAN	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
5.2	Second stage		ONAF	
5.3	Third stage		-	
6	Rated frequency	Hz	50	
7	Rated voltage			
7.1	HV	kVrms	132	
7.2	LV	kVrms	33	
8	Continuous power rating at principle tap			
8.1	Type		ONAN/ONAF	
8.2	Nominal power rating at site conditions	MVA	23	
8.3	At first stage of cooling:			
8.3.1	HV winding	MVA	18	
8.3.2	LV winding	MVA	18	
8.4	At second stage of cooling:			
8.4.1	HV winding	MVA	23	
8.4.2	LV winding	MVA	23	
9	Maximum temperature rise at rated power outputs corrected for altitude & ambient temperature of site			
9.1	Top oil	°C	56	
9.2	Winding	°C	61	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
9.3	Hottest spot	°C	74	
10	Off load tap changer		N.A	
10.1	Type		-----	
10.2	Manufacture		-----	
10.3	Rated current	Arms	-----	
10.4	Total range	%	-----	
10.5	Total number of steps		-----	
10.6	Variation per step	%	-----	
10.7	Position to tapings (winding)		-----	
11	On load tap changer			
11.1	Type		On-load	
11.1.1	Resistor/reactor		Resistor	
11.1.2	In tank/ out of tank		In Tank	
11.1.3	Vacuum or oil		Vacuum	
11.2	Manufacturer		MR	
11.3	Country of manufacturer		Should be Proposed By Tenderer	
11.4	Standards		IEC 60214	
11.5	Number of phases		3	
11.6	Arrangement of tapping (linear, coarse/fine, reversing)		Should be Proposed By Manufacturer	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
11.7	Rated current	Arms	Min (140)	
11.8	Rated step voltage	Vrms	Should be Proposed By Manufacturer	
11.9	Rated switching capacity	kVA	Should be Proposed By Manufacturer	
11.10.	Rated short circuit withstand current	kArms	Should be Proposed By Manufacturer	
11.11	Rated short circuit duration	sec	Should be Proposed By Manufacturer	
11.12	Total range	%	±13.36	
11.13	Total number of steps		±8(1.67%) steps	
11.14	Variation per step	V	2200	
11.15	Principle Tap Position		9	
11.16	Insulation level		Should be Proposed By Manufacturer	
11.16.1	Voltage class	kVrms	Should be Proposed By Manufacturer	
11.16.2	Highest voltage for equipment	kVrms	Should be Proposed By Manufacturer	
11.16.3	BIL to ground	kVpeak	Should be Proposed By Manufacturer	
11.16.4	BIL between diverter switch contacts	kVpeak	Should be Proposed By Manufacturer	
11.16.5	BIL across regulating winding	kVpeak	Should be Proposed By Manufacturer	
11.17	OLTC protection system		Should be Proposed By Manufacturer	
11.17.1	Is oil flow relay required? If so, type and manufacturer		Required	
11.17.2	Is pressure relief device required? If so, type and manufacturer		Required	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
11.17.3	Over pressure relay type and manufacturer		Should be Proposed By Manufacturer	
11.17.4	Other protection device type & manufacturer		Should be Proposed By Manufacturer	
11.18	Rated voltage of drive system	V	415/240	
11.19	Rated voltage of control circuit	V	110	
11.20.	All features, controls, alarms and interlocks as called for provide	Yes/No	Yes	
11.21	Whether remote control cubicle included in scope of work	Yes/No	Yes	
11.22	Whether AVR required?	Yes/No	Yes	
11.23	Type of AVR		Should be Proposed By Manufacturer	
11.24	Full description of remote OLTC control included	Yes/No	Yes	
11.25	Parallel operation control required for number of transformers		4	
11.26	Method of parallel control		Acc. to Specifications	
11.26.1	Master /follower			
11.26.2	Min circulating current			
11.26.3	Reverse reactance method			
11.27	Is line drop compensation required?	Yes/No	Yes	
11.28	Tap position output type		BCD/mA/Ohm/Contact	
12	Vector group		Dyn1 (Rumuruti)/ Dyn11(Kabarnet)	
13	Impedance			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
	On the base of rated power of main windings	MVA	23	
13.1	Positive sequence impedance at 75°C, on principal tapping and on:			
13.1.1	Between HV & LV winding	%	12	
13.1.2	Between HV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.1.3	Between LV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.2	Positive sequence impedance at 75°C, on max. raise voltage and on:			
13.2.1	Between HV & LV windings	%	Should be Filled By Manufacturer	
13.2.2	Between HV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.2.3	Between LV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.3	Positive sequence impedance at 75°C, on max. lower voltage and on:			
13.3.1	Between HV & LV windings	%	Should be Filled By Manufacturer	
13.3.2	Between HV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.3.3	Between LV & TV winding (if applicable)	%	Should be Filled By Manufacturer	
13.4	Zero sequence impedance at 75°C:			
13.4.1	Between HV & LV windings (LV open)	Ohm/ph.	Should be Filled By Manufacturer	
13.4.2	Between HV & LV windings (LV short)	Ohm/ph.	Should be Filled By Manufacturer	
13.4.3	Between LV & HV windings (HV open)	Ohm/ph.	Should be Filled By Manufacturer	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
13.4.4	Between LV & HV windings (HV short)	Ohm/ph.	Should be Filled By Manufacturer	
13.5	Resistance of windings at 75°C on principal tapping:			
13.5.1	HV	Ohm/ph.	Should be Filled By Manufacturer	
13.5.2	LV	Ohm/ph.	Should be Filled By Manufacturer	
13.6	Estimated winding capacitance's with:		Should be Filled By Manufacturer	
13.6.1	Series capacitance of HV phase winding	PF		
13.6.2	Series capacitance of LV phase winding	PF		
13.6.3	Shunt capacitance to earth of each HV phase winding with LV unearthed	PF		
13.6.4	Shunt capacitance to earth of each LV phase winding with HV unearthed	PF		
13.6.5	Capacitance of HV-LV phase winding with LV unearthed	PF		
14	Rated short circuit strength of windings (symmetrical values)		Should be Filled By Manufacturer	
14.1	HV system Indicate 1 and 3 phase	kA/kA	31.5	
14.2	LV system Indicate 1 and 3 phase	kA/kA	25	
14.3	Short circuit duration	sec	2	
14.4	Short circuit calculation will be submitted after award of contract	Yes/No	Yes	
15	Insulation levels			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
15.1	Lightning impulse withstand voltages:			
15.1.1	HV winding/bushing	kV _{peak} / kV _{peak}	750	
15.1.2	LV winding/bushing	kV _{peak} / kV _{peak}	250	
15.1.3	Neutral end winding/bushing	kV _{peak} / kV _{peak}	145	
15.2	Switching impulse withstand voltages:			
15.2.1	HV winding/bushing	kV _{peak} / kV _{peak}	N.A	
15.2.2	LV winding/bushing	kV _{peak} / kV _{peak}	N.A	
15.2.3	Neutral end winding/bushing	kV _{peak} / kV _{peak}	N.A	
15.3	One minute power frequency withstand voltages:			
15.3.1	HV winding/bushing	kV _{rms} / kV _{rms}	325	
15.3.2	LV winding/bushing	kV _{rms} / kV _{rms}	95	
15.3.3	Neutral end winding/bushing	kV _{rms} /	50	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data							
			REQUIRED				OFFERED			
		kVrms								
15.4	Partial discharge measurement:									
15.4.1	Standard		IEC 60270							
15.4.2	Test method		IVPD							
15.4.3	Long duration induced voltage	kVrms	Acc. to IEC 60076-3							
15.4.4	Enhancement voltage level	kVrms	Acc. to IEC 60076-3							
15.4.5	Maximum allowable partial discharge	pC	Acc. to IEC 60076-3							
16	Bushing data		HV	LV	TV	N	HV	LV	TV	N
16.1	Manufacturer & country									
16.2	Type (OIP/RIP/RBP/...)		OIP	OIP	-	OIP				
16.3	Rated service voltage	kV	132	33	-	24				
16.4	Nominal current rating	A	140	560	-	2000				
16.5	Rated short circuit current	kA	31.5	25	-	25				
16.6	Rated thermal short time current duration	sec	2	2	-	2				
16.7	Power frequency withstand voltage (complete with all fittings)	kV	315	95	-	50				
16.8	Radio influence voltage level measured at 1.1 rated system voltage at 1MHz	micro V	2500							
16.9	Is test tap required?	Yes/No	Yes	No	-	No				

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data							
			REQUIRED				OFFERED			
16.10.	Quantity of oil per bushing	liters	Acc. to Manufacturer Data	Acc. to Manufacturer Data	-	Acc. to Manufacturer Data				
16.11	Type of internal insulation (oil impregnated/resin type)		Oil Impregnated	Oil Impregnated	-	Acc. to Manufacturer Data				
16.12	Equipped with magnetic oil indicator (in case of oil type)	Yes/No	Yes	No	-	No				
16.13	Creepage distance	mm	4495	1116	-	>900				
16.14	Protected creepage distance	mm	Acc. to Manufacturer Data	Acc. to Manufacturer Data	-	Acc. to Manufacturer Data				
16.15	Loss angle (insulation power factor) at working Voltage		Acc. to Manufacturer Data	Acc. to Manufacturer Data	-	Acc. to Manufacturer Data				
16.16	Electrostatic capacity of complete bushing	PF	Acc. to Manufacturer	Acc. to Manufacturer	-	Acc. to Manufacturer Data				

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data							
			REQUIRED				OFFERED			
			Data a	Data a						
16.17	Cantilever load class (Acc to IEC 60137)		Level II	Level II	-	Level II				
16.18	Max. mechanical forces		Acc. to Bus work Calc.	Acc. to Bus work Calc.	-	Acc. to Bus work Calc.				
	Static, horizontal	N								
	Static, vertical	N								
	Dynamic, horizontal	N								
	Dynamic, vertical	N								
16.19	Min. corona inception voltage	kV								
16.20.	Washable in service	Yes/No	Yes	Yes	-	Yes				
16.21	Terminal leads full insulated at factory	Yes/No	Yes	Yes	-	Yes				
16.22	Bushing can be removed/ installed	Yes/No	Yes	Yes	-	Yes				
16.23	Bushing can be interchanged with spares	Yes/No	Yes	Yes	-	Yes				
16.24	Maximum external diameter of ring type current transformer which can be accommodated	mm	Acc. to Manufacturer Data	Acc. to Manufacturer Data	-	Acc. to Manufacturer Data				

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data							
			REQUIRED				OFFERED			
16.25	Minimum external diameter of ring type current transformer which can be accommodated	mm	Acc . to Ma nuf actu rer Dat a	Acc . to Ma nuf actu rer Dat a	-	Acc. to Man ufact urer Data				
17	Bushing type current transformer									
17.1	Fully complies with requirement	Yes/ No	Yes							
17.2	Number of cores (HV,LV,HV-N,LV-N,TV)		Acc to SLD							
17.3	Specification		Acc to SLD							
17.4	Ratio accuracy class and burdens will be selected acc to owner request during design review	Yes/ No	Yes							
17.5	Test conductor (winding) will be provided	Yes/ No	Yes							
18	Losses									
18.1	No load losses at 75 °C, rated frequency and rated voltage on principal tapping	kW	Max. 12 (Tolerance 0%)							
18.2	Load losses at rated frequency, 75 °C And rated current on principal tapping:	kW	(Tolerance 0%)							
18.2.1	At first stage of cooling		Should be Filled By Tenderer							
a	HV/LV	kW								
b	HV/TV (if applicable)	kW								

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
c	LV/TV (if applicable)	kW		
18.2.2	At second stage of cooling		Should be Filled By Tenderer	
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.2.3	At third stage of cooling			
a	HV/LV	kW	Max. 60 kW (RI2 Losses: 50 kW, Stray Losses: 10 kW)	
b	HV/TV (if applicable)	kW	Should be Filled By Tenderer	
c	LV/TV (if applicable)	kW	Should be Filled By Tenderer	
18.3	Load losses at 75 °C and max. raise Voltage tapping:		Should be Filled By Tenderer	
18.3.1	At first stage of cooling			
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.3.2	At second stage of cooling		Should be Filled By Tenderer	
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
18.3.3	At third stage of cooling		Should be Filled By Tenderer	
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.4	Load losses at 75 °C and max. lower voltage tapping:		Should be Filled By Tenderer	
18.4.1	At first stage of cooling			
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.4.2	At second stage of cooling			
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.4.3	At third stage of cooling			
a	HV/LV	kW		
b	HV/TV (if applicable)	kW		
c	LV/TV (if applicable)	kW		
18.5	Cooling plant losses at ONAF/OFAF rating	kW	Max. 2	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
19	Efficiency at winding temperature of 75 °C & PF=1			
19.1	At ONAN rating, full load, ¾ full load, ½ full load	%	9000	
19.2	At ONAF rating, full load, ¾ full load, ½ full load (ONAF1)	%	4000	
19.3	At OFAF rating, full load, ¾ full load, ½ full load (ONAF2)	%	Should be Filled By Tenderer	
19.4	No load losses capitalized value	US\$/KW	3000	
19.5	load losses capitalized value	US\$/KW	1080	
20	Cooling system data			
20.1	ONAF system		Should be Filled By Tenderer	
20.1.1	Number of coolers or cooler banks		Should be Filled By Tenderer	
20.1.2	Number of radiator units in each bank		Should be Filled By Tenderer	
20.1.3	Manufacturer and type of radiators		painted	
20.1.4	Number of fans		Should be Filled By Tenderer	
20.1.5	Make and type of fans		Should be Filled By Tenderer	
20.1.6	Capacity of each fan	kW	Should be Filled By Tenderer	
20.1.7	Rated operating voltage	Vrms	Should be Filled By Tenderer	
20.1.8	Three phase or single phase		Should be Filled By Tenderer	
20.1.9	Starting current of each	Arms	Should be Filled By Tenderer	
20.1.10	Efficiency of each fan	%	Should be Filled By Tenderer	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
20.2	OFAF system		Should be Filled By Tenderer	
20.2.1	Number of pumps		Should be Filled By Tenderer	
20.2.2	Manufacturer and type of pumps		Should be Filled By Tenderer	
20.2.3	Capacity of each pumps	HP	Should be Filled By Tenderer	
20.2.4	Rated operating voltage of pumps	Vrms	Should be Filled By Tenderer	
20.2.5	Three phase or single phase		Should be Filled By Tenderer	
20.2.6	Starting current of each	Arms	Should be Filled By Tenderer	
20.2.7	Efficiency of each pump	%	Should be Filled By Tenderer	
21	Capability of transformer to remain in operation from hot condition without Injurious heating at rated full load in case of failure of:		Should be Filled By Tenderer	
21.1	50% of air forced cooling	Minute		
21.2	100% of air forced cooling	Minute		
21.3	All of air and oil forced cooling	Minute		
21.4	Condition of injurious heating (hot spot temp.)	°C		
22	Exciting current		Should be Filled By Tenderer	
22.1	At rated voltage when excited from HV side	Arms		
22.2	At 110% rated voltage when excited from HV side	Arms		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
23	Core and winding data		Should be Filled By Tenderer	
23.1	Three limb/ five limb			
23.2	Type of core stacking		Step Lap	
23.3	Type of steel core lamination		Should be Filled By Tenderer	
23.4	Manufactures of steel core material			
23.5	Thickness of steel core lamination	mm	<0.3	
23.6	Flux density of core on principal tap			
23.6.1	At rated HV voltage	Wb/m2		
23.6.2	At 110% rated HV voltage	Wb/m2		
23.7	Main limb/yoke cross section	cm2/c m2		
23.8.	Types and arrangement of winding			
23.8.1	HV winding			
23.8.2	LV winding			
23.8.3	TV winding			
23.9	Winding arrangement			
23.10	Current density at rated power and voltage			
23.10.1	HV winding	A/m m2		
23.10.2	LV winding	A/m m2		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
23.10.3	TV winding	A/m m2		
23.10.4	Tap winding	A/m m2		
23.11	Insulation of core			
23.11.1	Lamination			
23.11.2	Core bolts			
23.11.3	Strapping			
23.12	Type of Insulation of winding (uniform/graded)			
23.12.1	HV		Graded	
23.12.2	LV		Uniform	
23.12.3	TV		Uniform	
23.13	Insulation material			
23.13.1	Turn insulation HV/LV			
23.13.2	Between windings HV/LV			
23.13.3	Between core and LV side			
23.13.4	Between laminations			
23.13.5	Core bolts			
23.13.6	Core bolts washers			
23.13.7	Side plates			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
23.13.8	Core lamination			
23.13.9	Tapping			
23.13.10	Tapping connections			
24	Calculated thermal time constant		Should be Filled By Tenderer	
24.1	Natural cooling	sec		
24.2	Forced cooling	sec		
25	Tank		Should be Filled By Tenderer	
25.1	Tank design conventional/bell shaped		Conventional	
25.2	Thickness of transformer plates:			
25.2.1	Cover of tank	mm		
25.2.2	Sides	mm		
25.2.3	Bottom	mm		
25.2.4	Conservator	mm		
25.2.5	Radiator plates	mm		
26	Vacuum withstand capability		Should be Filled By Tenderer	
26.1	Tank	mm Hg		
26.2	Radiators	mm Hg		
26.3	Conservator	mm Hg		
26.4	Positive pressure withstand capability for complete Transformer	mm Hg		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
27	Oil			
27.1	Manufacture		Shell	
27.2	Type designation		Diala S4 ZX-I	
27.3	Oil preservation system		Air-bag	
27.4	Country of manufacture			
27.5	Naphthenic or Paraphenic based oil		Naphthenic	
27.6	Type – inhibited/ trace inhibited/ non-inhibited		non-inhibited	
27.7	Details of inhibitor		By manufacturer	
27.8	Details of passivators		By manufacturer	
27.9	Viscosity at 40 °C (Acc. to ISO 3104)	mm2/s	Max. 12	
27.10	Viscosity at –30 °C (Acc. to ISO 3104)	mm2/s	Max. 1800	
27.11	Pour point (Acc. To ISO 3016)	°C	Max. -40	
27.12	Water content (Acc. To IEC 60814)	mg/kg	Max. 40 for delivery in drums (IBC)	
27.13	Breakdown voltage (Acc. To IEC 60156)			
27.13.1	As delivered	kV	Min. 30	
27.13.2	After laboratory treatment	kV	Min. 70	
27.14	Density at 20 °C (Acc. To ISO3675 or ISO12185)	g/ml	Max. 0.895	
27.15	DDF at 90 °C (Acc. To IEC 60247 / IEC 61620)		Max. 0.005	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
27.16	Appearance		Clear, free from sediment and suspended matter	
27.17	Acidity (Acc. To IEC 62021-1 / IEC 62021-2)	mg KOH/g	Max. 0.01	
27.18	Interfacial tension (Acc. To EN 14210/ASTM D971)	mN/m	Min. 40	
27.19	Total Sulphur content (Acc. To IP 373 / ISO 14596)	%	Max. 0.05	
27.20	Corrosive Sulphur (Acc. To DIN 51353)		Not corrosive	
27.21	Copper Corrosion (Acc. To IEC 62535)		Not corrosive	
27.22	Potentially corrosive Sulphur (Acc. To IEC 62535)		Not corrosive	
27.23	DBDS (Acc. To IEC 62697-1)	mg/k g	Not detectable (<5)	
27.24	Inhibitors of IEC 60666 (Acc. To IEC 60666)	%	(U) uninhibited oil (Max. 0.01)	
27.25	Metal passivator additives of IEC 60666	mg/k g	Max. 5	
27.26	2-Furfural and related compounds content (Acc. To IEC 61198)	mg/k g	Max. 0.05 (for each individual compound)	
27.27	Oxidation stability (Acc. To IEC 61125:1992 (Method C))			
27.27.1	Test duration (for uninhibited oil)	h	164	
27.27.2	Total acidity (Acc. To 1.9.4 of IEC 61125:1992)	mg KOH/g	Max. 1.2	
27.27.3	Sludge (Acc. To 1.9.1 of IEC 61125:1992)	%	Max. 0.80	
27.27.4	DDF at 90 °C (Acc. To 1.9.6 of IEC 61125, Amendment 1 (2004) +IEC 60247)		Max. 0.50	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
27.28	Flash point (Acc. To ISO 2719)	°C	Min. 135	
27.29	PCA content (Acc. To IP 346)	%	Max. 3	
27.30	PCB content (Acc. To IEC 61619)	mg/k g	Not detectable (Max. 2)	
27.31	Quantity of oil			
27.31.1	Main tank	Liters	By manufacturer	
27.31.2	Conservator	Liters	By manufacturer	
27.31.3	Radiator	Liters	By manufacturer	
27.32	Total oil required for commissioning	Liters	By manufacturer	
27.33	Total oil provided (including 5% extra)	Liters	By manufacturer	
27.34	Way of shipping		By drums	
27.35	Total number of drums provided		By manufacturer	
28	Maximum sound pressure level (NEMA TR1 – 5dB(A))	dB(A)	74	
29	Max. RIV at 1 MHz for complete transformer acc. to NEMA 107	Micro V	500	
30	Applicable standard for overload capacity of transformer with cooling system in operation		IEC 60076-3	
31	Vibration at rated frequency, voltage and 75 °C	Micro n	<=100	
32	Physical data		Should be Filled By Tenderer	
32.1	Overall height, including bushings	mm		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
32.2	Overall width, including mounted accessories	mm		
32.3	Overall length, including mounted accessories	mm		
32.4	Height over cover for lifting core and coils	mm		
32.5	Dimensions of transformer arranged for transport			
32.6	Length	m		
32.7	Height	m		
32.8	Width	m		
32.9	Weight of oil	kg		
32.10.	Weight of on load tap changer	kg		
32.11	Total weight of core and coils	kg		
32.12	Total weight of tank/cooler and fittings	kg		
32.13	Total weight of windings	kg		
32.14	Total weight of core (steel lamination)	kg		
32.15	Total weight steel (tank, fittings, conservator, etc)	kg		
32.16	Total weight of complete transformer	kg		
32.17	Max. shipping weight (heaviest item)	kg		
33	Provisions for tank mounting lightning arresters			
33.1	HV	Yes/ No	No	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
33.2	LV	Yes/ No	No	
33.3	TV	Yes/ No	No	
33.3.1	Type			
33.3.2	Type designation			
33.3.3	Standard			
33.3.4	Rated/system voltage	kV		
33.3.5	Maximum overvoltage factor on the system due to any switching duty	pu		
33.3.6	Rated system frequency	Hz		
33.3.7	Condition of system neutral			
33.3.8	Nominal Discharge current	kAcrest		
33.3.9	Energy capability as per IEC 60099-4	kJ/kV		
33.3.10	Rated Voltage – MOA	kV		
33.3.11	Long duration discharge class as per IEC 99-1	Class		
33.3.12	Maximum Continuous Operating Voltage (COV)	kV		
33.3.13	TOV capability for			
	1sec	kV		
	10sec	kV		
33.3.14	Maximum residual voltage with current wave			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
	Switching Surges – 1kA/2kA	kV		
	8/20 μs – 5kA	kV		
	8/20 μs – 20kA	kV		
33.3.1	Discharge current withstand strength			
5	High current 4/10 μs	KAp		
	Low current 2000 μs	KAp		
34	Anti-vibrations pads	Yes/No	Yes	
35	Radiators mounted separate	Yes/No	No	
36	Wheels	Yes/No	Acc. to Project Requirements	
36.1	Plain/ Flanged		Plain	
36.2	Unidirectional/ bi-directional		bi-directional (If Needed)	
36.3	Gauge	mm		
37	All accessories supplied as specified	Yes/No	Yes	
38	All drawings and documents enclosed	Yes/No	Yes	
39	Schedule of deviations filled	Yes/No		
40	Fire protection scheme	Yes/No	Acc. to Project Requirements	
41	All additional equipment specified provided	Yes/No	Yes	
42	Accessories make and type			
42.1	Buchholz relay with sampling device			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
42.1.1	For conservator main compartment		Yes	
42.1.2	For conservator OLTC		Yes	
42.2	Pressure relief Relay		Yes	
42.3	Oil level indicator:			
42.3.1	For conservator main compartment		Yes	
42.3.2	For conservator OLTC		Yes	
42.4	Temperature indicators:			
42.4.1	Oil		Yes	
42.4.2	HV winding		Yes	
42.4.3	LV winding		Yes	
42.4.4	TV winding		Yes	
42.5	Conservator type:			
42.5.1	Normal/air bag (diaphragm)		Air bag	
42.5.2	Air detector relay (for air bag)	Yes/ No	Yes	
42.6	breather		Maintenance free type	
42.7	Cables		By Contractor	
42.8	Control cabinets		By Contractor	
42.9	Fire extinguishing system:		Acc. to Project Requirements	
42.9.1	Drainage and mixing			

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
42.9.2	Water sprinkler system			
42.9.3	Whether full information are attached	Yes/ No	Should be confirmed by Tenderer	
42.10	Whether all catalogues of accessories are enclosed	Yes/ No	Should be confirmed by Tenderer	
43	Fault currents and mechanical forces and stresses.		Should be Filled by Tenderer	
43.1	Max. fault current in windings on which mechanical stresses are based.			
43.1.1	HV winding			
a	Symmetrical component current	Arms		
b	Asymmetrical crest current	Amp Peak		
43.1.2	LV winding			
a	Symmetrical component current	Arms		
b	Asymmetrical crest current	Amp Peak		
43.1.3	Tapped winding			
a	Symmetrical component current	Arms		
b	Asymmetrical crest current	Amp Peak		
43.2	Max. fault current on which mechanical stresses are based for OLTC (main+arcing contacts):			
43.2.1	Symmetrical short circuit current	kArms		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
43.2.2	Dynamic short circuit current value			
43.2.2	Asymmetrical crest current	Ampc rest		
43.3	Max. fault current on which mechanical stresses are based for leads to OLTC are:			
43.3.1	Symmetrical short circuit current	Arms		
43.3.2	Asymmetrical crest current	Ampc rest		
43.4	Max. fault current on which mechanical Stresses are based for various bushings of:			
43.4.1	HV side	kArms		
43.4.2	LV side	kArms		
43.4.3	Neutral HV/LV	kArms		
43.5	Current density in windings on principal tapping under the most onerous fault condition			
43.5.1	HV winding	A/m m2		
43.5.2	LV winding	A/m m2		
43.5.3	Tapped windings	A/m m2		
43.5.4	Tapping connections lead	A/m m2		
43.5.5	Neutral	A/m m2		
43.5.6	HV bushings	A/m m2		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
43.5.7	LV bushings	A/m m2		
43.5.8	Neutral bushings	A/m m2		
43.6	Hoop stress in winding conductors:			
43.6.1	HV winding	N/m2		
43.6.2	LV winding	N/m2		
43.6.3	Tapping	N/m2		
43.7	Total axial compressive force in windings:			
43.7.1	HV winding	N		
43.7.2	LV winding	N		
43.7.3	Tapped winding	N		
43.7.4	Tertiary winding	N		
43.8	Max. stress to flexion of conductor between two adjacent spacers:			
43.8.1	HV winding	N/m2		
43.8.2	LV winding	N/m2		
43.8.3	Tapping	N/m2		
43.9	Total axial and thrust in windings:			
43.9.1	HV winding	N		
43.9.2	LV winding	N		
43.9.3	Tapping	N		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
43.10.	Max. stresses in end insulation and supports:			
43.10.1	HV winding	N/m2		
43.10.2	LV winding	N/m2		
43.10.3	Tapped winding	N/m2		
43.11	Relative axial displacement at the windings assumed in items 43.9, 43.10 Above			
43.12	Cross sectional area of conductor for each windings:	%		
43.12.1	HV winding	mm2		
43.12.2	LV winding	mm2		
43.12.3	Tapped winding	mm2		
43.13	Cross section area of insulation for:			
43.13.1	HV winding	mm2		
43.13.2	LV winding	mm2		
43.13.3	Tapped winding	mm2		
43.14	Specific heat in watt-seconds per degree Celsius per pound of conductor Material for:			
43.14.1	HV winding	mm2		
43.14.2	LV winding	mm2		
43.14.3	Tapped winding	mm2		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
43.15	Position and magnitude of max. axial stress on inter turn insulation in:			
43.15.1	HV winding	N/m2		
43.15.2	LV winding	N/m2		
43.15.3	Tapped winding	N/m2		
44	On-line gas monitoring		Should be Filled by Tenderer	
44.1	Manufacturer			
44.2	Country of manufacturer			
44.3	Model/Type			
44.4	Detectable key gases			
44.5	Moisture detection	Yes/No	Yes	
44.6	Lower detection limit (LDL)	ppm	Should be confirmed by Tenderer	
44.7	Accuracy of sensor	%	Should be confirmed by Tenderer	
44.8	Response time	Minute	Should be confirmed by Tenderer	
44.9	Operating range			
44.9.1	Operating temperature	°C		
44.9.2	Operating oil temperature	°C		
44.9.3	Operating oil pressure	PSI		
44.9.4	Operating humidity	% RH		
44.9.5	Storage temperature	°C		

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
44.9.6	Storage humidity	% RH		
44.9.7	Altitude	m		
44.10	Input power requirement			
44.10.1	Voltage	V AC		
44.10.2	Frequency	Hz		
44.10.3	Current or power	A or kW		
44.11	Communication option			
44.11.1	Display			
44.11.2	Communication protocols			
44.11.3	Communication ports and analog I/O			
44.11.4	Measurement alarms			
44.11.5	Alarm contacts			
44.11.6	Data storage	Year		
44.12	Software			
44.13	Dimensions			
44.14	Weight	kg		
44.15	Whether all catalogues and description of the system attached	Yes/ No		
45	Minimum Clearances (IEC 60076-3)- (Should be according to Altitude of Substation)		Should be confirmed by Tenderer	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
45.1	Line to earth			
45.1.1	HV side	mm	1300	
45.1.2	LV side	mm	320	
45.2	Phase to phase			
45.2.1	HV side	mm	1500	
45.2.2	LV side	mm	320	
45	System Grounding			
45.1	HV system		Non-Effective	
45.2	LV system		Effective	
45.3	TV system		N.A.	
45	Winding and oil temp. (Dial type or temp. monitoring)		Dial type	
46	Size of copper ground conductor		240	
47	Type of terminals			
	HV		Air bushing	
	LV		Air bushing	
	TV		N.A.	
	Neutral		Air bushing	
48	Pre-stressed non-return valve (PNRV)	Yes/No	Yes	
49	Buchholz relay test pump	Yes/No	Yes	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
50	Color of exterior/finishing paint		Will be Finalized During Detail Design	
51	Manufacturer quality assurance		Yes	
52	According to ISO 9000, 9001, 9002, 9003 and 9004	Valid ity	Yes	
52.1	Certificate attached to the offer	Yes/ No	Yes	
52.2	Type test certificate to be issued by:		Yes	
53	Independent laboratory or independently witnessed type test certificate	Yes/ No		
53.1	Certificate attached to the offer	Yes/ No	Yes	
53.2	Special Tests to be performed: As Type test = T As Routine test = R		Yes	
54	Chopped Wave Lightning Impulse Test (*)Type or routine test as appropriate to transformer HV Um		Yes (*)	
54.1	Measurement of zero-sequence impedance		Yes (T)	
54.2	Determination of sound levels		Yes (T)	
54.3	Measurement of harmonics of no-load current		Yes (T)	
54.4	Frequency response analysis (FRA)		Yes (R)	
54.5	Measurement of the power by the fan motors and oil pumps		Yes (T)	
54.6	Check of external coating		Yes (R)	

132/33KV POWER TRANSFORMERS (AIS-AIS)		UNIT	Data	
			REQUIRED	OFFERED
54.7	Determination of capacitance, windings to earth and between windings		Yes (R)	
54.8	Measurement of insulation resistance to earth and loss angle of insulation system capacitances		Yes (R)	
54.9	Short circuit withstand test/calculations		Yes (Calculation)	
54.10	Wheel locking capability on Transformer rails	Yes/ No	Yes	

4. 33/0.415kV AUXILIARY TRANSFORMER

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
1	System performance data			
1.1	Nominal power rating at site conditions	KVA	250 and 315	
1.2	Nominal service voltage	kVrms	33/0.415kV	
1.3	Max. system voltage	kVrms	36	
1.4	System earthing		Solid	
1.5	Rated frequency	Hz	50	
1.6	3-Phase short circuit			
1.6.1	Rated value	kArms	25	
1.6.2	Dynamic value	kApeak	63	
1.7	Max radio interference level measured at 1.1 rated system voltage at 1 MHz	microV	By Manufacturer	
1.8	Station service aux. AC supply			
1.8.1	Rated voltage	V	415/240	
1.8.2	Voltage variation	%	±10%	
1.8.3	Phase		3 (4 wires)	
1.8.4	Frequency	Hz	50	
1.8.5	Neutral earthing		Solid	

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
1.9	Station service aux. DC supply			
1.9.1	Rated voltage	V	110	
2	Auxiliary transformer specifications			
2.1	Number of transformers		2	
2.2	Manufacturer, type designation and country		Should be Filled By Tenderer	
2.3	Type			
2.3.1	Indoor/Outdoor		Outdoor	
2.3.2	Stationary/Mobile		Stationary	
2.4	Rated capacity of secondary winding at site conditions	kVA	250 (Kabarnet) & 315 (Rumuruti)	
2.5	Type of cooling		ONAN	
2.6	Vector group		Dyn11/ Dyn11	
2.7	Impedance voltage between HV and LV windings at 75 °C	%	4.5	
2.8	Rated voltage of windings	kVrms	33	
2.9	Highest system voltages	kVrms	36	
2.10	Rated frequency	Hz	50	
2.11	Insulation levels			
2.11.1	Windings (HV/LV)			
2.11.1.1	Rated voltage	kVrms	33/0.415	
2.11.1.2	Highest voltage for equipment	kVrms	36/1	
2.11.1.3	Rated one min. power frequency withstand voltage	kVrms	95/3	
2.11.1.4	Rated lightning impulse withstand voltage	kVpeak	250/N.A	
2.11.2	Bushings (HV/LV)			
2.11.2.1	Rated voltage	kVrms	33/0.415	
2.11.2.2	Highest voltage for equipment	kVrms	36/1	
2.11.2.3	Rated one min. power frequency withstand voltage	kVrms	140/10	
2.11.2.4	Rated lightning impulse withstand voltage	kVpeak	325/20	
2.12	Tap changer			

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.12.1	Whether manual off circuit tap changer is required	Yes/No	Yes	
2.12.2	Type (Onload - Off load)		Off load	
2.12.3	Manufacturer & country			
2.12.4	Total range(number of steps)		$\pm 2 \times 2.5\%$	
2.12.5	Location		HV-N	
2.12.6	Rated current	A	5 (Min)	
2.13	Losses			
2.13.1	No load losses at 75 °C, rated frequency and rated voltage on principal tapping	kW	Max. 0.75	
2.13.2	Load losses at rated frequency, 75°C And rated current on principal tapping	kW	Max. 3.5	
2.13.3	Evaluation rate of no load loss at Tendering stage	\$/kW	9000	
2.13.4	Evaluation rate of load loss & cooling loss at Tendering stage	\$/kW	4000	
2.14	Exciting current			
2.14.1	At rated voltage	A	By manufacturer	
2.14.2	At 110% rated voltage	A	By manufacturer	
2.15	Temperature rise (corrected for altitude, ambient condition and IEC 60076-2)			
2.15.1	Top oil	°C	57	
2.15.2	Winding	°C	62	
2.15.3	Hot Spot	°C	75	
2.16	Max. sound level (acc. to IEC 60076-10)	dB	50	
2.17	Vacuum withstand capacity of total transformer	mmHg	Acc. To Technical Specification	
2.19	Core and winding data			
2.19.1	Manufacturer of steel core material			

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.19.2	Type of steel core lamination		By manufacturer	
2.19.3	Flux density of core			
2.19.3.1	At rated voltage	Wb/m ²	1.727	
2.19.3.2	As above at 110% rated voltage	Wb/m ²	1.9	
2.19.4	Thickness of steel core lamination	mm	≤0.3	
2.19.5	Main limb/yoke cross section	cm ²	By manufacturer	
2.19.6	Current density at rated power and voltage			
2.19.6.1	HV winding	A/mm ²	By manufacturer	
2.19.6.2	LV winding	A/mm ²	By manufacturer	
2.19.7	Current density at rated short circuit current			
2.19.7.1	HV winding	A/mm ²	By manufacturer	
2.19.7.2	LV winding	A/mm ²	By manufacturer	
2.20	Thickness of transformer plates			
2.20.1	Tank	mm	By manufacturer	
2.20.2	Sides	mm	By manufacturer	
2.20.3	Bottom	mm	By manufacturer	
2.20.4	Radiator plates	mm	By manufacturer	
2.21	Bushings (HV/LV)			
2.21.1	Manufacturer & country			
2.21.2	External creepage distance	mm	min (1116)	
2.21.3	Protected creepage distance	mm	By manufacturer	
2.21.4	Rated normal	A	5/420	
2.21.5	Short circuit current (HV)	kA	25	
2.21.6	Test tap required	Yes/No	No	

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.21.7	Rated normal/short circuit current for neutral	(A/kA)		
2.21.4	Bushing type current transformers (Required)	Yes/No	Yes	
2.21.4.1	No of cores (HV,HVN,LV,LVN)		According to SLD	
2.21.4.2	Specifications		According to SLD	
2.22	Type of terminals			
2.22.1	HV		Air bushing	
2.22.2	LV		Cable Box	
2.22.3	HV-N		Air bushing	
2.22.4	LV-N		Cable Box	
2.22.5	Filling medium for cable box		Air	
2.23	Overall Dimensions (H*W*L)	mm*mm*mm		
2.24	Weights			
2.24.1	Core and coils	kg	By manufacturer	
2.24.2	Tank and fittings	kg	By manufacturer	
2.24.3	Weight of oil	kg	By manufacturer	
2.24.4	Total Weight of complete transformer	kg	By manufacturer	
2.25	Regulation at full load and 75°C winding temperature			
2.25.1	a) Unity Power Factor		By manufacturer	
2.25.2	b) 0.8 PF lag		By manufacturer	
2.26	Efficiency (at P.F.=1)			
2.26.1	At full load	%	By manufacturer	
2.26.2	At 3/4 full load	%	By manufacturer	
2.26.3	At 1/2 full load	%	By manufacturer	
2.26.3	Max. and the load at which it occurs	%	By manufacturer	

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.27	Oil			
2.27.1	Manufacture			
2.27.2	Country of manufacture			
2.27.3	Naphthenic or Paraphenic based oil		Naphthenic	
2.27.4	Type – inhibited/ trace inhibited/ non-inhibited		non-inhibited	
2.27.5	Details of inhibitor			
2.27.6	Details of passivators			
2.27.7	Viscosity at 40 °C (Acc. to ISO 3104)	mm ² /s	Max. 12	
2.27.8	Viscosity at –30 °C (Acc. to ISO 3104)	mm ² /s	Max. 1800	
2.27.9	Pour point (Acc. To ISO 3016)	°C	Max. -40	
2.27.10	Water content (Acc. To IEC 60814)	mg/kg	Max. 40	
2.27.11	Breakdown voltage (Acc. To IEC 60156)			
2.27.11.1	As delivered	kV	Min. 30	
2.27.11.2	After laboratory treatment	kV	Min. 70	
2.27.12	Density at 20 °C (Acc. To ISO3675 or ISO12185)	g/ml	Max. 0.895	
2.27.13	DDF at 90 °C (Acc. To IEC 60247 / IEC 61620)		Max. 0.005	
2.27.14	Appearance		Clear, free from sediment and suspended matter	
2.27.15	Acidity (Acc. To IEC 62021-1 / IEC 62021-2)	mg KOH/g	Max. 0.01	
2.27.16	Interfacial tension (Acc. To EN 14210/ASTM D971)	mN/m	Min. 40	
2.27.17	Total Sulphur content (Acc. To IP 373 / ISO 14596)	%	Max. 0.05	
2.27.18	Corrosive Sulphur (Acc. To DIN 51353)		Not corrosive	
2.27.19	Copper Corrosion (Acc. To IEC 62535)		Not corrosive	

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.27.20	Potentially corrosive Sulphur (Acc. To IEC 62535)		Not corrosive	
2.27.21	DBDS (Acc. To IEC 62697-1)	mg/kg	Not detectable (<5)	
2.27.22	Inhibitors of IEC 60666 (Acc. To IEC 60666)	%	(U) uninhibited oil (Max. 0.01)	
2.27.23	Metal passivator additives of IEC 60666	mg/kg	Max. 5	
2.27.24	2-Furfural and related compounds content (Acc. To IEC 61198)	mg/kg	Max. 0.05 (for each individual compound)	
2.27.25	Oxidation stability (Acc. To IEC 61125:1992 (Method C))			
2.27.25.1	Test duration (for uninhibited oil)	h	164	
2.27.25.2	Total acidity (Acc. To 1.9.4 of IEC 61125:1992)	mg KOH/g	Max. 1.2	
2.27.25.3	Sludge (Acc. To 1.9.1 of IEC 61125:1992)	%	Max. 0.8	
2.27.25.4	DDF at 90 °C (Acc. To 1.9.6 of IEC 61125, Amendment 1 (2004) +IEC 60247)		Max. 0.5	
2.27.26	Flash point (Acc. To ISO 2719)	°C	Min. 135	
2.27.27	PCA content (Acc. To IP 346)	%	Max. 3	
2.27.28	PCB content (Acc. To IEC 61619)	mg/kg	Not detectable (Max. 2)	
2.27.29	Quantity of oil			
2.27.29.1	Main tank	Liters		
2.27.29.2	Conservator	Liters		
2.27.29.3	Radiator	Liters		
2.27.31	Total oil required for commissioning	Liters		
2.27.32	Total oil provided (including 5% extra)	Liters		
2.27.33	Way of shipping		By drums	
2.27.34	Total number of drums provided			

33/0.415kV AUXILIARY TRANSFORMER		UNIT	DATA	
ITEM	DESCRIPTION		ITEM	DESCRIPTION
2.28	Accessories make, type and country			
2.28.1	Buchholz relay		Yes	
2.28.2	Pressure relief device		Yes	
2.28.3	Silicagel breather		Yes	
2.28.4	Control Cabinet		Yes	
2.28.5	Cables		Yes	
2.28.6	Oil level gauge		Yes	
2.8.7	Winding temperature indicator		Yes	
2.28.8	Oil temperature indicator		Yes	
2.29	Whether wheels are required	Yes/No	No	
2.30	Whether switch-fuse unit is required	Yes/No	No	
2.31	Type of conservator (Air bag/ Conventional)		Conventional	
2.32	Max. vibration (at rated condition) P-P	Micron	50	

5. EARTHING AND LIGHTNING PROTECTION

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
1	EARTHING SYSTEM			
1.1	General			
1.1.1	Manufacturers			
1.1.2.	Standard Applied The following standards shall apply to the earthing installations and to the accessories:			
	– Guide for safety in A.C. substation grounding		IEEE80 & 81	
	– Earthing system in A.C. installation for rated voltages above 1000 V		VDE 0141	
1.1.3	Design ground fault current	kA rms	31.5	
1.1.4	Time duration of ground fault	sec	3	

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
1.1.5	Fault clearing time	sec	0.6	
1.1.6	Maximum Resistance of Earthing/Grounding System	Ohm	1 1 1	
1.1.7	Step length	m		
1.1.8	Body resistance	Ohm		
1.1.9	Maximum touch voltage	V		
1.1.10	Maximum step voltage	V		
1.1.11	Tolerable touch voltage	V		
1.1.12	Tolerable step voltage	V		
1.1.13	Maximum ground potential rise	kV	5	
1.1.14	Maximum allowable temperature for riser	°C	250	
1.1.15	Maximum allowable temperature for mesh grid	°C	450	
1.1.16.	Physical Properties of Copper			
	The most important physical properties of copper used for the earthing conductors:			
	– Density	kg/dm ³	8.89	
	– Electrical resistivity at 20°C	Ωmm ² /m	0.0176	
	– Melting point	°C	1083	
	– Current density at which the conductor temperature rises from 50°C to 300°C in a time of 1 s if all heat is retained in conductor	A/mm ²	190	
1.1.17.	Physical Properties of Lead-Sheathed Copper			
	The most important physical properties of lead-sheathed copper used for the earth electrodes:			
	– Thickness of lead sheath	mm	2.0	
	– Electrical resistivity of copper at 20°C	Ωmm ² /m	0.0176	
	– Copper melting point	°C	1083	
	– Lead melting point	°C	327	
	– Current density at which the conductor temperature rises from 40°C to 150°C in a time of 1 s if all heat is retained in conductor	A/mm ²	140	

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
1.2	Ground Grid and Risers			
1.2.1	Ground grid conductor			
	– Type			
	– Material		Stranded soft drawn annealed copper	
	– Minimum cross-section area to be confirmed by acceptance calculation	mm ²	min 150 /after acceptance of calculation	
	– Number of wires	No.		
	– Diameter of each wire	mm		
	– Conductor diameter	mm		
	– Density	kg/m		
1.2.2	Riser conductor			
	– Type			
	– Material		Stranded soft drawn annealed copper	
	– Minimum cross-section area to be confirmed by acceptance calculation	mm ²	after acceptance of calculation	
	– Number of wires	No.		
	– Diameter of each wire	mm		
	– Conductor diameter	mm		
	– Density	kg/m		
1.2.3	Connections			
	Mode of Connection in the Earthing Systems:			
	– Between earthing conductors and earth electrodes		Brazed	
	– Crossing of earth electrodes		Compression	
	– Type of connection of risers to steel structures		bolt and two hole cable lug	

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
1.2.4	Manufacturer of ground grid and risers conductor			
	Name			
	Country			
1.2.5	Ground resistivity	ohm.m	will be declared later	
1.2.6	Surface gravel resistivity	ohm.m	3000	
1.2.7	Minimum surface gravel height	cm	15	
1.2.8	Minimum depth of ground grid burial	cm	50	
1.3	Grounding Accessories			
1.3.1.	Earth Electrodes			
1.3.1.1.	Lead-sheathed stranded copper conductors			
	The following lead-sheathed stranded copper conductor will be used as earth electrodes:			
	– Thickness of lead sheath	mm		
	– Copper cross-section area	mm ²		
	– Number of wires	pcs		
	– Diameter of each wire	mm		
	– Conductor diameter	mm		
	– Density	kg/m		
1.3.1.2.	Earth rod			
	– Manufacturer			
	– Length	m	min(3)	
	– Diameter	mm	min(16)	
	– Material (copper, stainless steel)			
1.3.1.3.	Stainless steel electrodes			
	The following steel flat bars will be used as earth electrodes:			
	– Cross-section area	mm ²		
	– Dimensions	mm x mm		

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
	– Density	kg/m		
1.3.2	Equipment mat			
	Material			
	Size			
1.3.3	Manufacturer of moulds			
3.4	Type and size of cable connectors and cable lugs			
1.4	Miscellaneous			
1.4.1	Minimum estimated length of ground grid (without risers)	m	As per layout	
1.4.2	Minimum estimated quantity of rods inside substation			
1.4.3	Minimum estimated quantity of rods located at primeters of substation			
1.4.4	Is required one set of portable temporary earthing equipment?	Yes/No	Yes	
1.4.5	Temporary grounding device			
	Type			
	Material			
	Short time current (3 sec)	kA peak		
	Length of insulated stick			
	Type of insulated stick			
2.	LIGHTNING PROTECTION			
2.1.	Manufacturers			
2.2.	Standard Applied:			
	– Protection of structures against lightning		IEC 62305	
2.3.	Cross-section area	mm ²		
2.4.	Thickness of lead-sheath	mm		
2.5.	Supports			
	Conductor supports of the lightning protection system			
	– Type			

f) EARTHING AND LIGHTNING PROTECTION		UNIT	DATA	
			Required	Offered
2.6.	Earth rod			
	– Manufacturer			
	– Length	m		
	– Diameter	mm		
	– Material (copper, stainless steel)			
3.	Type test certificate (to be issued by independent laboratory or independently witnessed type test certificate available), to be attached to the offer	Yes/No	Yes	

6. TRANSFORMER ONLINE CONDITIONING MONITORING SYSTEM

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
1.	GENERAL			
1.1	Manufacturer			
1.2	Type			
2.	FIELD MODULE			
2.1	Sampling rate	ms		
2.2	Data resolution	ms	1	
2.3	Auxiliary voltage range (Vn = 110Vdc)	Vdc	88→150	
2.4	Protection degree of panel/box	IP	55	
2.5	Range of operating temperature	°C		
2.6	Communication			
2.6.1	Local interface for PC/Laptop connection		Yes	
	- Communication ports (Front/rear etc.)			

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
	- Physical links (RS232/Ethernet etc.)			
2.6.2	Remote Control and Monitoring			
	- Communication ports (Front/rear etc.)		Rear	
	- Physical links (RS485/Fibre optic etc.)		Fibre optic	
	- Protocol		IEC 61850	
2.6.3	Centralized HMI PC for analysis, evaluation and diagnostic			
	- Communication ports (Front/rear etc.)			
	- Physical links (RS485/Fibre optic etc.)		Fibre Optic	
	- Protocol			
3.	CENTRALIZED HMI PC FOR ANALYSIS, EVALUATION AND DIAGNOSTIC			
3.1	Manufacturer			
3.2	Model			
3.3	Processor			
	- Type			
	- Word length	Bits		
	- Clock speed (minimum)	GHz	3	
3.4	Memory size	GB	6	
	- Supplied (minimum)	Mb		
	- Supportable/expandable	Gb		
3.5	Hard disk size	GB		

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
	– Supplied (minimum)	Gb		
	– Supportable/expandable	Gb		
3.6	Optical Storage	Yes/No	Yes	
3.7	Pointer Device			
3.8	Operating system			
3.9	Operator interface screen	inch	24	
3.10	Operating temperature range	°C		
3.11	Maximum relative humidity	%		
3.12	Nominal voltage	Vac		
3.13	Operating frequency	Hz		
3.14	Power requirement	W		
4.	MINIMUM QUANTITIES TO BE MEASURED			
	- Oil temperature	Yes/No	Yes	
	- Hot-spot-temperature	Yes/No	Yes	
	- Moisture-in-oil content	Yes/No	Yes	
	- Gas-in-oil content and gas consistency	Yes/No	Yes	
	- Gas quantity and rate in Buchholz relay	Yes/No	Yes	
	- Oil pressure	Yes/No	Yes	
	- Oil level	Yes/No	Yes	
	- Winding temperature	Yes/No	Yes	
	- Humidity of air in conservator	Yes/No	Yes	

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
	- Actual losses	Yes/No	Yes	
	- Overload capacity	Yes/No	Yes	
	- Emergency overloading time	Yes/No	Yes	
	- Partial discharge	Yes/No	Yes	
	- Ambient air temperature	Yes/No	Yes	
	- Ambient air humidity	Yes/No	Yes	
	- Ambient air pressure	Yes/No	Yes	
	- Load currents of bushings	Yes/No	Yes	
	- Overcurrents of bushings	Yes/No	Yes	
	- Operating voltages of bushings	Yes/No	Yes	
	- Overvoltages of bushings	Yes/No	Yes	
	- Bushing capacitance and capacitive displacement currents	Yes/No	Yes	
	- Tap changer position and number of switching operations	Yes/No	Yes	
	- Sum of switched load current tap changer	Yes/No	Yes	
	- Power consumption of motor-drive	Yes/No	Yes	
	- Contact wear	Yes/No	Yes	
	- Operating conditions and operating time of fans	Yes/No	Yes	
	- Cooling efficiency and power	Yes/No	Yes	
	- Intake and outlet cooling equipment temperatures	Yes/No	Yes	
5.	TYPE TESTS			

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
5.1	Atmospheric Environment			
	– Operation -25°C and 55°C for 96hrs, IEC 60068-2-1	Yes/No	Yes	
	– Transport/storage -25°C and 70°C for 96hrs, IEC 60068-2-2	Yes/No	Yes	
5.2	Relative Humidity			
	– Operation at 93%	Yes/No	Yes	
	– Tested to IEC 60068-2-3 with severity class 56 days	Yes/No	Yes	
5.3	Enclosure			
	– IEC 60529		IP50	
5.4	Mechanical Environment			
	– Vibration IEC 60255-21-1	Yes/No	Yes	
	– Shock and bump IEC 60255-21-2	Yes/No	Yes	
	– Seismic IEC 60255-21-3	Yes/No	Yes	
5.5	Insulation			
	– Rated insulation			
	1000V high impedance protection CT inputs	Yes/No	Yes	
	250V for other circuits	Yes/No	Yes	
	1000V open contact withstand	Yes/No	Yes	
	– Dielectric Tests IEC 60255-5 Series C of table 1	Yes/No	Yes	
	– Impulse voltage IEC 60255-5 test voltage 5kV	Yes/No	Yes	
5.6	Electromagnetic compatibility			
	– 1MHz Burst disturbance test, IEC 60255-22-1 severity class III	Yes/No	Yes	

g) TRANSFORMER ONLINE CONDITION MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
	– Electrostatic Discharge IEC 60255-22-2 severity class III	Yes/No	Yes	
	– Radiated Electromagnetic Field Disturbance IEC 60255-22-3 severity class III	Yes/No	Yes	
	– Electromagnetic Emissions IEC 60255-25	Yes/No	Yes	
	– Fast Transient Disturbance IEC 60255-22-4 severity level IV	Yes/No	Yes	
5.7	Type test certificate provided	Yes/No	Yes	

7. PROTECTION, CONTROL AND METERING

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
1	General			
1.1	Applicable standard		Acc. to Protection, control and metering system Technical Specification	
			(Codes and Standards)	
1.2	Nominal system frequency	Hz	50	
1.3	Nominal current transformers secondary current	A	1	
1.4	Rated voltage transformers secondary voltage	V	110	
1.5	Auxiliary DC	V	110	
1.6	Variation of Aux. DC	%	-15 , +10	
1.7	Auxiliary AC	V	415 / 240	
1.8	Type of system grounding		132kV: Solid	
			33kV: Solid	

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
1.9	Accuracy class of CTs for protection and metering equipment		Acc. to Attached Drawing & relay requirement	
1.10	Accuracy class of CVTs for protection and metering		Acc. to Attached Drawing	
1.11	Control and metering system			
1.11.1	All sub-division of control and metering system such as operating system, interlocking, synchronizing, alarm annunciation, automatic and manual voltage control, metering and indication instruments, event and fault recorder, PMU (as required) and relays setting and configuration integrated control system		Acc. to Protection, control and metering system Technical Specification	
			(Control and Metering System)	
1.12	Protection system			
1.12.1	All sub-division of protection system such as protection design criteria, protection relays requirement, common circuit breaker protection, transmission line protection, sub-transmission line protection, power transformer protection, short transmission line protection, short sub-transmission line protection, bus section protection, reactor protection, load shedding and busbar protection		Acc. to Protection, control and metering system Technical Specification	
			(Protection system)	
1.13	Packing, transportation and storage		Acc. to Protection, control and metering system Technical Specification	
			(Packing, transportation and storage)	
1.14	Supervision over installation and erection procedure		Acc. to Protection, control and metering system Technical Specification	
			(Supervision over installation & erection procedure)	

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
1.15	Inspection and test		Acc. to Protection, control and metering system Technical Specification	
			(Inspection and test)	
2	Panel			
2.1	Manufacturer :			
2.1.1	Name			
2.1.2	Country			
2.2	Type of panels construction		Acc. to Protection, control and metering system Technical Specification	
			(Protection, Control and Metering Panel)	
2.2	Degree of protection of panels:			
	Indoor		IP54	
	Outdoor		IP55	
2.3	Color of Panel:			
	Indoor		RAL7035	
	Outdoor		RAL7032	
2.4	Thickness of Panel color	Micron	between 80 and 120	
2.5	Minimum thickness of steel panels	mm	2	
2.6	Overall dimensions :			
	protection & Relay panels	mm*m m*mm	800*800*2200	
	Control panels	mm*m m*mm	800*800*2200	

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
	AVR panel	mm*m m*mm	800*800*2200	
2.7	Size of wires :			
	CT & CVT circuits	mm2	>=4	
	control circuit	mm2	>=2.5	
2.8	Voltage rating of wirings	V		
2.9	Terminal blocks :			
	Manufacturer / Name / Country			
	Type designation			
	Spare	%	10	
2.1	Earthquake protection coefficient			
2.11	Lighting, door switch, heater, thermostat	yes/no	yes	
2.12	DC supervision for relay and control panel	yes/no	yes	
2.13	Type of mounting			
2.14	Other requirement		Acc. to Protection, control and metering system Technical Specification	
			(Protection, Control and Metering Panel)	
*	Over Head Line Protection			
1	Distance Protection (Main I Protection)		132kV , 33kV	
1.1	Manufacturer :			
	Name			
	Country			

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
	Type designation			
1.2	Applicable standard			
1.3	Type	Static/ Microp rocesso r based	Microprocessor based	
1.4	Rated current			
1.5	Rated voltage			
1.6	Rated auxiliary DC			
1.7	Method of starting			
1.8	Number of zones :		Minimum 5 zone ph- ph & ph-E	
	Forward reach			
	Reverse reach			
1.9	Mounting arrangement		Free standing modular cabinet	
1.10	Maximum zone 1 operating time			
1.11	Time setting range for :		As per relay coordination calculation	
	Zone 2			
	Zone 3			
1.12	power swing blocking provided	yes/no	yes	
1.13	Dielectric test voltage			
1.14	Type of relay characteristics			
1.15	Type of characteristics for phase- ground and three phase faults			

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
1.16	Number of measuring units			
1.17	Type of impedance measuring characteristic for phase to ground faults /setting range / step		quadrilateral , mho	
	Zone 1			
	Zone 2			
	Zone 3			
1.18	Type of impedance measuring characteristic for phase to phase faults /setting range / step		quadrilateral , mho	
	Zone 1			
	Zone 2			
	Zone 3			
1.19	Method of ensuring correct discrimination for three phase close up faults			
1.20	Fault locator feature built in	yes/no	yes	
1.21	Built in directional overcurrent/ earth fault relay	yes/no	yes	
1.22	Built in disturbance Recorder	yes/no	yes	
1.23	Built in DTT	yes/no	yes	
1.24	Built in SOTF	yes/no	yes	
1.25	Mutual compensation provided	yes/no		
1.26	internal Fuse failure blocking provided	yes/no	yes	
1.27	Filtering against CVT transients provided	yes/no		
1.28	Current carrying /making/breaking capacity for trip contacts	A		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
1.29	Weak-end in feed trip feature provided	yes/no	yes	
1.30	Current reversal logic (for double lines) provided	yes/no		
2	Directional EF Relay (In Distance Protection)		132kV , 33kV	
2.1	Manufacturer :			
	Name			
	Country			
	Type designation			
2.2	Applicable standard			
2.3	Rated zero sequence current	A		
2.4	Rated zero sequence polarizing voltage	V		
2.5	Whether the following characteristics provided :			
2.6	Normal inverse /Very inverse / Extremely inverse			
2.7	Whether instantaneous unit provided	yes/no	yes	
2.8	Mounting arrangement			
2.9	Current setting range in inverse characteristic / step	A		
2.10	Current setting range in instantaneous/ definite characteristic / step	A		
2.11	Time setting range / step	Sec		
2.12	Relay characteristic angle	deg		
2.13	Drop-off / pick-up ratio			

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
2.14	Hand reset operation indicator	yes/no		
2.15	Power consumption	VA		
2.16	Inrush current blocking	yes/no		
2.17	Transient over reach	yes/no		
2.18	Current reversal logic (for parallel lines) provided	yes/no		
2.19	Echo feature for tele-protection provided	yes/no		
3	Current Differential Protection		132kV , 33kV	
3.1	Manufacturer :			
	Name			
	Country			
	Type designation			
3.2	Fault setting with maximum number of current transformers connected primary amperes for :		As per relay calculation	
	Phase/earth fault	A		
	Phase/phase fault	A		
3.3	Basic sensitivity setting range	%		
3.4	Rated current	A		
3.5	Current setting range	A		
3.6	Current transformer supervision alarm setting with maximum number of current transformer			
3.7	Connected (primary amperes)	A		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
3.8	Pick up ration (slop) setting range	%		
3.9	Pick-up time :			
	At "3" times fault setting	Ms		
	At " 10" times fault setting	Ms		
3.10	Maximum through fault current at which protection is stable	A		
3.11	Current transformer requirement :			
	Knee point voltage	V		
	Winding resistance	Ohm		
	Maximum exciting current at knee point voltage	MA		
3.12	Max operating time	Ms		
3.13	Number of contacts available			
3.14	Relay burden	VA		
3.15	Built in distance function	yes/no	yes	
3.16	Setting of series connected reinforcing contactor	A		
3.17	Resistance of series connected	Ohm		
3.18	Values of series resistance and wattage			
3.19	Isolator Aux switches requirement :			
	Number of contacts normally open		>10	
	Number of contacts normally closed		>10	
	Timing sequence between aux switches and main contacts			

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
3.20	Maximum total lead burden	VA		
3.21	Recommended cable lead burden	Mm		
3.22	CT circuit supervision time setting range	S		
3.23	IEC 61850 communication protocol support	yes/no	yes	
4	Directional Earth Fault Relay (Include In Differential protection)		132kV , 33kV	
4.1	Manufacturer :			
	Name			
	Country			
	Type designation			
4.2	Applicable standard			
4.3	Rated zero sequence current	A		
4.4	Rated zero sequence polarizing voltage	V		
4.5	Rated auxiliary DC voltage	V	110	
4.6	Whether the following characteristics provided :	yes/no	yes	
	Normal inverse			
	Very inverse			
	Extremely inverse			
4.7	Mounting arrangement			
4.8	Whether instantaneous unit provided	yes/no		
4.9	Current setting range	A		

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
4.10	Drop-off / pick-up ratio					
4.11	Hand reset operation indicator provided	yes/no				
4.12	Power consumption	VA				
4.13	IEC 61850 communication protocol support	yes/no				
4.14	Normal inverse /Very inverse / Extremely inverse					
4.15	Whether instantaneous unit provided	yes/no				
4.16	Mounting arrangement					
4.17	Current setting range in inverse characteristic / step	A				
4.18	Current setting range in instantaneous/ definite characteristic / step	A				
4.19	Time setting range / step	Sec				
4.20	Relay characteristic angle	deg				
4.21	Drop-off / pick-up ratio					
4.22	Hand reset operation indicator	yes/no				
4.23	Power consumption	VA				
4.24	Inrush current blocking	yes/no				
4.25	Transient over reach	yes/no				
4.26	Current reversal logic (for parallel lines) provided	yes/no				
4.27	Echo feature for tele-protection provided	yes/no				
5	Under & Over Voltage Relay		Under Voltage	Over Voltage	Under Voltage	Over Voltage

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5.1	Manufacturer :					
	Name					
	Country					
	Type designation					
5.2	Applicable standard					
5.3	Rated voltage	V				
5.4	Rated auxiliary DC voltage	V				
5.5	Resetting ratio					
5.6	Time delay setting range / step	sec				
5.7	Time characteristic					
5.8	voltage Setting range / step	V				
5.9	Power consumption	VA				
5.10	Mounting arrangement					
5.11	Hand reset operation indicator	yes/no				
5.12	Manual blocking possibility	yes/no				
6	Autorecloser with Check synchro relay		132kV , 33kV			
6.1	Manufacturer :					
	Name					
	Country					
	Type designation					

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
6.2	Applied standard			
6.3	number of auto recloser shots			
6.4	Relay type	Static/ Microprocessor based	microprocessor	
6.5	whether operation indicator provided	yes/no		
6.6	provision for blocking and switching in the relay from :	Hz		
6.7	control / relay panel	yes/no		
6.8	remote control	yes/no		
6.9	range of dead time adjustment / step	sec		
6.10	range of reclaim time adjustment / step	sec		
6.11	closing pulse time	sec		
6.12	Method of blocking auto recloser			
6.13	when circuit breaker is open			
6.14	when closing into a fault			
6.15	Single and 3 pole reclosing	yes/no	yes	
6.16	whether operation counter provided	yes/no		
6.17	whether following features provided for safe closing			
6.18	synchronizing check in live bus / live line	yes/no	yes	
6.19	live line / dead bus	yes/no	yes	
6.20	live bus / dead line	yes/no	yes	

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
6.21	dead bus / dead line	yes/no	yes	
6.22	Time details (rag etc):			
	Number of timer			
	Auxiliary voltage	V		
	Timing range	sec		
6.23	Number of phases			
6.24	Range of voltage difference in percent of Un			
6.25	Range of phase angle difference			
6.26	Range of frequency difference			
6.27	Limiting Short time thermal withstand value			
6.28	Values of Auxiliary DC and its permissible variation	V		
6.29	DC consumption	W		
6.30	Contact data:			
	Number			
	Continuous rating at 110VDC	A		
6.31	Mounting position	flush/Surface/etc		
6.32	Accessories (if essential to relay performance) provided	yes/no		
6.33	Hand reset operation indicator with inscription provided	yes/no		
6.34	Burden	VA		
6.35	Manual close inhibit timer			

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
7	Breaker Failure Protection (with End Fault)		132kV , 33kV	
7.1	Manufacturer :			
	Name			
	Country			
	Type designation			
7.2	Applied standard			
7.3	Rated Value of Current			
7.4	Setting range & accuracy class of characteristic quantity			
7.5	Drop out current as % of pick up current			
7.6	Pick up time	ms		
7.7	Resetting time	ms		
7.8	Frequency	Hz		
7.9	Burden			
7.10	Time details (rag etc.):			
	Number of timer			
	Auxiliary voltage	V		
	Timing range	sec		
7.11	Number of phases			
7.12	Limiting Short time thermal withstand value			
7.13	Values of Auxiliary DC and its permissible variation	V		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
7.14	DC consumption	W		
7.15	Contact data:			
	Number			
	Continuous rating at 110VDC	A		
7.16	Mounting position	flush/S urface/ etc		
7.17	Accessories (if essential to relay performance) provided	yes/no		
7.18	Hand reset operation indicator with inscription provided	yes/no		
7.19	Burden	VA		
7.20	Dielectric test voltage	KV/sec		
7.21	IEC 61850 communication protocol support	yes/no	yes	
8	STUB Protection		132kV	
8.1	Manufacturer			
	Name			
	Country			
	Type designation			
8.2	Applicable standard			
8.3	Rated current			
8.4	Current setting range			
8.5	Mounting arrangement			
8.6	Number of phases	ms		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
8.7	Rated aux DC voltage	ms		
8.8	Hand reset operation indicator	Hz		
8.9	Time setting range			
8.10	Burden			
8.11	IEC 61850 communication protocol support		yes	
9	Point On Wave Switching Relay			
9.1	Manufacturer			
	- Name			
	- Country			
	- Type designation			
9.2	Applicable standard			
9.3	ambient temperature	°C		
9.4	controlled switching (opening , closing or both of them)		Both	
9.5	operation modes	single mode / double mode		
9.6	adaptation control function	yes/no		
9.7	targets for controlled switching	rapid mode/ secured mode/ both of them		
9.8	adaptation control function	yes/no		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
9.9	type of controlled load	transmission line/ power transformer/ capacitor/reactor		
9.10	analogue inputs:			
	- Voltage reference input value / range	V		
	- Current measuring input value / range	A		
	- Control voltage input value / range	V		
	- Temperature variation sensor input / range			
	- Pressure variation sensor input / range			
9.11	Drop-off/ pick-up ratio			
9.12	Hand reset operation indicator	yes/no		
9.13	Mounting arrangement			
9.14	Power Supply	V		
9.15	Power consumption	VA		
9.16	digital input data:	yes/no		
	- Number			
	- Application			
	- Continuous rating	A		
9.17	open/ close power output data:	yes/no		

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
	- Number			
	- Continuous rating	A		
	- Breaking capacity	A		
	- Operating time	sec		
9.18	signal output data	yes/no		
9.19	- Number			
	- Continuous rating	A		
	- Breaking capacity	A		
9.20	interface communication			
9.21	Accessories (if essential to relay performance) provided	yes/no		
9.22	EMC tests	KV/sec		
*	Power Transformer Protection	132/33 kV		
1	Biased Differential Protection Relay		132kV , 33kV	
1.1	Manufacturer :			
	Name			
	Country			
	Type designation			
1.2	Applicable standard			
1.3	Relay type	Static/ Microprocessor based	microprocessor	

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.4	Rated current	A				
1.5	Rated auxiliary DC voltage	V				
1.6	Bias setting range	(%)				
1.7	Mounting arrangement					
1.8	Hand reset operation indicator provided	yes/no				
1.9	Method of preventing tripping during magnetizing inrush current					
1.10	Maximum through fault current for which the relay is stable	A				
1.11	Rated value of the auxiliary DC voltage	V				
1.12	Fifth harmonic restrain feature	yes/no	yes			
2	Restricted Earth Fault Relay		132kV SIDE	33kV SIDE		
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Relay type	Static/ Microprocessor based	microprocessor	microprocessor		
2.3	Hand reset operation indicator provided	yes/no				
2.4	Rated auxiliary DC voltage	V				
2.5	Mounting arrangement					
2.6	Current setting range	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.7	Voltage setting range	V				
2.8	Time setting range	sec				
2.9	Resetting ratio	(%)				
3	Over Current Protection Relay		132kV SIDE	33kV SIDE		
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Applicable standard					
3.3	Rated current	A				
3.4	Current setting range in inverse characteristic / step	A				
3.5	Current setting range in instantaneous/ definite characteristic / step	A				
3.6	Time setting range / step	Sec				
3.7	Number of contacts					
3.8	Mounting arrangement					
3.9	Number of phases					
3.10	Rated auxiliary DC voltage	V				
3.11	Hand reset operation indicator	yes/no				
3.12	Current setting range of instantaneous unit	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.13	Second harmonic blocking feature	yes/no				
3.14	Minimum pick-up time	ms				
3.15	Relay design (microprocessor-based, numerical)	Yes/No	Yes	Yes		
4	Neutral point Earth Fault Relay		132kV SIDE	33kV SIDE		
4.1	Manufacturer :					
	Name					
	Country					
	Type designation					
4.2	Applicable standard					
4.3	Rated current	A				
4.4	Current setting range in inverse characteristic / step	A				
4.5	Current setting range in instantaneous/ definite charactristic / A step	A				
4.6	Time setting range / step	Sec				
4.7	Number of contacts					
4.8	Mounting arrangement					
4.9	Number of phases					
4.10	Rated auxiliary DC voltage	V				
4.11	Hand reset operation indicator	yes/no				
4.12	Current setting range of instantaneous unit	A				
4.13	Second harmonic blocking feature	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
4.14	Minimum pick-up time	ms				
5	Aux/Earthing Trans OC & EF Protection Relay		33kV	0.415kV	33kV	0.415kV
5.1	Manufacturer :					
	Name					
	Country					
	Type designation					
5.2	Applicable standard					
5.3	Rated current	A				
5.4	Current setting range in inverse characteristic / step	A				
5.5	Current setting range in instantaneous/ definite characteristic / step	A				
5.6	Time setting range / step	Sec				
5.7	Number of contacts					
5.8	Mounting arrangement					
5.9	Number of phases					
5.10	Rated auxiliary DC voltage	V				
5.11	Hand reset operation indicator	yes/no				
5.12	Current setting range of instantaneous unit	A				
5.13	Second harmonic blocking feature	yes/no				
5.14	Minimum pick-up time	ms				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
6	Directional Over Current Relay		132kV SIDE	33kV SIDE		
6.1	Manufacturer :					
	Name					
	Country					
	Type designation					
6.2	Applicable standard					
6.3	Rated current	A				
6.4	Rated polarizing voltage	V				
6.5	Whether the following characteristics provided :					
6.6	Normal inverse /Very inverse / Extremely inverse					
6.7	Whether instantaneous unit provided	yes/no				
6.8	Mounting arrangement					
6.9	Current setting range in inverse characteristic / step	A				
6.10	Current setting range in instantaneous/ definite characteristic / step	A				
6.11	Time setting range / step	Sec				
6.12	Relay characteristic angle	deg				
6.13	Drop-off / pick-up ratio					
6.14	Hand reset operation indicator	yes/no				
6.15	Power consumption	VA				
6.16	Inrush current blocking	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
6.17	Transient over reach	yes/no				
6.18	Current reversal logic (for parallel lines) provided	yes/no				
6.19	Echo feature for tele-protection provided	yes/no				
7	Directional Earth Fault Relay		132kV SIDE	33kV SIDE		
7.1	Manufacturer :					
	Name					
	Country					
	Type designation					
7.2	Applicable standard					
7.3	Rated zero sequence current	A				
7.4	Rated zero sequence polarizing voltage	V				
7.5	Whether the following characteristics provided :					
7.6	Normal inverse /Very inverse / Extremely inverse					
7.7	Whether instantaneous unit provided	yes/no				
7.8	Mounting arrangement					
7.9	Current setting range in inverse characteristic / step	A				
7.10	Current setting range in instantaneous/ definite characteristic / step	A				
7.11	Time setting range / step	Sec				
7.12	Relay characteristic angle	deg				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
7.13	Drop-off / pick-up ratio					
7.14	Hand reset operation indicator	yes/no				
7.15	Power consumption	VA				
7.16	Inrush current blocking	yes/no				
7.17	Transient over reach	yes/no				
7.18	Current reversal logic (for parallel lines) provided	yes/no				
7.19	Echo feature for tele-protection provided	yes/no				
8	Under & Over Relay		Under Voltage	Over Voltage	Under Voltage	Over Voltage
8.1	Manufacturer :					
	Name					
	Country					
	Type designation					
8.2	Applicable standard					
8.3	Rated voltage	V				
8.4	Rated auxiliary DC voltage	V				
8.5	Resetting ratio					
8.6	Time delay setting range / step	sec				
8.7	Time characteristic					
8.8	voltage Setting range / step	V				
8.9	Power consumption	VA				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
8.10	Mounting arrangement					
8.11	Hand reset operation indicator	yes/no				
8.12	Manual blocking possibility	yes/no				
9	Over Flux Relay					
9.1	Manufacturer :					
	Name					
	Country					
	Type designation					
9.2	Applicable standard					
9.3	Rated voltage	V				
9.4	Rated auxiliary DC voltage	V				
9.5	Resetting ratio					
9.6	Time delay setting range / step	sec				
9.7	Time characteristic					
9.8	voltage Setting range / step	V				
9.9	Power consumption	VA				
9.10	Mounting arrangement					
9.11	Hand reset operation indicator	yes/no				
9.12	Manual blocking possibility	yes/no				
11	Thermal over load Protection Relay					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
11.1	Manufacturer :					
	Name					
	Country					
	Type designation					
11.2	Applicable standard					
11.3	Rated current	A				
11.4	Rated auxiliary DC voltage	V				
11.5	Power consumption	VA				
11.6	Mounting arrangement					
11.7	Hand reset operation indicator	yes/no				
11.8	Current setting range of inverse unit / step					
11.9	Number of phases					
11.10	fifth harmonic blocking feature	yes/no				
11.11	Current setting range / step of instantaneous unit					
11.12	type of characteristic					
13	Breaker Failure Protection (with End Fault)		132kV SIDE	33kV SIDE		
13.1	Manufacturer :					
	Name					
	Country					
	Type designation					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
13.2	Applied standard					
13.3	Rated Value of Current					
13.4	Setting range & accuracy class of characteristic quantity					
13.5	Drop out current as % of pick up current					
13.6	Pick up time	ms				
13.7	Resetting time	ms				
13.8	Frequency	Hz				
13.9	Burden					
13.10	Time details (rag etc):					
	Number of timer					
	Auxiliary voltage	V				
	Timing range	sec				
13.11	Number of phases					
13.12	Limiting Short time thermal withstand value					
13.13	Values of Auxiliary DC and its permissible variation	V				
13.14	DC consumption	W				
13.15	Contact data:					
	Number					
	Continuous rating at 110VDC	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
13.16	Mounting position	flush/Surface/etc				
13.17	Accessories (if essential to relay performance) provided	yes/no				
13.18	Hand reset operation indicator with inscription provided	yes/no				
13.19	Burden	VA				
13.20	Dielectric test voltage	KV/sec				
13.21	IEC 61850 communication protocol support	yes/no	yes	yes		
14	AVR Relay		132kV , 33kV			
14.1	Manufacturer :					
	Name					
	Country					
	Type designation					
14.2	Applicable standard					
14.3	Relay rated current	A				
14.4	Relay rated voltage	V				
14.5	Rated auxiliary DC voltage	Vdc				
14.6	Current circuit power consumption	VA				
14.7	Voltage circuit power consumption	VA				
14.8	Rated frequency range	Hz				
14.9	Regulating voltage setting range / step	V				
14.10	Dead band voltages setting / step	V				

PROTECTION, CONTROL AND METERING		UNIT	DATA	
			REQUIRED	OFFERED
14.11	Initial time delay setting / step :			
	Inverse			
	Definite			
14.12	Inter tap delay			
14.13	Under voltage setting /step	V		
14.14	Over voltage setting / step	V		
14.15	Load over current setting / step	A		
14.16	Circulating current setting /step			
14.17	Line drop compensation setting / step :			
	Reactive setting			
	Reactive setting			
14.18	Out-put contacts :			
	Number			
	Type	NO/NC		
	Rated breaking capacity	VA		
	Rated continuous current	A		
14.19	Mounting arrangement			
14.20	Hand reset operation indicator	yes/no		
14.21	IEC 61850 communication protocol support	yes/no	yes	
*	Busbar Protection			

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1	Differential Protection Relay		132kV	33kV		
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					
1.2	Type reference					
1.3	Applicable standard					
1.4	Relay type, static or elec. Mech. or other system of measuring basis (Low imp, restrain current , directional comparison, etc)		Low Imp	Low Imp		
1.5	Relay rated current	A				
1.6	Relay burden	VA				
1.7	Frequency	Hz				
1.8	Current setting range :					
1.9	Phase / earth fault	A				
1.10	Phase / Phase fault	A				
1.11	Time between fault commencement and initiation of trip:					
1.12	At 3 times fault setting	ms				
1.13	At 10 times fault setting	ms				
1.14	Max through fault current for which relay is stable	KA				
1.15	CT supervision relay	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.16	Current Transformer requirement :					
	Formula for knee point voltage					
	Max of magnetization current					
1.17	CT Supervision relay details:					
	Type and manufacturer					
	Alarm pick up current					
	Alarm pick up time					
	short circuit CT lead provided	yes/no				
	Blocking trip after a preset time provided	yes/no				
1.18	Relay allowable saturation factor					
1.19	Hand reset operation indicator provided	yes/no				
1.20	Mounting position (flush , surface , etc)					
1.21	Rated values of auxiliary energizing quantity & its permissible variation	VDC				
1.22	Short time rating	KA/sec				
1.23	Fault setting with maximum number of CTs connected					
1.24	Isolating auxiliary switches provided	yes/no				
1.25	Accessories (Essential to really performance) provided	yes/no				
1.26	No of tripping relays					
1.27	Interference test (Mhz)	KV				
1.28	Surge test (12/50 micro second)	KV				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.29	Self monitoring of its important circuit possible	yes/no				
1.30	Automatic testing is possible	yes/no				
1.31	IEC 61850 communication protocol support	yes/no	yes	yes		
2	U/O Voltage Relay for Distribution Busbars		Under Voltage	Over Voltage	Under Voltage	Over Voltage
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Applicable standard					
2.3	Rated voltage	V				
2.4	Rated auxiliary DC voltage	V				
2.5	Resetting ratio					
2.6	Time delay setting range / step	sec				
2.7	Time characteristic					
2.8	voltage Setting range / step	V				
2.9	Power consumption	VA				
2.10	Mounting arrangement					
2.11	Hand reset operation indicator	yes/no				
2.12	Manual blocking possibility	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3	High Speed Auxiliary Relay (self reset)		132kV	33kV		
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Rated voltage	VDC				
3.3	Targets	yes/no				
3.4	Number of contacts					
3.5	Pick up time:					
	Make Contact (NO)	ms				
	Break contact (NC)	ms				
3.6	Pickup/ drop off ratio					
3.7	Permitted ambient temperature indoor	- °c				
3.8	Permitted ambient temperature outdoor	- °c				
3.9	Contacts detail:					
	rated voltage (ac/dc)	V				
	Maximum system voltages					
3.10	Current carrying capacity:					
	short time	A				
	continuously	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Making and conducting capacity					
	Breaking Capacity					
3.11	Type of Mounting					
*	Bus Coupler & Section Feeder Protection		132kV	33kV	132kV	33kV
1	Over Current Protection Relay					
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					
1.2	Applicable standard					
1.3	Rated current	A				
1.4	Current setting range in inverse characteristic / step	A				
1.5	Current setting range in instantaneous/ definite characteristic / step	A				
1.6	Time setting range / step	Sec				
1.7	Number of contacts					
1.8	Mounting arrangement					
1.9	Number of phases					
1.10	Rated auxiliary DC voltage	V				
1.11	Hand reset operation indicator	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.12	Current setting range of instantaneous unit	A				
1.13	Second harmonic blocking feature	yes/no				
1.14	Minimum pick-up time	ms				
2	Earth Fault Protection Relay					
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Applicable standard					
2.3	Rated current	A				
2.4	Current setting range in inverse characteristic / step	A				
2.5	Current setting range in instantaneous/ definite characteristic /A step					
2.6	Time setting range / step	Sec				
2.7	Number of contacts					
2.8	Mounting arrangement					
2.9	Number of phases					
2.10	Rated auxiliary DC voltage	V				
2.11	Hand reset operation indicator	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.12	Current setting range of instantaneous unit	A				
2.13	Second harmonic blocking feature	yes/no				
2.14	Minimum pick-up time	ms				
3	Breaker Failure Protection (with End Fault)			33kV SIDE		33kV SIDE
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Applied standard					
3.3	Rated Value of Current					
3.4	Setting range & accuracy class of characteristic quantity					
3.5	Drop out current as % of pick up current					
3.6	Pick up time	ms				
3.7	Resetting time	ms				
3.8	Frequency	Hz				
3.9	Burden					
3.10	Time details (rag etc):					
	Number of timer					
	Auxiliary voltage	V				
	Timing range	sec				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.11	Number of phases					
3.12	Limiting Short time thermal withstand value					
3.13	Values of Auxiliary DC and its permissible variation	V				
3.14	DC consumption	W				
3.15	Contact data:					
	Number					
	Continuous rating at 110VDC	A				
3.16	Mounting position	flush/Surface/etc				
3.17	Accessories (if essential to relay performance) provided	yes/no				
3.18	Hand reset operation indicator with inscription provided	yes/no				
3.19	Burden	VA				
3.20	Dielectric test voltage	KV/sec				
*	Distribution Feeder Protection					
1	Over Current Protection Relay			33kV		33kV
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.2	Applicable standard					
1.3	Rated current	A				
1.4	Current setting range in inverse characteristic / step	A				
1.5	Current setting range in instantaneous/ definite characteristic / step	A				
1.6	Time setting range / step	Sec				
1.7	Number of contacts					
1.8	Mounting arrangement					
1.9	Number of phases					
1.10	Rated auxiliary DC voltage	V				
1.11	Hand reset operation indicator	yes/no				
1.12	Current setting range of instantaneous unit	A				
1.13	Second harmonic blocking feature	yes/no				
1.14	Minimum pick-up time	ms				
2	Earth Fault Protection Relay					
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Applicable standard					
2.3	Rated current	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.4	Current setting range in inverse characteristic / step	A				
2.5	Current setting range in instantaneous/ definite characteristic / step	A				
2.6	Time setting range / step	Sec				
2.7	Number of contacts					
2.8	Mounting arrangement					
2.9	Number of phases					
2.10	Rated auxiliary DC voltage	V				
2.11	Hand reset operation indicator	yes/no				
2.12	Current setting range of instantaneous unit	A				
2.13	Second harmonic blocking feature	yes/no				
2.14	Minimum pick-up time	ms				
3	Distance Protection (Backup Protection)			33kV		33kV
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Applicable standard					
3.3	Type	Static/ Microprocessor based				
3.4	Rated current					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.5	Rated voltage					
3.6	Rated auxiliary DC					
3.7	Method of starting					
3.8	Number of zones :					
	Forward reach					
	Reverse reach					
3.9	Mounting arrangement					
3.10	Maximum zone 1 operating time					
3.11	Time setting range for :					
	Zone 2					
	Zone 3					
3.12	power swing blocking provided	yes/no				
3.13	Dielectric test voltage					
3.14	Type of relay characteristics					
3.15	Type of characteristics for phase-ground and three phase faults					
3.16	Number of measuring units					
3.17	Type of impedance measuring characteristic for phase to ground faults /setting range / step					
	Zone 1					
	Zone 2					
	Zone 3					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.18	Type of impedance measuring characteristic for phase to phase faults /setting range / step					
	Zone 1					
	Zone 2					
	Zone 3					
3.19	Method of ensuring correct discrimination for three phase close up faults					
3.20	Fault locator feature built in	yes/no				
3.21	Built in directional overcurrent/ earth fault relay	yes/no				
3.22	Built in disturbance Recorder	yes/no				
3.23	Built in DTT	yes/no				
3.24	Built in SOTF	yes/no				
3.25	Mutual compensation provided	yes/no				
3.26	internal Fuse failure blocking provided	yes/no				
3.27	Filtering against CVT transients provided	yes/no				
3.28	Current carrying /making/breaking capacity for trip contacts	A				
3.29	Weak-end in feed trip feature provided	yes/no				
3.30	Current reversal logic (for double lines) provided	yes/no				
4	Under & Over Voltage Relay					
4.1	Manufacturer :					
	Name					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Country					
	Type designation					
4.2	Applicable standard					
4.3	Rated voltage	V				
4.4	Rated auxiliary DC voltage	V				
4.5	Resetting ratio					
4.6	Time delay setting range / step	sec				
4.7	Time characteristic					
4.8	voltage Setting range / step	V				
4.9	Power consumption	VA				
4.10	Mounting arrangement					
4.11	Hand reset operation indicator	yes/no				
4.12	Manual blocking possibility	yes/no				
5	Autorecloser with Check synchro relay					
5.1	Manufacturer :					
	Name					
	Country					
	Type designation					
5.2	Applied standard					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5.3	number of auto recloser shots					
5.4	Relay type	Static/ Microp rocesso r based	microproce ssor	micropro cessor		
5.5	whether operation indicator provided	yes/no				
5.6	provision for blocking and switching in the relay from :	Hz				
5.7	control / relay panel	yes/no				
5.8	remote control	yes/no				
5.9	range of dead time adjustment / step	sec				
5.10	range of reclaim time adjustment / step	sec				
5.11	closing pulse time	sec				
5.12	Method of blocking auto recloser					
5.13	when circuit breaker is open					
5.14	when closing into a fault					
5.15	Single and 3 pole reclosing	yes/no				
5.16	whether operation counter provided	yes/no				
5.17	whether following features provided for safe closing					
5.18	synchronizing check in live bus / live line	yes/no				
5.19	live line / dead bus	yes/no				
5.20	live bus / dead line	yes/no				
5.21	dead bus / dead line	yes/no				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5.22	Time details (rag etc):					
	Number of timer					
	Auxiliary voltage	V				
	Timing range	sec				
5.23	Number of phases					
5.24	Range of voltage difference in percent of Un					
5.25	Range of phase angle difference					
5.26	Range of frequency difference					
5.27	Limiting Short time thermal withstand value					
5.28	Values of Auxiliary DC and its permissible variation	V				
5.29	DC consumption	W				
5.30	Contact data:					
	Number					
	Continuous rating at 110VDC	A				
5.31	Mounting position	flush/S urface/ etc				
5.32	Accessories (if essential to relay performance) provided	yes/no				
5.33	Hand reset operation indicator with inscription provided	yes/no				
5.34	Burden	VA				
5.35	Manual close inhibit timer					
6	Directional Over Current Relay				Short Line	Cable Feeder

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
6.1	Manufacturer :					
	Name					
	Country					
	Type designation					
6.2	Applicable standard					
6.3	Rated zero sequence current	A				
6.4	Rated zero sequence polarizing voltage	V				
6.5	Whether the following characteristics provided :					
	Normal inverse					
	Very inverse					
	Extremely inverse					
6.6	Mounting arrangement					
6.7	Current setting range	A				
6.8	Whether instantaneous unit provided	yes/no				
6.9	Drop-off / pick-up ratio					
6.10	Hand reset operation indicator	yes/no				
6.11	Power consumption	VA				
6.12	IEC 61850 communication protocol support	yes/no				
7	Directional Earth Fault Relay					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
7.1	Manufacturer :					
	Name					
	Country					
	Type designation					
7.2	Applicable standard					
7.3	Rated zero sequence current	A				
7.4	Rated zero sequence polarizing voltage	V				
7.5	Rated auxiliary DC voltage	V				
7.6	Whether the following characteristics provided :					
	Normal inverse					
	Very inverse					
	Extremely inverse					
7.7	Mounting arrangement					
7.8	Whether instantaneous unit provided	yes/no				
7.9	Current setting range	A				
7.10	Drop-off/ pick-up ratio					
7.11	Hand reset operation indicator provided	yes/no				
7.12	Power consumption	VA				
7.13	IEC 61850 communication protocol support	yes/no				
*	General Relays					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1	Self-Reset Trip Relay				Heavy Duty	High Speed
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					
1.2	Number of contacts					
1.3	Pick-up time	msec				
1.4	Voltage in percent of rated voltage for :					
	Pick-up					
	Reset					
1.5	Continuous current carrying capacity of already					
1.6	closed contacts	A				
1.7	Current breaking capacity (L/R >10 msec)	A				
1.8	Current making capacity (L/R >10 msec)	A				
1.9	Mounting arrangement					
2	Fuse Failure relay					
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.2	Applicable standard					
2.3	Operating time	ms				
2.4	Rated voltage	V				
2.5	Mounting voltage					
2.6	Monitoring fuse fail of 1, 2 or 3 phase	yes/no				
2.7	Hand reset operation indicator	yes/no				
2.8	setting range					
3	Close Relay					
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Number of contacts					
3.3	Pick-up time	msec				
3.4	Voltage in percent of rated voltage for :					
	Pick-up					
	Reset					
3.5	Closed contacts continuous current capacity	A				
3.6	Current breaking capacity (L/R >10 msec)	A				
3.7	Current making capacity (L/R >10 msec)	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.8	Mounting arrangement					
4	Lockout Relay					
4.1	Manufacturer :					
	Name					
	Country					
	Type designation					
4.2	Number of contacts					
4.3	Pick-up time	msec				
4.4	Voltage in percent of rated voltage for :					
	Pick-up					
	Reset					
4.5	Continuous current carrying capacity of already					
4.6	closed contacts	A				
4.7	Current breaking capacity (L/R >10 msec)	A				
4.8	Current making capacity (L/R >10 msec)	A				
4.9	Hand reset operation indicator	yes/no				
4.10	Mounting arrangement					
5	TCS & CCS relay		TCS	CCS	TCS	CCS
5.1	Manufacturer :					
	Name					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Country					
	Type designation					
5.2	Rated auxiliary DC voltage	V				
5.3	Supervision of CB open and close position	yes/no				
5.4	Hand reset operation indicator provided	yes/no				
5.5	Mounting arrangement					
5.6	Circuit breaker trip coil current	mA				
5.7	Pick-up time	msec				
5.8	Continuous current carrying for closed contacts	A				
6	Pole Discordance Relay		132kV	33kV		
6.1	Manufacturer :					
	Name					
	Country					
	Type designation					
6.2	Applied standard					
6.3	Rated Value of Current					
6.4	Setting range & accuracy of characteristic quantity					
6.5	Drop out current as % of pick up current					
6.6	Pick up time	ms				
6.7	Resetting time	ms				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
6.8	Frequency	Hz				
6.9	Burden					
6.10	Number of timers					
6.11	Auxiliary voltage	V				
7	Auxiliary Relay With Flag					
7.1	Manufacturer :					
	Name					
	Country					
7.2	Type designation					
7.3	Number of contacts					
7.4	Pick-up time	msec				
7.5	Voltage in percent of rated voltage for :					
	Pick-up					
	Reset					
7.6	Continuous current carrying capacity of already					
7.7	closed contacts	A				
7.8	Current breaking capacity (L/R >10 msec)	A				
7.9	Current making capacity (L/R >10 msec)	A				
7.10	Hand reset operation indicator	yes/no				
7.11	Mounting arrangement					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
8	Auxiliary relay (self reset)					
8.1	Manufacturer :					
	Name					
	Country					
	Type designation					
8.2	Rated voltage	VDC				
8.3	Targets	yes/no				
8.4	Number of contacts					
8.5	Pick up time :					
	Make Contact (NO)	ms				
	Break contact (NC)	ms				
8.6	Pickup / drop off ratio					
8.7	Permitted ambient temperature indoor	-°C				
8.8	Permitted ambient temperature outdoor	-°C				
8.9	Contacts detail:					
	rated voltage (ac/dc)	V				
	Maximum system voltages					
8.10	Current carrying capacity:					
	short time	A				
	continuously	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Making and conducting capacity	A				
	Breaking Capacity	A				
8.11	Type of Mounting					
9	High Speed Auxiliary Relay (self reset)					
9.1	Manufacturer :					
	Name					
	Country					
	Type designation					
9.2	Rated voltage	VDC				
9.3	Targets	yes/no				
9.4	Number of contacts					
9.5	Pick up time:					
	Make Contact (NO)	ms				
	Break contact (NC)	ms				
9.6	Pickup/ drop off ratio					
9.7	Permitted ambient temperature indoor	-°C				
9.8	Permitted ambient temperature outdoor	-°C				
9.9	Contacts detail:					
	rated voltage (ac/dc)	V				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Maximum system voltages					
9.10	Current carrying capacity:					
	short time	A				
	continuously	A				
	Making and conducting capacity					
	Breaking Capacity					
9.11	Type of Mounting					
10	Time Delay Relay					
10.1	Manufacturer :					
	Name					
	Country					
	Type designation					
10.2	Rated voltage	VDC				
10.3	Output contact function					
10.4	Reset time					
10.5	Target provided					
10.6	Number of contacts					
10.7	Consistency in operate time					
10.8	Principle of operation					
10.9	Permitted ambient temperature indoor	-°C				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
10.10	Permitted ambient temperature outdoor	-°c				
10.11	Type of mounting					
10.12	Setting range					
11	Protection Relay Test Block					
11.1	Manufacturer :					
	Name					
	Country					
11.2	Type designation					
11.3	Rated voltage	V				
11.4	Rated Current	A				
11.5	short circuit current capacity	A/s				
11.6	Number of contacts					
11.7	Type of mounting					
11.8	number of current contacts					
11.9	secondary CT contacts are shorted	yes/no				
11.10	storage/ working temperature range					
11.11	impulse withstand voltage	kV				
11.12	test plug type designation					
	Control System Equipment					
1	Synchronizing Equipment					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					
1.2	Applicable standard					
1.3	Rated auxiliary DC voltage	V				
1.4	Rated frequency	Hz				
1.5	Rated CVT secondary voltage	V				
1.6	Mounting arrangement					
1.7	Maximum slip frequency at which CB closes	Hz				
1.8	Maximum phase difference at which CB closes					
1.9	Accuracy					
1.10	Continuous over voltage rating	V				
1.11	Short time rating					
2	Double voltmeter:					
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Setting Range / step					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.3	Overall dimensions	mm*m m				
2.4	Type of mounting					
2.5	Method of mounting					
2.6	Total deflection angle					
2.7	Total scale length					
2.8	Burden					
2.9	Accuracy					
3	Double frequency meter:					
3.1	Manufacturer :					
	Name					
	Country					
	Type designation					
3.2	Range					
3.3	Overall dimensions					
3.4	Type of mounting					
3.5	Method of mounting					
3.6	Total deflection angle					
3.7	Total scale length					
3.8	Burden					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.9	Accuracy					
3.10	Synchroscope:					
3.11	Overall dimensions					
3.12	Type of mounting					
3.13	Method of mounting					
4	Synchro-scope meter:					
4.1	Manufacturer :					
	Name					
	Country					
	Type designation					
4.2	Type and manufacturer					
4.3	Rated voltage / frequency					
4.4	Voltage difference setting range					
4.5	Phase angle difference setting range					
4.6	Frequency difference setting range (slip)					
	Paralleling					
	Synchronizing					
4.7	Operating time					
4.8	Resetting time					
4.9	Duration of output signal					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
4.10	Dead voltage limit					
4.11	Live voltage limit					
4.12	Over load capacity					
4.13	Pick-up to drop-off ratio					
4.14	Duration of output signal					
5	Synchronizing relay					
5.1	Manufacturer :					
	Name					
	Country					
	Type designation					
5.2	Applied standard					
5.3	number of auto recloser shots					
5.4	Relay type (microprocessor)	V				
5.5	whether operation indicator provided	yes/no				
5.6	provision for blocking and switching in the relay from :	Hz				
5.7	control / relay panel	yes/no				
5.8	remote control	yes/no				
5.9	range of dead time adjustment	sec				
5.10	range of reclaim time adjustment	sec				
5.11	closing pulse time	sec				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5.12	Method of blocking auto recloser					
5.13	when circuit breaker is open					
5.14	when closing into a fault					
5.15	whether operation counter provided	yes/no				
5.16	whether following features provided for safe closing					
5.17	synchronizing check in live bus / live line	yes/no				
5.18	live line / dead bus	yes/no				
5.19	live bus / dead line	yes/no				
5.20	dead bus / dead line	yes/no				
5.21	Time details (rag etc):					
	Number of timer					
	Auxiliary voltage	V				
	Timing range	sec				
5.22	Number of phases					
5.23	Limiting Short time thermal withstand value					
5.24	Values of Auxiliary DC and its permissible variation	V				
5.25	DC consumption	W				
5.26	Contact data:					
	Number					
	Continuous rating at 110VDC	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5.27	Mounting position	flush/Surface/etc				
5.28	Accessories (if essential to relay performance) provided	yes/no				
5.29	Hand reset operation indicator with inscription provided	yes/no				
5.30	Burden	VA				
5.31	Dielectric test voltage	KV/sec				
*	Annunciators					
1	DC Operated					
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					
1.2	Applicable standard					
1.3	Rated auxiliary DC supply voltage					
1.4	Speed of operation msec					
1.5	Dimensions of each window mm					
1.6	Type of reset	manual / auto				
1.7	Urgent and non-urgent alarm discrimination	yes/no				
1.8	Type of audible alarm for :					
	Urgent cases					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Non-Urgent cases					
1.9	Whether suitable for normally open contacts	yes/no				
1.10	Type (solid state/digital type)	solidstate/ digital type				
1.11	Total power consumption per alarm point :					
	Normal condition	W				
	Flashing condition	W				
	Steady condition	W				
1.12	Number of windows :					
1.13	On each control panel					
1.14	Total					
1.15	10% spare windows provided	yes/no				
1.16	Suitable for normally open contacts	yes/no				
1.17	Whether lamp test , acknowledge , accept and reset push button is provided for each panel	yes/no				
*	Metering and Measuring equipment					
1	Ammeter (Separate from MC)					
1.1	Manufacturer :					
	Name					
	Country					
	Type designation					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
1.2	Applicable standard					
1.3	Type	digital				
1.4	Range	A				
1.5	Accuracy class					
1.6	Rated frequency					
1.7	CT secondary current	A				
1.8	Total deflection angle					
1.9	Continuous overload rating of current coil in Percent of rated current					
1.10	Mounting arrangement					
1.11	Dimensions	mm*m m				
2	Voltmeters (Separate from MC)					
2.1	Manufacturer :					
	Name					
	Country					
	Type designation					
2.2	Applicable standard					
2.3	Type	Moving coil / digital				
2.4	Range	kV				
2.5	Accuracy class					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
2.6	Rated frequency					
2.7	PT secondary voltage V					
2.8	Total deflection angle Degree					
2.9	Continuous over voltage rating of voltage coil in percent of rated voltage					
2.10	Mounting arrangement					
2.11	Dimensions	mm*m m				
3	PF and Freq. meters (Separate from MC)				PF	Freq
3.1	Type and manufacturer					
3.2	Accuracy class					
3.3	Permitted ambient temperature C					
3.4	Voltage rating					
3.5	Current rating					
3.6	Total deflection angle					
3.7	Continuous overload rating of current circuit A					
3.8	Continuous overload rating of voltage circuit V					
3.9	Short time overload rating of current circuit(3 sec)A					
3.10	Short time overload rating of voltage circuit (3 sec)V					
3.11	Lead-lag measuring Yes/No					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.12	Measuring range					
3.13	Wide range between 0/8 to 1 on both sides (lead & leg) with transducer	yes / no				
3.14	Output voltage / current range of the transducer					
3.15	Overall dimensions	mm*m m				
3.16	Rated frequency	Hz				
3.17	Type of mounting					
3.18	Insulation test voltage for one minute	KVrms				
3.19	Low reflection glass	yes / no				
3.20	Protection degree					
4	MW and MVAR meters (Separate from MC)					
4.1	Manufacturer :					
	Name					
	Country					
	Type designation					
4.2	Applicable standard					
4.3	Accuracy					
4.4	Frequency					
4.5	Current range A					
4.6	Voltage range V					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
4.7	Continuous rating of :					
	Current circuit	% In				
	Voltage circuit	% V _n				
4.8	Dimensions	mm* mm				
4.9	Mounting arrangement					
4.10	Type (static)					
5	Measuring center					
5.1	Type					
5.2	Manufacturer :					
	Name					
	Country					
	Type designation					
5.3	Accuracy :					
	Active and reactive energy					
	Voltage					
	Current					
	Power					
	Frequency					
5.4	Voltage input :					
	Rated voltage					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Measuring range with separate auxiliary supply					
	Measuring range - self Powered					
	Burden with auxiliary supply					
	Burden - self powered					
	Rated frequency					
	Frequency range					
	Overload capacity					
5.5	Current input :					
	Rated current					
	Maximum current					
	Burden					
	Overload capacity					
5.6	AC auxiliary supply :					
	Auxiliary voltages					
	Optional auxiliary voltages					
	Supply voltage range					
	Burden					
	Overload					
5.7	Display :					
	LCD (No of lines)					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Number of digits					
	Height of digits					
	Width of digits					
5.8	Output relays :					
	Contact rating					
	Maximum switching power					
	Maximum number of pulses					
	Pulse duration					
5.9	Design :					
	Degree of protection					
	Weight					
	Dimensions					
	Mounting					
5.10	Ambient conditions :					
	Temperature - operation					
	Temperature - storage					
	Humidity					
6	Tariff Metering System		132kV	33kV		
6.1	Manufacturer :					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Name					
	Country					
	Model					
6.2	Applicable standard					
6.3	Construction					
	Measuring Principle		3ph, 4wire	3ph, 4wire		
	Type		Numerical	Numerical		
	Display/Reading digits		≥ 7	≥ 7		
	Backlit LCD		Yes	Yes		
6.4	Frequency	Hz				
6.5	Current range suitable for	A				
6.6	Auxiliary voltage range					
	DC ($V_n = 110V_{dc}$)	Vdc	88→125	88→125		
	AC	Vac	230	230		
6.7	Reverse running stop provided	yes/no				
6.8	Impulse contact provided	yes/no	yes	yes		
6.9	Whether test blocks provided	yes/no				
6.10	Mounting arrangement					
6.11	CT analog inputs					

PROTECTION, CONTROL AND METERING			UNIT	DATA		
				REQUIRED		OFFERED
	Rated current	A	1	1		
	Current measuring range	pu	1.2	1.2		
	Power consumption (burden)	VA				
	CT analog inputs					
6.12	VT analog inputs					
	Rated voltage	V	110	110		
	Voltage measuring range	pu	0.8 – 1.15	0.8 – 1.15		
	Power consumption (burden)	VA				
6.13	Accuracy Class					
	Watt hour (IEC 602053-22)		0.2s	0.2s		
	VAr hour (IEC 602053-23)		2.0	2.0		
6.14	Measurements					
	kWh, MWh, kVArh, MVarh (Accumulated values)	Yes/No	Yes	Yes		
	kW, kVAr, MW, MVar	Yes/No	Yes	Yes		
	V, I	Yes/No	Yes	Yes		
	Four quadrant reactive energy	Yes/No	Yes	Yes		
	Max Demand	Yes/No	Yes	Yes		
	THD	Yes/No	Yes	Yes		
6.15	Outputs					
	Pulsed Outputs (IEC 62053-31)		5 (min)	5 (min)		

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
6.16	Data Logging					
	Integral Logging/Storage function					
	Duration	days	180	180		
	Channels		4	4		
	Programmable Periods	Yes/No	Yes	Yes		
	Inputs from external meters	Yes/No				
6.17	Other functions					
	Battery Back-up	Yes/No	Yes	Yes		
	Back-up duration	days	≥14	≥14		
	GPS clock	Yes/No	Yes	Yes		
	Self-monitoring and alarm facility	Yes/No	Yes	Yes		
	Dual supply changeover (VT)	Yes/No	Yes	Yes		
	Remote Transmission of Energy and Power Values	Yes/No	Yes	Yes		
	Remote Interrogation via TCP/IP Link	Yes/No	Yes	Yes		
6.18	Communications					
	Communication ports (Front/rear etc.)					
	RS232	Yes/No				
	RS485	Yes/No	Yes	Yes		
	Optical (IEC 62056-21)	Yes/No	Yes	Yes		
	Ethernet-IEC 61850	Yes/No	Yes	Yes		

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Protocols supported					
	IEC 62056-21, DLMS	Yes/No	Yes	Yes		
	IEC 61850	Yes/No	Yes	Yes		
	Others (please list)					
6.19	Type Tests					
6.19.1	Atmospheric Environment					
	Operation -25°C and 55°C for 96hrs, IEC 60068-2-1	Yes/No	Yes	Yes		
	Transport/storage -25°C and 70°C for 96hrs, IEC 60068-2-2	Yes/No	Yes	Yes		
6.19.2	Relative Humidity					
	Operation at 93%	Yes/No	Yes	Yes		
	Tested to IEC 60068-2-3 with severity class 56 days	Yes/No	Yes	Yes		
6.19.3	Enclosure					
	IEC 60529		IP50	IP50		
6.19.4	Mechanical Environment					
	Vibration IEC 60255-21-1	Yes/No	Yes	Yes		
	Shock and bump IEC 60255-21-2	Yes/No	Yes	Yes		
	Seismic IEC 60255-21-3	Yes/No	Yes	Yes		
6.19.5	Insulation					
	Rated insulation					
	1000V high impedance protection CT inputs	Yes/No	Yes	Yes		

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	250V for other circuits	Yes/No	Yes	Yes		
	1000V open contact withstand	Yes/No	Yes	Yes		
	Dielectric Tests IEC 60255-5 – Series C of table 1	Yes/No	Yes	Yes		
	Impulse voltage IEC 60255-5 test voltage 5kV	Yes/No	Yes	Yes		
6.19.6	Electromagnetic compatibility					
	1MHz Burst disturbance test, IEC 60255-22-1 severity class III	Yes/No	Yes	Yes		
	Electrostatic Discharge IEC 60255-22-2 severity class III	Yes/No	Yes	Yes		
	Radiated Electromagnetic Field Disturbance IEC 60255-22-3 severity class III Test method A, 27MHz through 500MHz	Yes/No	Yes	Yes		
	Electromagnetic Emissions IEC 60255-25	Yes/No	Yes	Yes		
	Fast Transient Disturbance IEC 60255-22-4 severity level IV	Yes/No	Yes	Yes		
6.19.7	Type test certificate provided	Yes/No	Yes	Yes		
*	Transducer					
1	MW/MVAR					
1.1	Make and type					
1.2	Compliance with IEC 60688					
1.3	Auxiliary power voltage range	V				
1.4	Combined or separate units					
1.5	Service conditions (temperature & RH)					
1.6	Connections (eg two voltage & two current)					

PROTECTION, CONTROL AND METERING			UNIT	DATA			
				REQUIRED		OFFERED	
1.7	Input voltage range	V					
1.8	Input current range	A					
1.9	Output current	A					
1.10	Accuracy class						
1.11	Burden	VA					
1.12	Overload	%					
1.13	Case or rack mounted						
2	Voltage						
2.1	Make and type						
2.2	Compliance with IEC 69688						
2.3	Auxiliary power voltage range	V					
2.4	Service conditions (temperature & RH)						
2.5	Input current Amps	A					
2.6	Output current Amps	A					
2.7	Accuracy class	%					
2.8	Burden	VA					
2.9	Overload	%					
2.10	Case or rack mounted						
3	Current						
3.1	Make and type						

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
3.2	Compliance with IEC 60688					
3.3	Auxiliary power voltage range	V				
3.4	Service conditions (temperature & RH)					
3.5	Input current range	A				
3.6	Output current	A				
3.7	Accuracy class	%				
3.8	Burden	VA				
3.9	Overload	%				
3.10	Case or rack mounted					
4	Frequency					
4.1	Make and type					
4.2	Compliance with IEC 60688					
4.3	Auxiliary power voltage rang Watts	W				
4.4	Service conditions (temperature e& RH)					
4.5	Input frequency range (eg nominal = 5%)	Hz				
4.6	Output current Amps	A				
4.7	Accuracy class	%				
4.8	Burden	VA				
4.9	Overload	%				
4.10	Case or rack mounted					

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
5	Auxiliary relay (self reset)					
5.1	Manufacturer					
5.2	Type					
5.3	Rated voltage	Vdc				
5.4	Targets	yes/no				
5.5	Number of contacts					
5.6	Pick up time :					
	Make Contact (NO)	ms				
	Break contact (NC)	ms				
5.7	Pickup / drop off ratio					
5.8	Permitted ambient temperature indoor	- °c				
5.9	Permitted ambient temperature outdoor	- °c				
5.10	Type of Mounting					
5.11	Utilization category					
5.12	Contacts detail:					
	rated voltage (ac/dc)	V				
	Maximum system voltages	V				
	Current carrying capacity	A				
	short time	A				
	continuously	A				

PROTECTION, CONTROL AND METERING		UNIT	DATA			
			REQUIRED		OFFERED	
	Making and conducting capacity	A				
	Breaking Capacity	A				
6	Time Delay Relay					
6.1	Manufacturer/Country					
6.2	Type					
6.3	Rated voltage	Vdc				
6.4	Output contact function					
6.5	Reset time					
6.6	Target provided					
6.7	Number of contacts					
6.8	Consistency in operate time					
6.9	Principle of operation					
6.10	Permitted ambient temperature indoor	- °c				
6.11	Permitted ambient temperature outdoor	- °c				
6.12	Type of mounting					
6.13	Setting range / step					

8. LOW VOLTAGE AC SYSTEM

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
1	General			

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
1.1	Rated power of station service transformers	kVA	As Per Drawings	
1.2	Rated frequency	Hz	50	
1.3	Max. Permissible voltage variation	%	10	
1.4	Max. Permissible voltage drop	%	5	
1.5	Number of phases		3	
1.6	Number of wires		4	
1.7	Short circuit current/time	kA/S	25/1	
1.8	System grounding		Solid	
1.9	Control phase Unit	Yes/ No	Yes	
1.10	Automatic Transfer Scheme provided	Yes/ No	Yes	
2	AC Main and Distribution Panels			
2.1	Manufacturer of panels:			
	Name			
	Type			
	Country			
2.2	Degree of protection of panels:			
	- Indoor		IP54	
	- Outdoor		IP55	
2.3	Panel color		RAL7035	
2.4	Minimum thickness of steel panels	mm	2.5	
2.5	Type of main circuit breakers	ACB/ MCC B	ACB	

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
2.6	Type of outgoing circuit breakers	MCB / MCCB	MCB/MCCB	
2.7	Continuous rating of busbars	A	>1000	
2.8	Min. power frequency withstand voltage	kV	2.5	
2.9	Single front /double front			
2.10	Single front /double front			
2.11	Type of insulation on busbars and connections			
2.12	Main and earth busbar type and material			
2.13	Maximum temperature rise inside panel	°C		
2.14	Method of neutral grounding			
2.15	Method of grounding incoming supply circuit			
2.16	Type of protection provided within cubicles (shutters , insulating cover ,)			
2.17	Rear or front access			
2.18	Type of Main cubicles construction		Single Front Compartmented/Fix	
2.19	Type of Distribution cubicles construction		withdrawable	
3	Air Circuit Breaker (ACB)			
3.1	Manufacturer of :			
	Name			
	Type			

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
	Country			
3.2	Degree of protection	IP		
3.3	Type of circuit breaker	Draw out/ Plug-in/Fix	Draw out	
3.4	Type of mounting			
3.5	Rated voltage	V	415/240	
3.6	Type of operating mechanism			
3.7	Type of motor			
3.8	Normal voltage for operation of motors	VDC	110	
3.9	Normal voltage for trip coils	VDC	110	
3.10	Voltage of operating mechanism motor	V		
3.11	Rated making current	kA		
3.12	Number of Air circuit breaker poles		4	
3.13	Breaking current :			
	Symmetrical	kA		
	Asymmetrical	kA		
3.14	Make time with 100% rated making current	ms		
3.15	Number of N/C auxiliary contact		>10NO+ >10NC	
3.16	Number of N/O auxiliary contact		>10NO+ >10NC	

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
3.1 7	Operating duty cycle		CO-15sec-CO	
3.1 8	Over load relay is required	Yes/ No		
3.1 9	Short circuit relay is required	Yes/ No		
4	Molded Case Circuit Breaker (MCCB)			
4.1	Manufacturer of:			
	Name			
	Type			
	Country			
4.2	Degree of protection	IP		
4.3	Type of MCCB	Draw out/ Plug-in/Fix	Fix	
4.4	Rated voltage	V	415/240	
4.5	Rated current	A		
4.6	Number of poles		3	
4.7	Type of operating mechanism			
4.8	Whether circuit breakers are motorized	Yes/ No	NO	
4.9	Normal voltage for operation of motors	VDC	110	
4.1 0	Normal voltage for trip coils	VDC	110	
4.1 1	Rated making current	KA		

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
4.1 2	Breaking current :			
	Symmetrical	KA		
	Asymmetrical	KA		
4.1 3	Make time with 100% rated making current	ms		
4.1 4	Number Of N/C auxiliary contact		>10NO+ >10NC	
4.1 5	Number of N/O auxiliary contact		>10NO+ >10NC	
4.1 6	Over load relay is required.....	Yes/ No	YES	
4.1 7	Short circuit relay is required...	Yes/ No	YES	
5	Miniature Circuit Breakers (MCB)			
5.1	Manufacturer of:			
	Name			
	Type			
	Country			
5.2	Degree of protection	IP		
5.3	Rated voltage	V	415/240	
5.4	Rated current	A		
5.5	Number of MCB poles		3/1	
5.6	Rated short time withstand current (1 sec.)	kA	25	
5.7	Number of poles			

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
5.8	Service short circuit breaking capacity	kA		
5.9	Rated short circuit making capacity	kA		
5.10	Total fault elimination time	ms		
5.11	Type of MCB characteristic			
6	Fuse Switches			
6.1	Manufacturer of :			
	Name			
	Type			
	Country			
6.2	Degree of protection	IP		
6.3	Type of mounting	Fix/p lugin/ Draw able		
6.4	Rated voltage	V	415/240	
6.5	Rated current	A		
6.6	Max. load break capacity			
6.7	Making capacity	kA		
6.8	Breaking capacity	kA		
6.9	Type of operating mechanism			
6.10	Number of N/C auxiliary contact		>10NO+ >10NC	

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
6.1 1	Number of N/O auxiliary contract		>10NO+ >10NC	
7	Fuses			
7.1	Manufacturer of :			
	Name			
	Type			
	Country			
7.2	Rated voltage	V	415/240	
7.3	Rated current	A		
7.4	Max. breaking capacity	kA		
7.5	Operation indicator	Yes/ No		
7.6	Bases, carrier and holder required	Yes/ No		
8	Load Breaker Switch (LBS)			
8.1	Manufacturer of :			
	Name			
	Type			
	Country			
8.2	Rated voltage	V	415/240	
8.3	Rated current	A		
8.4	Max. breaking capacity	KA		

LOW VOLTAGE AC SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
8.5	Operation indicator	Yes/ No	YES	
8.6	Bases, carrier and holder required	Yes/ No	YES	
8.7	Number of poles			
9	Contactors			
9.1	Manufacturer of:			
	Name			
	Type			
	Country			
9.2	Type of mounting	Fix/p lugin/ Draw able		
9.3	Rated voltage	V	415/240	
9.4	Contact rating	A		
9.5	Number of auxiliary contacts		>10NO+ >10NC	

9. LOW VOLTAGE DC SYSTEM

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
1	GENERAL		110V	48V	110V	48V
1.1	Variation of DC voltage	%	-15 +10	, -15 +10		
1.2	Grounding of DC system		High Resistan ce	High Resistan ce		

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
2	DC MAIN AND DISTRIBUTION PANEL					
2.1	Manufacturer :					
	Name					
	Type					
	Country					
2.2	Type of cubicles construction		Single Front/ Compartmented / Fix	Single Front/ Compartmented / Fix		
2.3	Finishing colour		RAL70 35	RAL70 35		
2.4	Continuous rating of busbars	A				
2.5	Continuous rating of incoming/bus coupler CBs	A				
2.6	Short circuit current/time	kA/S				
2.7	Applicable standards					
2.8	Rated current of main indoor DC panel	A				
2.9	Min. power frequency withstand voltage (kVrms)	kV	2.5	2.5		
2.10	Rated short time withstand current (1 sec)	KA	10	6		
2.11	Degree of protection for indoor panels	IP	IP51	IP51		
2.12	Degree of protection for outdoor panels	IP	IP55	IP55		
2.13	Reference ambient temperature	°C	As per section 1	As per section 1		

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
2.14	Altitude above sea level		As per section 1	As per section 1		
2.15	Padlocking facility for switches required	Yes/ No				
2.16	Rated short time withstand of busbars and connections (1 sec)	KA				
2.17	Type of insulation on busbars and connections					
2.18	Whether down dropper connections segregated from incoming/outgoing connections	Yes/ No				
2.19	Automatic changeover operation provided in DC main panel	Yes/ No	Yes	Yes		
2.20	Main and earth busbar type and material					
2.21	Maximum temperature rise inside panel	oC				
2.22	Method of neutral grounding					
2.23	Method of grounding incoming supply circuit					
2.24	Type of protection provided within cubicles (shutters, insulating cover....)					
2.25	Rear or front access					
2.26	Wall thickness	mm	2.5	2.5		
2.27	Height of main indoor distribution panels	mm	2.5	2.5		
2.28	Width of main indoor distribution panels	mm	2.5	2.5		
3	Batteries					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
3.1	Manufacturer :					
	Name					
	Type		Ni-Cd	Ni-Cd		
	Country					
3.2	Battery voltage :					
	Normal	V/cel l	1.2	1.2		
	Equalizing	V/cel l	1.49	1.49		
	Initial	V	1.2	1.2		
	Min. after 10 hr discharge period	V	1.11	1.11		
3.3	Rated discharge capacity :					
	1 hr rate	Ah				
	10 hr rate	Ah	400	300		
3.4	Type of cells	lead acid/ seale d acid/ nicke l- cadm ium	nickel- cadmiu m	nickel- cadmiu m		
3.5	Amper hour capacity of each battery at 15°C, 10 hr rate to give final cell voltage of 1.11 V	Ah				
3.6	Amper hour capacity of each battery at max temp, 10 hr rate to give final cell voltage	Ah	400	300		

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
3.7	Charging current (continuous)	A	100	60		
3.8	Discharge duty :					
	Continuous load/duration					
	Emergency load/duration					
	Momentary load/duration					
3.9	Voltage per cell at end of 10 hr discharge period	V	1.11	1.22		
3.10	Min. temperature	°C				
3.11	Max. temperature	°C				
3.12	Quantity of cells					
3.13	Quantity of cell per battery					
3.14	Quantity of cells per battery set		90	40		
3.15	Type of positive plate					
3.16	Type of negative plate					
3.17	Weight of one battery with electrolyte	Kg				
3.18	Complete mass of battery set	Kg				
3.19	Complete battery set dimensions					
3.20	Expected life of battery	year				
3.21	Method of battery charging		Boost / Float	Boost / Float		
3.22	Rated discharge capacity of batteries	Ah	400	300		

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
3.23	Number of battery set		2	2		
3.24	Number of cells	lead-acid /nick el - cadmium	92	40		
3.25	Cell nominal voltage	lead - acid /nick el - cadmium	2/1.2	2/1.2		
3.26	Min. final cell voltage	V	1.85/1.14	1.85/1.14		
3.27	Material of stands					
4	Battery chargers					
4.1	Manufacturer :					
	Name					
	Type					
	Country					
4.2	Type		Solid State	Solid State		
4.3	Number of battery charger set		2	2		
4.4	Input voltage	V	415/240	415/240		
4.5	Maximum current rating	A	>45	>40		
4.6	Voltage ripple when charging battery	%	5	5		
4.7	AC system data :					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
	Supply voltage	V	415/240	415/240		
	Supply frequency	Hz	50	50		
	Variation in supply voltage	%	0.5	0.5		
	Variation in supply frequency	%				
	Short circuit level for AC supply at charger terminals for 3 Sec./1 Sec	KA				
4.8	Load current limiter provided	Yes/ No				
4.9	Float charging current of the battery	A				
4.10	Equalize charging current of the battery	A				
4.11	Initial charging current of the battery	A				
4.12	Voltage rating :					
	Input voltage	V(A C)				
	Output voltage	V(A C)				
	Rated output voltage (float)	V				
	Rated output voltage (boost)	V				
	Period adjustable for equalizing charging	Hz				
4.13	Method of cooling					
4.14	Permissive ripple of battery charger	%				
4.15	Type of outgoing feeder short circuit protection					
4.16	Boost charge with relevant timer provided	Yes/ No				

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
4.17	Ground fault protection provided	Yes/ No				
4.18	Percent of regulation with AVR for float charge					
4.19	Rectifier transformer :					
	Type					
	Rating					
4.20	Semi-conductor rectifiers :					
	Manufacture					
	Type					
	Type of cooling					
	Type of voltage surge suppression					
4.21	Ambient conditions :					
4.22	Temperature	°C				
4.23	Altitude	m				
4.24	Humidity	%				
4.25	Type of protections :					
	AC phase failure	Yes/ No				
	AC phase sequence	Yes/ No				
	Blocking diode	Yes/ No				
4.26	Dropper	Yes/ No				

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
	Inrush current	Yes/ No				
	Battery reverse	Yes/ No				
4.27	Alarm & Indications :					
	Over voltage alarm for AC/ DC					
	Under voltage alarm for AC/ DC					
	Earth fault alarm for AC/ DC					
	Current indication for AC/ DC					
4.28	Rated discharge period hours		10	10		
4.29	Type		Solid State	Solid State		
4.30	Number of battery charger set		2	2		
4.31	Automatic changeover operation provided in charger	Yes/ No	Yes	Yes		
4.32	Charger can be parallel to another	Yes/ No	Yes	Yes		
4.33	Panel :					
4.34	Total weight	Kg				
4.35	Dimensions (WxHxD)	cm				
4.36	Color	RAL				
4.37	protection degree	IP	IP51	IP51		
4.38	Rear or front access					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
5	Molded Case Circuit Breaker (MCCB)					
5.1	Manufacturer of :					
	Name					
	Type					
	Country					
5.2	Type of mounting	Fix/p lugin/ Draw able	Fix	Fix		
5.3	Degree of protection	IP				
5.4	Applicable standard					
5.5	Rated voltage	V	110	48		
5.6	Rated current	A				
5.7	Rated short time withstand current (1 sec.)	KA				
5.8	Number of poles		2	2		
5.9	Type of operating mechanism					
5.10	Type of motor					
5.11	One minute power frequency withstand level	KV				
5.12	Whether circuit breakers are motorized	Yes/ No				
5.13	Normal voltage for operation of motors	VDC	110	110/48		
5.14	Normal voltage for trip coils	VDC	110	110/48		

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
5.15	Rated making current	KA				
5.16	Breaking current :					
	Symmetrical	KA				
	Asymmetrical	KA				
5.17	Make time with 100% rated making current	ms				
5.18	Design:	Fix/p lugin/ Draw able				
5.19	Number Of N/C auxiliary contact		>10NO + >10NC	>10NO + >10NC		
5.20	Number of N/O auxiliary contact		>10NO + >10NC	>10NO + >10NC		
5.21	Antipumping feature is required	Yes/ No				
5.22	Over load relay is required	Yes/ No				
5.23	Short circuit relay is required	Yes/ No				
6	Miniature Circuit Breakers (MCB)					
6.1	Manufacturer of :					
	Name					
	Type					
	Country					
6.2	Type of mounting (Fix/plug in/Drawable)					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
6.3	Applicable standard					
6.4	Rated voltage	V	110	48		
6.5	Rated current	A				
6.6	Rated short time withstand current (1 sec.)	KA				
6.7	Number of poles		2	2		
6.8	Service short circuit breaking capacity	KA				
6.9	Rated short circuit making capacity	KA				
6.10	Total fault elimination time	ms				
6.11	Type of MCB characteristic					
6.12	Degree of protection	IP				
7	Fuse Switches					
7.1	Manufacturer of :					
	Name					
	Type					
	Country					
7.2	Type of mounting	Fix/p lugin/ Draw able				
7.3	Degree of protection	IP				
7.4	Applicable standard					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
7.5	Rated voltage	V	110	48		
7.6	Rated current	V				
7.7	Max. load break capacity					
7.8	Making capacity	KA				
7.9	Breaking capacity	KA				
7.10	Type of operating mechanism					
7.11	Number of N/C auxiliary contact		>10NO + >10NC	>10NO + >10NC		
7.12	Number of N/O auxiliary contract		>10NO + >10NC	>10NO + >10NC		
8	Fuses					
8.1	Manufacturer of :					
	Name					
	Type					
	Country					
8.2	Type of mounting (Fix/plug in/Drawable)	Fix/p lugin/ Draw able				
8.3	Applicable standard					
8.4	Rated voltage	V	110	48		
8.5	Rated current	V				

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
8.6	Rated frequency	Hz				
8.7	Max. breaking capacity	KA				
8.8	Operation indicator	Yes/ No				
8.9	Bases, carrier and holder required	Yes/ No				
9	Load Breaker Switch (LBS)					
9.1	Manufacturer of :					
	Name					
	Type					
	Country					
9.2	Type of mounting (Fix/plug in/Drawable)					
9.3	Applicable standard					
9.4	Rated voltage	V	110	48		
9.5	Rated current	V				
9.6	Rated frequency	Hz				
9.7	Max. breaking capacity					
9.8	Operation indicator	Yes/ No				
9.9	Bases, carrier and holder required	Yes/ No				
9.10	Number of poles					
10	Contactors					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
10.1	Manufacturer of :					
	Name					
	Type					
	Country					
10.2	Type of mounting	Fix/p lugin/ Draw able				
10.3	Applicable standard					
10.4	Rated voltage	V				
10.5	Contact rating	A				
10.6	Number of auxiliary contacts		>10NO + >10NC	>10NO + >10NC		
11	UPS System					
11.1	Manufacturer/model					
11.2	Type of switch					
11.3	Type of MCB					
11.4	Distribution circuits (numbers and ratings)					
11.5	Number of cubicles					
11.6	Forced limits at one meter					
11.7	Noise limits at one meter					
11.8	Instrumentation					

LOW VOLTAGE DC SYSTEM		UNIT	DATA			
			REQUIRED		OFFERED	
11.9	Alarms					
11.10	Efficiency and power factor at 25.50% & 100% outputs					
11.11	Modular desing/system extention facilities					
11.12	Provision of maintenance switch					
11.13	Radio ferquency interference					

10. SUBSTATION AUTOMATION SYSTEM (SAS)

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
1	GENERAL			
1.1	Protocol communication		IEC61850	
1.2	Communication protocol for all Measuring Centers		MODBUS	
1.3	Vertical communication (base on Client/Server)	Yes/ No	Yes	
1.4	Horizontal communication (base on peer to peer)	Yes/ No	Yes	
1.5	Type of computers (Industrial / Commercial)		Industrial	
1.6	Communication technology		Ethernet LAN	
1.7	Communication topology		Star/Ring	
1.8	Monitoring protocol in station level		SNMP	
1.9	Supported protocol for time synchronizing		SNTP/NTP	
1.10	Redundant configuration		Acc. to SAS structure type	
1.11	Number of server	No.	As Required	

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
1.12	Number of monitor for each workstation	No.	As Required	
1.13	Number of gateway	No.	As Required	
1.14	Indoor communication media		Fiber optic/Copper (twisted pair)	
1.15	Outdoor communication media		Fiber optic	
1.16	Workstation LAN Protocol communication		Compliant with ISO/IEEE 802.3	
1.17	Rated voltage	V	240 AC / 110V DC	
1.18	Variation of Aux. AC/DC	%	-15 , +10	
1.19	Nominal system frequency for AC	Hz	50	
1.20	maximum noise level for the operation of any equipment	dB	50	
1.21	Separate BCU provided		Yes	
1.22	Consideration of future extension in SW (Yes/No)		Yes	
1.23	Consideration of future extension in HW (Yes/No)		Yes	
1.24	SCADA remote center		N.C.C , R.C.C , N.S.C.C	
1.25	SCADA remote center protocols		Acc. to DWGs	
2	Substation Automation System (SAS) Design			
2.1	Manufacturer's Name			
2.2	Manufacturer's Country			
2.3	Type designation			
2.4	No. of references, indicating similar transmission level projects included in the reference list (Manufacturer's Reference list)			
2.5	No. of references in similar transmission level projects included in the reference list (Iranian Supplier Reference list)			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
2.6	User friendly Software (As generally accepted, comparing MicroSoft products)			
2.7	Maintenance, modification or extension of components without a shutdown of the whole station automation system			
2.8	Is protection an integral part of the SAS system?	Yes/ No		
2.9	Possibility to read and alter relay settings, extract fault, event and disturbance records from SA			
2.10	Analysis software for protection relays provided			
2.11	Years of experience in design and supply of numerical equipment related to SA			
2.12	Specify the Kind of LAN used for IED & protection level			
2.13	Specify Data exchange rate between the electronic devices on IED level LAN (Preferably at 10/100 M bit/s)			
2.14	Ethernet LAN used for Station level			
2.15	Data exchange between the electronic devices on Station level shall take place via LAN at 10/100 M bit/s			
2.16	Possibility to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail.			
2.17	Prevent initiation of operation of a single switch at the same time from more than one of the various control levels via, control center,			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	remote computer, station level, bay level.			
2.18	Does 'System' functioning require multiple alarm acknowledgement or manual entries (at different workstations) for the same data.			
2.19	Substation, by single line displays with paging			
2.20	Multiple windows facility with size selectable			
2.21	Event processing facility			
2.22	Alarm processing facility			
2.23	Separate loud ringing audible alarm			
2.24	Analogue measurement handling (e.g. 'change of state' or other methods)			
2.25	MWH & MVARH data from substation or calculated			
2.26	Individual and sequence control facilities			
2.27	Event printing highlighting			
2.28	Scheduled logging facility			
2.29	Page logging facility to hard copy color printer			
2.30	Method of storage of historical data			
2.31	Trend displays of analogues			
2.32	Plant database schedule			
2.33	Record of number of operations of plant			
2.34	Operator manual entry facility etc.			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
2.35	SCMS equipment status display			
2.36	Fault incident record facility			
2.37	Operator defined formats			
2.38	Transfer of control between SCS & SMS and SCADA			
2.39	Tap position by binary or digital input			
2.40	Provision of simple method of database and display updating system manager tasks. Details of proposals included			
2.41	Tagging facility			
2.42	Interlocking / redundancy feature			
2.43	Distributed Synchro-check facility			
2.44	Automatic and manual tap change control via SCMS			
2.45	Protection relay and fault recorder data, work station display			
2.46	Dynamic busbar coloring feature			
2.47	Possibility of displaying of all substation and AC interlocking by the special picture			
2.48	IEC61850 Standard Protocol Supporting		IEC104	
3	SCMS Hardware and Software			
3.1	Identification of any special hardware and software required to be developed, with estimate of the work required			
3.2	Design life, in service experience, design history and future development plans			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
3.3	Computer equipping for ultimate system			
3.4	Integrated SCS & SMS database/more than one database			
3.5	Database tools compliant with ODBC			
3.6	Compatibility of database tools with tools at SCADA control center			
3.7	Editing tools for sequential / logic functions			
3.8	Analogue accuracy from bay unit to display			
3.9	Automatic/manual diagnostics provided for all SCS & SMS equipment			
3.10	Automatic system restart following power interruption			
3.11	Stall alarm facility			
3.12	Fault / event record files auto upload to SCMS			
3.13	No. of levels of system access protection			
3.14	Multiple passwords available within each level of system access			
3.15	Any specified SCS & SMS function propose			
3.16	System redundancy in station computer configuration			
3.17	System redundancy in LAN communication configuration			
3.18	System redundancy in communication server configuration			
3.19	Communication between bay level and station level			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
4	Station Computer (Server)			
4.1	Manufacturer / model			
4.2	Type	Industrial/ Commercial		
4.3	Real time industrial strength equipment			
4.4	AC voltage working range.	V		
4.5	Service conditions (temperature & RH)			
4.6	Power consumption.	W		
4.7	Architecture			
4.8	Individual processors for each function			
4.9	Operating system software			
4.10	Method of processor Expansion (e.g. Number of free slots when supplied)			
4.11	Main (semiconductor) memory			
	Type			
	Supplied size			
	Maximum size			
4.12	Hard Disc storage			
	Type			
	Supplied size			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Maximum size			
4.13	Clock			
4.14	Type			
	Drift per day (when not synchronized to master clock)			
	Method of synchronization with master clock			
	Battery back up			
4.15	Details of mass storage devices and data archiving devices			
5	Operator/Engineering Workstation (MMI)			
5.1	Manufacturer / model			
5.2	Type	Industrial/ Commercial		
5.3	AC voltage working range	V		
5.4	Service conditions (temperature and RH)			
5.5	Power consumption	W		
5.6	Architecture			
5.7	Operating system software			
5.8	Method of processor expansion (e.g. number of free slots when supplied)			
5.9	Main (semiconductor) memory			
	Type			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Supplied size			
	Maximum size			
5.10	Hard Disc storage			
	Type			
	Supplied size			
	Maximum size			
5.11	Clock			
	Type			
	Drift per day (when not synchronized to master clock)			
	Method of synchronization with master clock			
5.12	Processing system intercommunications interface			
	Number supported			
	Type (e.g. LAN etc.)			
	Speed			
5.13	Video Display Unit (VDU)			
	Type			
	Number to be supplied at a workstation			
	Screen size			
	Screen pixel resolution			
	Compliance with recognized EMC and safety standards			
	Type of interface			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
5.14	Keyboard			
	Type			
	Number to be supplied			
	Total number of keys			
	Alphanumeric character key set			
	Control keys provided			
	Number of special function keys			
	Type of interface			
5.15	Cursor control device (Mouse)			
	Number to be supplied			
	Number of buttons			
	Type (e.g. optical)			
	Mat			
	Type of interface			
5.16	C.D Writer			
	Manufacturer			
	Speed			
	Type			
5.17	D.V.D Writer			
	Manufacturer			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Speed			
	Type			
6	Event Printer			
6.1	Manufacturer/model			
6.2	Type	Dot matrix/Other type		
6.3	AC voltage working range.	V		
6.4	Power consumption.	W		
6.5	Service conditions (temperature & RH)			
6.6	Print speed	ppm.		
6.7	Printing pitch/width			
6.8	No. of print pins/jets or resolution			
6.9	No. of fonts/character sets			
6.10	Paper feed proposed/width			
6.11	Self-test facility			
6.12	Number of colors			
6.13	Type of interface			
6.14	Stand/trays			
6.15	Acoustic noise at one meter	dB		
6.16	Alarms local and remote			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
6.17	Configuration/dual network connection			
7	Hard Copy Color Laser Printer			
7.1	Manufacturer/model			
7.2	Type			
7.3	AC voltage working range	V		
7.4	Power consumption	W		
7.5	Service conditions (temperature & RH).			
7.6	Print speed for color graphics printing (PPM)	Ppm.		
7.7	No. of colors/toners			
7.8	Resolution			
7.9	Paper handling			
7.10	Paper size			
7.11	Type of interface			
7.12	Stand / trays			
7.13	Acoustic noise at one meter	dB		
7.14	Alarms local and remote			
7.15	Configuration/dual network connection			
8	Master Clock/G.P.S			
8.1	Manufacturer/model			
8.2	Type			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
8.3	AC/DC voltage working range	V		
8.4	Power consumption	W		
8.5	Service conditions (temperature & RH)			
8.6	Battery standby capacity			
8.7	Type, speed and no. of output interfaces			
8.8	Time and date facility			
8.9	Seasonal changeover/automatic			
8.10	Local display			
	Day : Mon : Yr			
	HH : MM : SS			
8.11	Drift per day (when not synchronized to radio signal)			
8.12	Receiver for UT from NVASTAR satellites			
8.13	Loss of radio synch alarm			
8.14	Other alarms			
8.15	Local alarms and contacts for alarms to SCMS			
8.16	Synchronization of station server with G.P.S			
8.17	Accuracy class			
9	Furniture			
9.1	Workstation desk			
9.2	Material of desk			
9.3	Durable desk top surface			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
9.4	Writing area			
9.5	Drawers/shelves			
9.6	Support for VDUs			
9.7	Size			
9.8	Height			
9.9	Workstation chair			
9.10	Material			
9.11	Swivel and castor action			
9.12	High backed design			
9.13	Arm rests			
9.14	Desk lighting			
9.15	Window blinds			
10	Workstation LAN			
10.1	Manufacturer/model			
10.2	Type			
10.3	Coaxial / optical fiber cable			
10.4	Operating speed.	Hz		
10.5	Protocols/compliance with IEC Standard-			
10.6	Media connection			
10.7	Network functionality			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
10.8	Network management software			
10.9	Software packages			
10.10	Dual redundant configuration			
11	Real Time LAN			
11.1	Manufacturer/model			
11.2	Type			
11.3	Coaxial/optical fiber cable			
11.4	Operating speed.	Hz		
11.5	Protocols/compliance with IEC Standard			
11.6	Media connection			
11.7	Network functional			
11.8	Network management			
11.9	Software packages			
11.10	Dual redundant configuration			
11.11	Deterministic operational behavior			
11.12	Peer to peer communications			
12	Communications			
12.1	Manufacturer/model			
12.2	Type			
12.3	Protocol/between station computer and BCU/BCPU			
	Manufacturer/model			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Compliant with IEC 60870-5-101 and IEC61850			
	Info transfer efficiency	data bits/total bits		
	Hamming distance			
	Security of control messages			
	Interface			
	Transmission rate			
12.4	Type and no. of communication cables to BCU/BCPU			
12.5	Type & no. of communications cables to protection relay and disturbance recorder			
12.6	Peer to Peer signaling/client server architecture			
12.7	Cyclic & event initiated transmissions initiated by BCU/BCPU			
12.8	Continued functioning of station computer and data management in the event of workstations out of service. Limitations applicable			
12.9	Protocol between SCMS and SCADA			
	Emulation of functionality of existing SCADA RTU			
	Support Protocol Indactive 33			
	Support Protocol HDLC			
	Support Protocol IEC101			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Download of database from SCADA control center			
12.10	LDC modem			
	Manufacturer and model			
	Type			
	DC voltage working range.	V		
	Service conditions (temperature and RH).			
	Signaling method			
	Transmission rate and frequency			
	Range of transmitter output			
	Range of receiver input			
	Low level receive alarm			
	Compliant with ITU-T recommendations			
	Modem switchover			
12.11	Laptop workstation and SCMS fault analysis			
	Modem manufacturer and model			
	Type			
	DC voltage working range	V		
	Service conditions (temperature and RH)			
	Signaling method			
	Transmission rate and frequency			
	Range of transmitter output			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Range of receiver input			
	Low level receive alarm			
	Compliant with ITU-T recommendations			
12.1 2	Communications with adjacent SCMS system			
	Details of gateway			
	Provision of optical fiber link			
	Protocol			
	Transmission rate			
13	BCU/BCPU			
13.1	Manufacturer/model			
13.2	Type			
13.3	DC voltage working range	V		
13.4	Service conditions (temperature)			
13.5	Power consumption	W		
13.6	Architecture			
13.7	Memory type			
13.8	Memory maximum			
13.9	Memory supplied			
13.1 0	System bus interface/speed			
13.1 1	Provision of two redundant interfaces to LANs.			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
13.1 2	Method of loading/extending database			
13.1 3	Logic functions & sequences			
13.1 4	Clock			
	Type			
	Drift per day (when not synchronized to master clock)			
	Method of synchronization to master clock			
13.1 5	I/O equipping including 10% spare provided			
13.1 6	Method of data exchange with station computer (e.g. peer to peer).			
13.1 7	Provision of logic functions and sequences			
13.1 8	Direct AC input from CT/VT for analogue values			
	Model			
	Maximum no. inputs per card			
	Outputs available per input			
	Resolution/accuracy			
	Scan cycle			
	Burden	VA		
	Input CT/VT range			
	Input isolation			
	Analogue limit monitoring facility at BCU			
	No. of limits per analogue			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Analogue threshold monitoring range/steps available			
13.1 9	Transducer			
	Model			
	Maximum no. inputs per card			
	Outputs available per input			
	Resolution/accuracy			
	Scan cycle			
	Burden	VA		
	Input CT/VT range			
	Input isolation			
	Analogue limit monitoring facility at BCU			
	No. of limits per analogue			
	Analogue threshold monitoring range/steps available			
13.2 0	Conventional DC analogue inputs			
	Model			
	Maximum no. of inputs per card			
	ADC resolution/accuracy			
	Current input values supported			
	Solid state switching of inputs to ADC			
	Scan cycle per ADC			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Input isolation (common/series mode)			
	Series and common mode noise rejection			
	Analogue limit monitoring facility at BCU			
	No. of limits per analogue			
	Analogue threshold monitoring range/steps available			
13.2 1	Digital inputs			
	Number of inputs per module			
	Digital/software filtering to suppress plant contact bounce			
	Plant common connection at +48V (earth)			
	Maximum input contact frequency			
	Minimum contact closure capture time			
	Time tagging resolution			
	Isolation withstand			
13.2 2	Pulse counter signal inputs			
	Number of inputs per module			
	Digital / software filtering to suppress plant contact bounce			
	Plant common connection at +48V (earth)			
	Maximum input contact frequency			
	Minimum contact closure capture time			
	Time tagging resolution			
	Isolation withstand			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
13.2 3	Digital outputs			
	Number of outputs per module			
	Select/check back/execute facility			
	Measurement of output circuit facility			
	Double pole switching of output			
	Output rating (VER)			
	Range of output pulse			
	Isolation withstand			
13.2 4	Set point outputs			
	Maximum numbers			
	Number of outputs per module			
	Output rating			
	Digital set point / number of digits possible			
	Analogue set point/output values			
	Isolation withstand			
13.2 5	Serial link to protection relay			
	Protocols supported			
	Protocols required for this project			
	Interface			
	Transmission rate			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Optical fiber cable			
13.2 6	Hardware interlocking with backup mimic (if the BCU fail)			
14	Gateway			
14.1	Manufacturer / model			
14.2	Type			
14.3	Service conditions (temperature, RH)			
14.4	Protocol supporting	IEC1 01/10 3/DN 03/H DLC/ IND UCTI C33		
14.5	Designation type (Hardware/Software)			
14.6	Processor speed			
14.7	Size of hard disc			
14.8	Size of RAM			
14.9	Operating system			
14.1 0	Modem / speed / connecting lead			
15	External Modem			
15.1	Manufacturer / model			
15.2	Type			
15.3	Service conditions			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
15.4	Speed			
15.5	Connecting lead			
15.6	Software and provide compatible with AT & T ,			
16	System Software			
16.1	Manufacturer/model			
16.2	Type			
16.3	Make and version of operating systems			
16.4	Details of programming languages			
16.5	Release versions of software			
16.6	Details of any software development			
16.7	Software licensing details			
16.8	Fault and event analysis software			
16.9	SCADA protocol			
16.10	SCMS protocol to BCUs/BCPUs and speed			
16.11	Reconfiguration system software (Yes/No)			
16.12	Supporting Future extension according to SLD			
16.13	Geographical information system software			
16.14	Diagnose software			
17	LAPTOP			
17.1	Manufacturer/model			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
17.2	Type			
17.3	Service conditions			
17.4	Method of processor expansion (e.g. number of free slots when supplied).			
17.5	Amount of main memory			
17.6	Size of hard disc.			
17.7	Processor speed			
17.8	Size of color display			
17.9	Build in mouse			
17.10	Operating system software			
17.11	SCMS application software			
17.12	Relay and fault recorder analysis software			
17.13	Mains power supply unit			
17.14	Battery backup period			
17.15	Carry case			
17.16	Modem/speed/connecting lead			
17.17	Other Accessories			
18	Performance/Availability			
18.1	Compliance with performance requirements (start and restart)			
	Time for redundant station computer to assume online duties			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
	Time for full updating of information			
	Confirmation the redundant station computer database is in step with the one line computer			
18.2	Inclusion of availability calculations			
19	Inverter System			
19.4	Manufacturer/model			
19.5	Type			
19.6	Input DC voltage and range	V		
19.7	Input AC voltage and range	V		
19.8	Service conditions (temperature and RH)			
19.9	Output AC voltage range	V		
19.10	Output AC voltage dynamic response	V		
19.11	Output AC voltage and static regulation	%		
19.12	Output frequency regulation (unsynchronized)	%		
19.13	Output AC voltage harmonic distortion	V		
19.14	Output rating Watts / Max raking	W		
19.15	Output current overload	A		
19.16	Output frequency tracking range	Hz		
19.17	Thermal trip	A		
19.18	Output load power factor			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
19.19	Efficiency at 25, 50, 75 and 100% output			
20	AC Main Power Transient Protector			
20.1	Manufacturer/model			
20.2	Type			
20.3	Nominal AC voltage and range.	V		
20.4	Input AC frequency and range	Hz		
20.5	Service conditions (temperature and RH).			
20.6	Power factor			
20.7	Peak discharge current	A		
20.8	Leakage current			
20.9	Connection details			
20.10	Dimensions/housing			
21	Inverter Distribution			
21.1	Manufacturer/model			
21.2	Type of switch			
21.3	Type of MCB			
21.4	Distribution circuits (numbers and ratings)			
21.5	Number of cubicles			
21.6	Forced limits at one meter			
21.7	Noise limits at one meter			
21.8	Instrumentation			

SUBSTATION AUTOMATION SYSTEM (SAS)		UNIT	DATA	
			REQUIRED	OFFERED
21.9	Alarms			
21.1 0	Efficiency and power factor at 25.50% & 100% outputs			
21.1 1	Modular tesing/system extension facilities			
21.1 2	Provision of maintenance switch			
21.1 3	Radio frequency interference			

11. FAULT MONITORING SYSTEM

h) FAULT MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
1.	FAULT MONITORING SYSTEM			
1.1	Manufacturer			
1.2	Type reference			
	– DAU unit type			
	– Master Station type			
	– HMI type			
	– Printer type			
1.3	Auxiliary voltage range ($V_n = 110V_{dc}$)	Vdc	88→150	
1.4	Analogue Inputs		24	
1.5	Binary inputs		48	
1.6	A/D converter	bit	16bit	
1.7	Current input max amplitude	In	30	

h) FAULT MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
1.8	Current/voltage accuracy	% fsd	≤0.5	
1.9	Scan Rate			
	– Analogue Channel	Hz	≥4000	
	– Event Channel	Hz	≥2000	
1.10	Time stamp resolution	ms	1	
1.11	Recording range			
	– Pre Fault	ms	≥500	
	– Post Fault	ms	≥2000	
1.12	Trigger response time			
	– Analogue	ms		
	– Event	ms		
1.13	Memory			
	– RAM (Non Volatile)	GB	8	
	– HDD	Terabyte	1	
1.14	Battery back-up duration	days	≥14	
1.15	GPS clock input	Yes/No	Yes	
1.16	System software			
1.17	Self-monitoring and alarm facility	Yes/No	Yes	
1.18	Communications			
	– Communication ports (Front/rear etc.)			
	RS232	Yes/No		

h) FAULT MONITORING SYSTEM			UNIT	DATA	
				Required	Offered
	RS485		Yes/No		
	RJ45		Yes/No		
	Other		Yes/No		
	– Protocols supported				
	IEC 61850		Yes/No		
	Others (please list)				
	– Graphical data presentation on SCADA HMI		Yes/No	Yes	
1.19	Type Tests				
1.19.1	Atmospheric Environment				
	– Operation -25°C and 55°C for 96hrs, IEC 60068-2-1		Yes/No	Yes	
	– Transport/storage -25°C and 70°C for 96hrs, IEC 60068-2-2		Yes/No	Yes	
1.19.2	Relative Humidity				
	– Operation at 93%		Yes/No	Yes	
	– Tested to IEC 60068-2-3 with severity class 56 days		Yes/No	Yes	
1.19.3	Enclosure				
	– IEC 60529			IP50	
1.19.4	Mechanical Environment				
	– Vibration IEC 60255-21-1		Yes/No	Yes	
	– Shock and bump IEC 60255-21-2		Yes/No	Yes	
	– Seismic IEC 60255-21-3		Yes/No	Yes	
1.19.5	Insulation				

h) FAULT MONITORING SYSTEM		UNIT	DATA	
			Required	Offered
	– Rated insulation			
	1000V high impedance protection CT inputs	Yes/No	Yes	
	250V for other circuits	Yes/No	Yes	
	1000V open contact withstand	Yes/No	Yes	
	– Dielectric Tests IEC 60255-5 Series C of table 1	Yes/No	Yes	
	– Impulse voltage IEC 60255-5 test voltage 5kV	Yes/No	Yes	
1.19.6	Electromagnetic compatibility			
	– 1MHz Burst disturbance test, IEC 60255-22-1 severity class III	Yes/No	Yes	
	– Electrostatic Discharge IEC 60255-22-2 severity class III	Yes/No	Yes	
	– Radiated Electromagnetic Field Disturbance IEC 60255-22-3 severity class III	Yes/No	Yes	
	– Electromagnetic Emissions IEC 60255-25	Yes/No	Yes	
	– Fast Transient Disturbance IEC 60255-22-4 severity level IV	Yes/No	Yes	
1.19.7	Type test certificate provided	Yes/No	Yes	

12. SDH AND MULTIPLEXER

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
1	SDH			
1.1	Manufacturer's name			
1.2	Year of Manufacturing			

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
1.3	Product Trade Name			
1.4	Type of Model/Version Number			
1.5	FAT Location			
1.6	Applicable Standard(s)		ITU-T,IEEE,IEC	
1.7	Platform		To be defined	
1.8	Type tests reports and certification docs		Required	
1.9	Availability (based on MTBF)		To be defined	
1.10	Flexibility		Required	
1.11	Expandability		Required	
1.12	Automatic Laser Shutdown (ALS)		G.664 Appendix III.2	
1.13	Rack & Shelf Information			
1.13.1	19" or ETSI rack mounting (44U)		Required	
1.13.2	Sub rack Dimension		To be defined	
1.13.3	Rack Dimension		To be defined	
1.13.4	Sub rack Weight (fully populated)	kg	To be defined	
1.13.5	Power Consumption (fully populated)	watt	To be defined	
1.13.6	Power Supply	watt	(-48 VDC)	
1.13.7	No of Slots (Total & Traffic)		To be defined	
1.13.8	No of Traffic Slots		To be defined	
1.13.9	Traffic Slot Capacity (Full duplex)		To be defined	
1.14	Environment Condition			
1.14.1	Transport			

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
1.14.1.1	Max. Transport Temperature	°C	(+ 60)	
1.14.1.2	Min. Transport Temperature	°C	(- 20)	
1.14.1.3	Humidity		(0% to 90%)	
1.14.2	Storage			
1.14.2.1	Max. Transport Temperature	°C	(+ 60)	
1.14.2.2	Min. Transport Temperature	°C	(- 10)	
1.14.2.3	Humidity (0% to 90%)		TBD	
1.14.3	Operation			
1.14.3.1	Max. Transport Temperature	°C	(+ 55)	
1.14.3.2	Min. Transport Temperature	°C	(- 5)	
1.14.3.3	Humidity		(0% to 90%)	
1.15	Certifications (MANDATORY)			
1.15.1	EMC		Required	
1.15.2	EMI		Required	
1.15.5	Reference List only for Proposed systems		Required	
1.16	Redundancy			
1.16.1	CPU		(1+1)	
1.16.2	CXC (Cross connection)		(1+1)	
1.16.3	Power supply		(1+1)	

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
1.16.4	2M Electrical port (E1)		1:N (N shall be specified)	
1.16.5	clock card		shall be specified	
1.16.6	Protection for STM1/16-1 Cards in Linear Links (G.841 - clause 7.1)		1+1 Linear MSP	
1.17	Network Side Protection			
1.17.1	1+1 Linear MSP		Required	
1.17.2	SNCP		Required	
1.18	Switch Capacity Centralized architecture			
1.18.1	TDM- STM 16 system	G	Min 20	
1.18.2	TDM- STM 1 system	G	Min 10	
1.18.2	Packet		Advantage	
1.19	Ethernet interfaces			
1.19.1	10/100 Base-TX L2 switching Ethernet port		Required	
1.19.2	Auto-negotiation		Required	
1.19.3	Auto-crossover		Required	
1.19.4	Unique MAC address to each Ethernet port		Required	
1.20	Ethernet services			
1.20.1	E-Line		Required	
1.20.2	E-LAN		Required	
1.21	Ethernet protection			

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
1.21.1	Spanning Tree Protocol		Required	
1.21.2	Rapid Spanning Tree Protocol		Required	
1.22	NG-SDH Management LCT Functionalities			
1.22.1	local and remote management of NE's over the network		Required	
1.22.2	Alarm display		Required	
1.22.3	Fault Management		Required	
1.22.4	Performance Monitoring and Management		Required	
1.22.5	Configuration Management		Required	
1.22.6	Remote operation		Required	
1.22.7	Access and testing functions		Required	
1.22.8	Graphical view of entire network		Required	
1.22.9	Local Craft terminal Port		Required	
1.23	LCT Hardware (Laptop specification)			
1.23.1	Type & CPU	G	CPU: Core I7	
1.23.2	HHD Capacity	G	>500	
1.23.3	RAM		6	
1.23.4	LCD size (inch)		Less than 15	
2	Access Mux			
2.1	GENERAL			

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
2.1.1	Manufacturer name			
2.1.2	Year of manufacturing			
2.1.3	Product trade name			
2.1.4	Type of designation and model number			
2.1.5	Date of manufacturing			
2.1.6	FAT location			
2.1.7	Applicable Standard(s)		ITU-T	
2.1.8	Type tests reports and certification documents		To be defined	
2.1.9	Availability (based on MTBF)		To be defined	
2.1.1	Flexibility		Required	
2.1.11	Expandability		Required	
2.2	Rack and shelf information			
2.2.1	19" or ETSI rack mounting		To be defined	
2.2.2	Shelf Dimension (height x width x length)		To be defined	
2.2.3	Shelf Weight(fully populated)		To be defined	
2.2.4	Power Consumption(fully populated)		To be defined	
2.2.5	Power Supply		To be defined	
2.2.6	No of Slots (Total & Traffic)		To be defined	
2.2.7	No of Traffic Slots		To be defined	

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
2.3	General Functionality			
2.3.1	Time multiplexing/ de-multiplexing of all voice and data channels		Required	
2.3.2	Sub rate data multiplexing based on ITU-T V-Series synch/asynch data		Required	
2.3.3	Cross-Connecting		at n×64 Kbps, 64 Kbps, Time Slot and Bit levels	
2.3.4	Cross-connect capacity		To be defined	
2.3.5	Drop/Insert		Required	
2.3.6	IP routing		Optional	
2.3.7	VF operation		Required	
2.3.8	Signaling		To be defined	
2.3.9	Transmission delay	μs	<250	
2.4	Line Interface			
2.4.1	E1		Required	
2.4.2	STM1		Advantage	
2.5	Interfaces			
2.5.1	6 wire E&M signaling with ring generator		Required	
2.5.2	2 wire voice channel		Required	
2.5.3	FXO/FXS		Required	
2.5.4	0.3-64 Kbps Sync./Async. V.24/V.28		Required	

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
2.5.5	N × 64 Kbps Sync./Async.		Required	
2.5.6	RS-232, RS-485		Required	
2.5.7	Ethernet		Required	
2.6	Redundancy			
2.6.1	Line card redundancy		1+1	
2.6.2	Power Supply redundancy		1+1	
2.6.3	Cross Connection redundancy		1+1	
2.6.4	Redundancy of Processor		1+1	
2.6.5	Clock		To be defined	
2.6.6	Cooling fans redundancy		To be defined	
2.7	Environmental condition			
2.7.1	Operating Temperature (Long/Short term)		To be defined	
2.7.2	Storage & Transportation temperature		To be defined	
2.7.3	Humidity (St., Tr., Op.) (%)		To be defined	
2.8	Configurations			
2.8.1	Terminal with Multiplexing & Sub multiplexing		Required	
2.8.2	ADM in Linear & Ring		Required	
2.8.3	CXC in Mesh & Tree		Advantage	
2.9	Access MUX Management LCT Functionalities			

SDH AND MULTIPLEXER		UNIT	DATA	
			REQUIRED	OFFERED
2.9.1	local and remote management of NE's over the network		Required	
2.9.2	Alarm display		Required	
2.9.3	Fault Management		Required	
2.9.4	Performance Monitoring and Management		Required	
2.9.5	Configuration Management		Required	
2.9.6	Remote operation		Required	
2.9.7	Access and testing functions		Required	
2.9.8	Graphical view of entire network		Required	

13. TPS SYSTEM

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
1	MANUFACTURER			
1.1	NAME AND COUNTRY			
1.2	TYPE REFERENCE			
2	COMMANDS			
2.1	COMMANDS PRIORITY		Yes	
2.2	TYPE OF COMMAND TRANSMISSION:			
2.2.1	CODED			
2.2.2.	NONCODED			

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
3	ALL OF THE PERIPHERAL EQUIPMENTS, TOOLS, HARDWARE, SOFTWARE AND TECHNICAL DOCUMENTS INCLUDED WITH EACH TPS TERMINAL			
4	Power consumption		shall be defined	
5	High voltage interfaces			
5.1	Type of command contacts			
5.2	Type of alarm contacts			
6	Tripping type:			
6.1	Inter-tripping (Direct)		Yes	
6.2	Permissive tripping (under reach)		Yes	
6.3	Permissive tripping (over reach)		Yes	
6.4	Blocking		Yes	
7	Operation time			
7.1	Direct tripping	ms	< 14	
7.2	Permissive tripping	ms	< 14	
7.3	Blocking tripping	ms	< 14	
7.4	Minimum initialization time for command	ms	2	
7.5	Maximum acceptable propagation time for telecommunication link	ms	100	
7.6	Additional delay by noise range	ms	40	

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
7.7	Distortion of the total pulse at the output of the receiving compared to the sending equipment	ms	4	
8	Transmitter			
8.1	Tx level range for :			
	Command	dBm	-15 to 0	
	Guard	dBm	-25 to -10	
8.2	Return loss	dBm	≥ 20	
8.3	Number of signals for each command		1	
8.4	Harmonic distortion		$\%5 \geq$	
8.5	Level boosting of commands	dB	≥ 9	
9	Receiver			
9.1	Rx level range for :			
	Command	dBm	-15 to 0	
	Guard	dBm	-25 to -10	
9.2	Return loss	dB	≥ 20	
9.3	Dynamic range	dB	≥ 25	
9.4	Receiver selectivity – 300 Hz out of guard's and command's range	dBm0	≥ 55	
9.5	S/N Ratio	dB	≥ 5	
10	High voltage interfaces			

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
10.1	Command and start input voltage ranges	V	220 ~ 48	
10.2	Number of contacts for each command		≥ 6	
10.3	Number of alarm contact for each command		≥ 4	
10.4	Command and alarm contacts ratings	VA	250	
10.5	Duration time before operating of alarm relays	ms		
11	Alarm conditions			
11.1	Transmitter failed		Yes	
11.2	PLC failed		Yes	
11.3	Guard signal absence		Yes	
11.4	Low S/N Ratio		Yes	
11.5	No card located		Yes	
11.6	Any damaged board		Yes	
11.7	Far-end TPS turned off		Yes	
11.8	Presence of guard and command signal simultaneously		Yes	
11.9	Presence of command signal continuously		Yes	
11.10	Watch dog activation alarm		Yes	
12	Basis of time			
12.1	Internal time base		Yes	

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
12.2	External time base – real time		Yes	
	clock such as GPS interface			
13	Dependability and security (pu<10⁻⁶)			
13.1	S / N Ratio	dB	≤ 5	
13.2	Operating time	ms	≤ 15	
14	Power supply			
14.1	Nominal supply voltage	V dc	48	
14.2	Supply tolerance		-15%,+20%	
14.3	Power supply ripple		<%5	
15	Environmental condition			
15.1	Operation			
15.1.1	Temperature range	°C	-5 ~+55°C	
15.1.2	Relative Humidity	%	≥ 95% @ 40°C	
15.1.3	Class of standard for mechanical		IEC 721 .3.3	
			CLASS 3 M 1	
15.2	Storage			
15.2.1	Temperature range	°C	40 ~ +70°C	
15.2.2	Relative humidity	%	≥ 95% @ 40°C	
15.2.3	Class of standard for mechanical		IEC.721.3.3	

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
			CLASS 1 K 5	
16	Electromagnetic and insulation			
16.1	HF disturbance		2500 V / IEC.255.22.1	
16.2	Fast transient burst		2000 V / IEC.801.4	
16.3	Electromagnetic discharge		8000 V / IEC.801.2	
17	Valid Test Reference			
17.1	According to IEC-60834 and other relative standards		Yes	
18	Interfaces			
18.1	Interface between TPS and PLC Based on IEC495 Clause 3.10.5.1		ANALOG 600Ω, 300~2400Hz	
18.2	Interface between TPS and other telecommunication systems such as Fiber Optic or Digital channel		OPTICAL INTERFACE / G.703-64Kbps	
19	Commands			
19.1	Number of independent commands		≤ 4	
19.2	Number of simultaneous commands at least		2	
20	Software Facilities			
20.1	TPS hardware assignment		Yes	
20.2	TPS configuration		Yes	
20.3	Command assignment		Yes	
20.4	Command and alarm assignment		Yes	
20.5	Operation time assignment for each command independently		Yes	

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
20.6	Duration and Delay time assignment for each command independently		Yes	
20.7	Record for counters, Events and Faults with Time Tag		Yes	
20.8	Remote TPS configuration and monitoring		Yes	
21	Test Facilities			
21.1	Local test		Yes	
21.2	Local loop test		Yes	
21.3	Remote loop test		Yes	
21.4	Periodically auto test		Yes	
22	Diagnostic			
22.1	Online maintenance and diagnostic		Yes	
22.2	Checking Facilities:			
	Power Supply		Yes	
	Others		Yes	
23	Interfaces for connecting distance protection devices:		Yes	
23.1	- IEC 61850 interface (GOOSE)		Yes	
23.2	- Binary command I/O interface		Yes	
24	Interfaces for integration into telecommunication networks:		Yes	
24.1	Digital electrical interface (PDH, SDH)		Yes	

h) TPS SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
24.2	Ethernet line interface (MPLS-TP)		Yes	
25	Combinations of path protection for alternative transmission routes		Yes	
26	Event memory with time stamp 8000 events ,1 ms resolution,		Yes	
27	date- and time-stamped, nonvolatile		Yes	
28	Remote access to devices via TCP/IP and Remote readout of the event recorder		Yes	
29	SNMP agent for NMS integration		Yes	
30	Message authentication to ensure Cyber Security Real-time clock, external synchronization sources (NTP)		Yes	

14. LIGHTING AND TELEPHONE SYSTEM

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
1	<u>General</u>			
1.1	Rated voltage	V	415/240	
1.2	Rated frequency	HZ	50	
1.3	Max. Permissible voltage drop	%	2	
1.4	Number of phases		3	
1.5	Number of wires		4	

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
1.6	Short circuit current/time	kA/ S	Acc. To short circuit level of main LVAC panel	
2	<u>Degree of protection</u>			
2.1	Outdoor equipment	IP	IP55	
2.2	Indoor equipment	IP	IP52	
3	<u>Normal illumination level:</u>			
3.1	Control areas/room	Lux	250-500	
3.2	Data printers	Lux	300	
3.3	Project Managers/offices	Lux	300	
3.4	Monitoring room	Lux	300	
3.5	Telecoms room	Lux	300	
3.6	Mess room	Lux	200	
3.7	Metering room	Lux	200	
3.8	Switch room	Lux	200	
3.9	Toilets	Lux	150	
3.10	Access corridors	Lux	150	
3.11	HV equipment floors	Lux	150	
3.12	Marshalling room/stairwells	Lux	150	
3.13	Cable floor/cable risers	Lux	50	
3.14	Battery room	Lux	150	

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
3.15	Entrance	Lux	150	
3.16	Fuel oil plant room	Lux	150	
3.17	Stairwells/corridors	Lux	150	
3.18	Station unit switch room	Lux	200	
3.19	Workshop/store	Lux	300	
3.20	C&I equipment	Lux	300	
3.21	Electronics room	Lux	300	
3.22	Switchgear room	Lux	200	
3.23	Prayer room	Lux	250	
3.24	Stores	Lux	200-300	
3.25	Kitchens	Lux	500	
3.26	Conference rooms	Lux	300-500	
3.27	Locker rooms	Lux	200	
3.28	Cable tunnels	Lux	50	
3.29	Transformer compounds	Lux	30	
3.30	• Transformer area	Lux	30	
3.31	• Operating plant areas:			
3.32	○ Machinery areas	Lux	200	
3.33	○ Platforms/ladders (active)	Lux	50	

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
3.34	○ Walkways	Lux	50	
3.35	○ Road, platform/ladders (inactive),	Lux	30	
4	<u>Minimum illumination level (emergency lighting):</u>			
4.1	Control room	Lux	50	
4.2	AC/DC room	Lux		
4.3	Relay room	Lux		
4.4	Battery room	Lux		
4.5	Transformers and circuit breakers	Lux		
5	<u>Lighting factors taken in to consideration</u>			
5.1	Uniformity factor(Emin/Eave), (Emin/Emax)		1:3, 1:6	
5.2	Maintenance factor for indoor lighting		0.7	
5.3	Maintenance factor for outdoor lighting		0.65	
5.4	The minimum p.f. of the lighting		0.9	
6	<u>Switchyard lighting:</u>			
6.1	Manufacturer			
6.2	Type of fixture		Flood light	
6.3	Type of lamp	w	176 W (Min) (LED)	
6.4	Type of fixture mounting		Structure mounted	
6.5	lamp life	hr		

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
6.6	Lamp efficiency	Lu m/w		
6.7	Lamp flux	lm	20000 (Min)	
6.8	Fixture mounted height	m		
6.9	Number of fixture			
7	<u>Access and main road lighting</u>			
7.1	Manufacturer			
7.2	Type of fixture		Street light	
7.3	Type of lamp	w	104 W (Min) (LED)	
7.4	Type of mounting		Pole mounted	
7.5	Pole distance from road	m	0.9	
7.6	Pole height	m		
7.7	Fixture mounting heigh	m		
7.8	lamp life	hr		
7.9	Lamp flux	lm	20000 (Min)	
7.10	Lamp efficiency	Lu m/w		
7.11	Type of lighting poles		Hot dip galvanized steel	
7.12	Thickness of painting	µm	80	
8	<u>110 V DC emergency lighting:</u>			
8.1	Manufacturer			

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
8.2	Type of fitting			
8.3	Type of outdoor lamp		LED	
8.4	Type of indoor lamp		LED	
8.5	Location mounted for outdoor DC lighting			
8.6	Degree of protection	IP	55/42	
9	<u>Main indoor lighting equipment</u>			
9.1	Manufacturer			
9.2	Type of lighting fixture		LED	
9.3	Type of lamp	w	bi-pin cap & white type lamp	
10	<u>Lighting Panel</u>			
10.1	Type of incoming circuit breaker		MCCB	
10.2	Type of outgoing circuit breakers		(MCCB or MCB)	
11	<u>Minimum cross section of lighting cables</u>	mm²		
11.1	Minimum cross section of outdoor lighting cables		4	
11.2	Minimum cross section of indoor lighting cables		1.5	
11.3	Minimum cross section of socket cables		2.5	
12	<u>Photo-cell</u>			
12.1	Type			

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
12.2	Location			
13	<u>Electrical Socket</u>			
13.1	Manufacturer			
13.2	Type(s)			
13.3	Voltage Rating		415/240	
13.4	Phases		1/3	
13.5	Rating of socket			
13.6	Single phase	A	>16	
13.7	Three phase	A	Acc. To calculation	
13.8	Current Rating			
13.9	Quantity			
14	<u>Telephone System</u>			
14.1	Subsets			
14.2	Manufacturer			
14.3	Type		Desk mounted / wall mounted/VOIP	
14.4	Type of control & communication cable in telephone system		Ethernet Cable	
14.5	Degree of protection for terminal boxes			
14.6	Indoor	IP	51	

i) LIGHTING AND TELEPHONE SYSTEM		UNIT	DATA	
			REQUIRED	OFFERED
14.7	Outdoor	IP	55	
14.8	Quantities Required (minimum):			
14.9	Desk Mounted Type			
14.10	Wall Type			
14.11	Spare Units:			
14.12	Desk Mounted Type			
14.13	Wall Type			
14.14	Outdoor Wall Type			
15	<u>Type of equipment in battery room</u>		explosion proof	

15. FIRE FIGHTING SYSTEM

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	Transformer Nitrogen Injection and Oil Evacuation Fire Protection System	NA	NA	
1.1	Manufacturer			
1.2	Country of manufacturing			
1.3	Details of System equipment (Model name)			
1.4	Applicable standards		UL, FM, VdS, LPCB, NFPA	
1.5	Certified By			
1.6	Power Supply for control		110/ 48 V DC, variation $\pm 15\%$	
1.7	Power supply for service/lighting		220 V AC, variation $\pm 10\%$	

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
1.8	Fire Extinguishing cubicle (FEC)			
1.8.1	Dimension	L x W x H mm		
1.8.2	Weight	Kg		
1.8.3	Capacity of nitrogen cylinder	m3		
1.8.4	Number of cylinders	nos.		
1.8.5	Pressure of nitrogen filling	Kg/cm2		
1.8.6	Minimum distance of FEC from the transformer	m		
1.8.7	Method of mounting			
1.8.8	Whether the following items are provided in FEC. If so, furnish make, type and other details			
1.8.8.1	Contact Manometer			
1.8.8.2	Pressure Regulator			
1.8.8.3	Oil release unit			
1.8.8.4	Gas release unit			
1.8.8.5	Oil drain assembly			
1.8.8.6	Pressure switch : Back up for nitrogen release			
1.8.8.7	Limit switch: No. of contacts and spare contacts (NO & NC)			
1.8.9	Oil drain valve (above FEC)			
1.8.9.1	Make			
1.8.9.2	Type			
1.8.9.3	Size			
1.8.9.4	Type of metal			
1.8.10	Nitrogen injection valve (above FEC)			
1.8.10.1	Make			
1.8.10.2	Type			
1.8.10.3	Size			
1.8.11	Oil drain pipe			
1.8.11.1	Size			
1.8.11.2	Length			
1.8.11.3	Number of openings in the transformer tank			
1.8.11.4	Material			
1.9	Control Box			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
1.9.1	Dimension	L x W x H mm		
1.9.2	Weight	Kg		
1.9.3	Type & thickness of sheet steel			
1.9.4	Details of components provided in the control box			
1.9.5	Control voltage	V		
1.9.6	Method of mounting			
1.9.7	Whether audio and visual alarms provided?	Yes/No		
1.10	Transformer Conservator isolation valve (TCIV)			
1.10.1	Make			
1.10.2	Type			
1.10.3	Location of installation			
1.10.4	Whether suitable for pipe of size 80mm diameter	Yes/No		
1.10.5	Provision for glass window for inspection	Yes/No		
1.10.6	No. of contacts & spare contacts (NO & NC)	Nos.		
1.10.7	Padlocking provision for service position	Yes/No		
1.10.8	Padlocking provision for filtration/filing/refilling position	Yes/No		
1.11	Fire Detectors			
1.11.1	Make			
1.11.2	Type			
1.11.3	Quantity required	Nos.		
1.11.4	Method of fixing			
1.11.5	Effective heat sensing area	m ²		
1.11.6	Temperature recommended for effective heat sensing	°C		
1.11.7	Number of contacts NO/NC	Nos.		
1.11.8	Necessity and condition of refilling			
1.12	Manufacturer quality system in accordance with ISO 9000, 9001, 9002, 9003 and 9004	Yes/No	Yes	
	Firefighting Equipment for Hydrants and Sprinkler Systems			
2.1	Firefighting Equipment			
2.1.1	Main Pump	Yes/No	Yes	
2.1.2	Jockey Pump	Yes/No	Yes	
2.1.3	Stand by pump	Yes/No	Yes	
2.1.4	Booster pump	Yes/No		
2.1.5	Electric Motor	Yes/No	Yes	
2.1.6	Diesel Engine	Yes/No	Yes	
2.1.7	Control panel (Instrumentation & Control System)	Yes/No	Yes	
2.1.8	Pressure Gauge and Switches	Yes/No	Yes	
2.1.9	Pipes, Nozzles, Fittings and Accessories	Yes/No	Yes	
2.1.10	Pressure Tank	Yes/No	Yes	

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.1.11	Suction Line	Yes/No	Yes	
2.1.12	Common Fabricated steel base frame	Yes/No	Yes	
2.1.13	Fire Detection and Alarm System	Yes/No	Yes	
2.1.14	Sprinkler System	Yes/No	No	
2.1.15	Hydrant Valves	Yes/No	Yes	
2.1.16	Firefighting box (containing hose and fire extinguisher)	Yes/No	Yes	
2.2	Firefighting Package (Fire Pump Package)			
2.2.1	General information			
2.2.1.1	Manufacturer			
2.2.1.2	Country of manufacturing			
2.2.1.3	Year of manufacturing			
2.2.1.4	System type			
2.2.1.5	System model			
2.2.1.6	Applicable standards			
2.2.1.7	Certification			
2.2.1.8	Pressure vessel			
2.2.1.9	No. of pumps			
2.2.1.1	No. of Electric motors			
0				
2.2.1.1	Motor pump	Yes/No		
1				
2.2.1.1	Diesel pump	Yes/No		
2				
2.2.1.1	Control panel (Instrumentation & Control System)			
3				
2.2.1.1	Annunciation System			
4				
2.2.1.1	Power Supply for control system			
5				
2.2.1.1	Power supply for service/lighting			
6				
2.2.2	Main pump			
2.2.2.1	Standby Pump	Yes/No		
2.2.2.2	Manufacturer			
2.2.2.3	Country of manufacturing			
2.2.2.4	Year of manufacturing			
2.2.2.5	Applicable standard			
2.2.2.6	Certification		UL & FM	
2.2.2.7	Listed	Yes/No		
2.2.2.8	Type		Split Case	
2.2.2.9	Model			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.2.1 0	Size			
2.2.2.1 1	Dimensions			
2.2.2.1 2	Dry Weight	kg		
2.2.2.1 3	Flow (Capacity)	GPM	1000	
2.2.2.1 4	Head	m	102	
2.2.2.1 5	Discharge pressure	bar	10	
2.2.2.1 6	Speed	rpm		
2.2.2.1 7	Mounting			
2.2.2.1 8	Casing material			
2.2.2.1 9	Impeller material			
2.2.2.2 0	Shaft material			
2.2.2.2 1	Wearing rings material			
2.2.2.2 2	Mechanical seal material			
2.2.2.2 3	Bearing lubrication			
2.2.2.2 4	Operating temperature			
2.2.2.2 5	Suction x delivery dia.	mm x mm		
2.2.2.2 6	Painting			
2.2.2.2 7	Required electric motor power	HP		
	Electric motor manufacturer			
	Country of manufacturing			
	Year of manufacturing			
	Model name			
	Certification			
	Rated power	HP		
	Applicable standard			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	Voltage	V	415	
	Frequency			
	Speed	RPM		
	Current	A		
	Service factor			
	Service duty			
	Starting	DOL/Soft starter/VFD		
	Enclosure			
	Ingress protection			
	Insulation class			
	Design temperature	°C		
	Design altitude (above sea level)	m		
	Temperature rise			
	Efficiency class			
	Frame size			
	Mounting			
	Direction of rotation (view from drive end)			
	Painting			
2.2.3	Jockey pump			
2.2.3.1	Manufacturer			
2.2.3.2	Country of manufacturing			
2.2.3.3	Year of manufacturing			
2.2.3.4	Applicable standard			
2.2.3.5	Certification			
2.2.3.6	Listed	Yes/No		
2.2.3.7	Type			
2.2.3.8	Model			
2.2.3.9	Size			
2.2.3.10	Dimensions			
2.2.3.11	Dry Weight	kg		
2.2.3.12	Flow (Capacity)	GPM	80	
2.2.3.13	Head	m		
2.2.3.14	Discharge pressure	bar	10.7	
2.2.3.15	Speed	rpm		

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.3.1 6	Mounting			
2.2.3.1 7	Casing material			
2.2.3.1 8	Impeller material			
2.2.3.1 9	Shaft material			
2.2.3.2 0	Wearing rings material			
2.2.3.2 1	Mechanical seal material			
2.2.3.2 2	Bearing lubrication			
2.2.3.2 3	Operating temperature			
2.2.3.2 4	Suction x delivery dia.	mm x mm		
2.2.3.2 5	Painting			
2.2.3.2 6	Required electric motor power	HP		
	Electric motor manufacturer			
	Country of manufacturing			
	Year of manufacturing			
	Model name			
	Certification			
	Rated power	kW		
	Applicable standard			
	Voltage	V	415	
	Frequency			
	Speed	RPM		
	Current	A		
	Service factor			
	Service duty			
	Starting	DOL/Soft starter/VFD		
	Enclosure			
	Ingress protection			
	Insulation class			
	Design temperature	°C		
	Design altitude (above sea level)	m		

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	Temperature rise			
	Efficiency class			
	Frame size			
	Mounting			
	Direction of rotation (view from drive end)			
	Painting			
2.2.4	Booster pump			
2.2.4.1	Manufacturer			
2.2.4.2	Country of manufacturing			
2.2.4.3	Year of manufacturing			
2.2.4.4	Applicable standard			
2.2.4.5	Certification			
2.2.4.6	Listed	Yes/No		
2.2.4.7	Type			
2.2.4.8	Model			
2.2.4.9	Size			
2.2.4.10	Dimensions			
2.2.4.11	Dry Weight	kg		
2.2.4.12	Flow (Capacity)	m3/h		
2.2.4.13	Head	m		
2.2.4.14	Discharge pressure	psi		
2.2.4.15	Speed	rpm		
2.2.4.16	Mounting			
2.2.4.17	Casing material			
2.2.4.18	Impeller material			
2.2.4.19	Shaft material			
2.2.4.20	Wearing rings material			
2.2.4.21	Mechanical seal material			
2.2.4.22	Bearing lubrication			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.4.2 3	Operating temperature			
2.2.4.2 4	Suction x delivery dia.	mm x mm		
2.2.4.2 5	Painting			
2.2.4.2 6	Required electric motor power	HP		
	Electric motor manufacturer			
	Country of manufacturing			
	Year of manufacturing			
	Model name			
	Certification			
	Rated power	HP		
	Applicable standard			
	Voltage	V		
	Frequency			
	Speed	RPM		
	Current	A		
	Service factor			
	Service duty			
	Starting	DOL/Soft starter/VFD		
	Enclosure			
	Ingress protection			
	Insulation class			
	Design temperature	°C		
	Design altitude (above sea level)	m		
	Temperature rise			
	Efficiency class			
	Frame size			
	Mounting			
	Direction of rotation (view from drive end)			
	Painting			
2.2.5	Engine			
2.2.5.1	Manufacturer			
2.2.5.2	Country of manufacturing			
2.2.5.3	Year of manufacturing			
2.2.5.4	Applicable standards		UL&FM	
2.2.5.5	Design temperature	°C		
2.2.5.6	Design altitude (above sea level)	m		
2.2.5.7	Air inlet temperature	°C		

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.5.8	Fuel inlet temperature	°C		
2.2.5.9	Power rating	HP	152	
2.2.5.10	Speed	RPM	3000	
2.2.5.11	Min. and Max. rating	kW @ RPM		
2.2.5.12	Min. and Max. torque	Nm @ RPM		
2.2.5.13	Engine type			
2.2.5.14	Injection Type			
2.2.5.15	Model			
2.2.5.16	Service	Indoor/ outdoor	Indoor	
2.2.5.17	Intake type			
2.2.5.18	Starting type			
2.2.5.19	No. of cylinders			
2.2.5.20	Bore x Stroke	mm		
2.2.5.21	Displacement	cm ³		
2.2.5.22	Compression ratio		By vendor	
2.2.5.23	Emission certification			
2.2.5.24	Max. Temp. rise between ambient air and Engine air inlet	°C		
2.2.5.25	Air cleaner element			
2.2.5.26	Exhaust temperature	°C		
2.2.5.27	Exhaust gas flow	L/sec		
2.2.5.28	Max. back pressure imposed by exhaust system	kPa		
2.2.5.29	Exhaust pipe size	mm		

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.5.3 0	Exhaust protection			
2.2.5.3 1	Aspiration			
2.2.5.3 2	Fuel type		Gas Oil	
2.2.5.3 3	Max. fuel temperature @ lift pump inlet	°C		
2.2.5.3 4	Oil consumption	Kg/hr	0.2	
2.2.5.3 5	Oil sump capacity	Liter		
2.2.5.3 6	Dry weight	kg		
2.2.5.3 7	Wet weight	kg		
2.2.5.3 8	Lubrication type			
2.2.5.3 9	Lubrication system oil pressure	psi		
2.2.5.4 0	Lube oil filter			
2.2.5.4 1	Oil capacity of pan (High-Low)	Liter		
2.2.5.4 2	Lube oil cooler			
2.2.5.4 3	Lube oil pump			
2.2.5.4 4	Battery voltage	V DC		
2.2.5.4 5	Battery capacity	Ah		
2.2.5.4 6	Valves per cylinder: Intake / Exhaust			
2.2.5.4 7	Gate valves			
2.2.5.4 8	Check valves			
2.2.5.4 9	Power take off flywheel			
2.2.5.5 0	Flywheel size			
2.2.5.5 1	Direction of rotation (view from power take-off side)			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.5.5 2	Cooling fan			
2.2.5.5 3	Fitted water radiator (heat exchanger)			
2.2.5.5 4	Raw water pressure at heat exchanger	psi		
2.2.5.5 5	Coolant water capacity (engine side)	Liter		
2.2.5.5 6	Water temperature switch			
2.2.5.5 7	Engine heater	VAC, Watt		
2.2.5.5 8	Centrifugal speed governor			
2.2.5.5 9	Torque regulator			
2.2.5.6 0	Manual start control			
2.2.5.6 1	Overspeed control			
2.2.5.6 2	Run-stop control			
2.2.5.6 3	Run solenoid			
2.2.5.6 4	Stop solenoid			
2.2.5.6 5	Throttle control			
2.2.5.6 6	Water pump type			
2.2.5.6 7	Sound pressure level (front / side / exhaust)	dB(A)		
2.2.5.6 8	Crankcase material			
2.2.5.6 9	Painting			
2.2.6	Control panel			
2.2.6.1	Manufacturer			
2.2.6.2	Country of manufacturing			
2.2.6.3	Year of manufacturing			
2.2.6.4	Applicable standards			
2.2.6.5	Design temperature	°C		
2.2.6.6	Enclosure IP			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
2.2.6.7	Main door lock disconnect switch			
2.2.6.8	MCB			
2.2.6.9	Fuses			
2.2.6.1 0	No. of switching battery chargers			
2.2.6.1 1	Control circuits relay			
2.2.6.1 2	Thermal overload relay			
2.2.6.1 3	Terminal board			
2.2.6.1 4	Motor-Pump-Engine control unit			
2.2.6.1 5	Multifunction instrument with display			
	Voltmeter			
	Ammeter			
	Rev counter			
	Duty hours counter			
	Fuel level gauge			
	Oil pressure gauge			
	Start and stop pushbuttons			
2.2.6.1 6	Indicator lights			
2.2.6.1 7	Test button for first start-up			
2.2.6.1 8	AUT - 0 - MAN selector with key			
2.2.6.2 0	Contacts on the terminal board to remote signals panel			
	Pump running			
	Selector not on AUT			
	Failed starting			
	Control panel and/or batteries fault			
2.2.6.2 1	Automatic engine cranking system			
2.2.6.2 2	Automatic battery charger			
2.2.7	Pipes and valves and fittings			
2.2.7.1	Pipe			
	Manufacturer			
	Country of manufacturing			
	Year of manufacturing			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	manufacturing standards			
	OD	mm		
	Thickness	mm		
	Material			
2.2.7.2	Valves			
	Manufacturer			
	Country of manufacturing			
	Year of manufacturing			
	Manufacturing standard			
	Testing standard			
	Type			
	Model			
	Size			
	Quantity			
	Service condition			
	Construction			
	End connections			
	Rating			
	Face to face			
	Size			
	M.O.C			
	Body			
	Adaptor			
	Ball/ Disc material			
	Gland			
	Spindle			
	Seat			
	Seal			
	Packing			
	Fasteners			
	Actuation			
	Hydro Test pressure	Kg/cm2		
	Pneumatic Test pressure	Kg/cm2		
2.2.7.3	Fittings			
	Manufacturer			
	Country of manufacturing			
	No. and type			
	Material			
	Applicable standard			
2.3	Fire hydrant system (only after full electrical isolation)			
	Manufacturer			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	Country of manufacturing			
	Year of manufacturing			
	Fire hydrant No.		6	
	Fire hydrants locations			
	Near buildings		Yes	
	Transformers		Yes	
	Reactors		Yes	
	Fire hydrant type			
	Fire hydrant dimensions			
	Fire hydrant class			
	Fire hydrant flow	GPM	500	
	Fire hydrant working pressure	psi	10	
	Fire hydrant hydrostatic test pressure	psi	12	
	Fire hydrant clearance	m		
	Size of nozzle	inch		
	Pumper nozzle size	inch		
	Fire hydrants installation			
	Applicable standard			
	Hydrants distance from substation buildings	m	12	
	Hydrants distance from each other	m	90	
	Water Supply			
	Hose Boxes			
	Hose Pipe size and material		2 1/2", The single jacket hose made of high tenacity polyester staple and polyester filaments. Lining is natural rubber	
	Branch pipes size and material			
	Nozzles size and material		2 1/2", Bronze	
	Provision of Hose Reel and wet Riser in the buildings	Yes/No	Yes	
	Hydrant system design for farthest point of the switchyard considering the present scope & future bays	Yes/No	Yes	

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
	Warning plates	Yes/No	Yes	
2.4	Fire water tank			
	Capacity		230	
	Construction type			
	Manufacturer			
	Country of origin			
	Model			
	International listing UL, FM, VdS or LPCB		UL	
2.5	Main fire alarm & extinguishing control panel			
	Manufacturer			
	country of origin			
	Model			
	Type		Analogue addressable	
	International listing UL, FM, VdS or LPCB			
	Number of loops			
	Display type		LCD	
	Enclosure			
	Mounting		Floor	
	Rack size		19" rack system	
	Dimension		2.2x0.8x0.8	
	Batteries for fire alarm panel			
	Type		Maintenanc e free	
	Voltage	V DC	48	
	Backup	hr	24	
	Primary power supply voltage	V	220	
	Printer		Non- thermal	
	Battery type		Maintenanc e free, dry fit and gas tight	
	Secondary power supply from UPS	Yes/No	Yes	
	Mimic Panel	Yes/No	Yes	
	Fascia material		SS (matte finish)	
	Size	mm	800 x 800	
	Fire Extinguishers			

FIRE FIGHTING SYSTEM		UNIT	DATA	
			Required	Offered
3.1.	CO2 Wall Mounting Extinguisher			
3.1.1	Manufacturer			
3.1.2	Country of manufacturing			
3.1.3	Year of manufacturing			
3.1.4	Dimensions			
3.1.5	Weight	Kg		
3.1.6	Type of dry powder		CO2	
3.1.7	Test pressure	Bar g	250	
3.1.8	Working pressure	Bar g	60	
3.1.9	Applicable standards		NFPA	
3.1.10	International listing UL, FM, VdS or LPCB			
3.2.	Dry Powder Wall Mounting Extinguisher			
3.2.1	Manufacturer			
3.2.2	Country of manufacturing			
3.2.3	Year of manufacturing			
3.2.4	Dimensions			
3.2.5	Weight	Kg		
3.2.6	Type of dry powder		ABC	
3.2.7	Test pressure	Bar g	27	
3.2.8	Working pressure	Bar g	15	
3.2.9	Applicable standards		NFPA	
3.2.10	International listing UL, FM, VdS or LPCB			
3.3.	CO2 wheeled Extinguisher			
3.3.1	Manufacturer			
3.3.2	Country of manufacturing			
3.3.3	Year of manufacturing			
3.3.4	Dimensions			
3.3.5	Weight	Kg		
3.3.6	Type of dry powder		CO2	
3.3.7	Test pressure	Bar g	250	
3.3.8	Working pressure	Bar g	55	
3.3.9	Applicable standards		NFPA	
3.3.10	International listing UL, FM, VdS or LPCB			
	Fire Blanket			
	Manufacturer			
4.2	Weight	Kg		
4.3	Temperature Resistance	°C		
4.4	Size	m		
4.5	Material			
4.6	Applicable standards		BS 7944, BS EN 1869:1997	

16. HEATING, VENTILATION AND AIR CONDITIONING

j) HEATING VENTILATION AND AIR CONDITIONING (HVAC)		UNIT	DATA	
			Required	Offered
1.	MAIN HVAC CONTROL PANEL			
	Manufacturer / country of origin			
	Model			
	Applicable standards			
	Enclosure color code			
	HVAC CONTROL PANEL FIRE PUMP ROOM			
	Manufacturer / country of origin			
	Model (wall mounted)			
	Applicable standards			
	Enclosure color code			
2.	SPLIT UNITS			
	Manufacturer / country of origin			
	Quantity		18	
	Model			
	Applicable standards			
	Type			
	Power	kW		
	Condenser model			
3.	AIR COOLED CONDENSING UNITS			
	Manufacturer / country of origin			
	Quantity			
	Model			

j) HEATING VENTILATION AND AIR CONDITIONING (HVAC)	UNIT	DATA	
		Required	Offered
Applicable standards			
Type of refrigerant			
Cooling capacity	Btu/hr	9000,12000,18000,24000	
Number of cooling circuit	No		
Compressors per cooling circuit	No		
Compressor model			
Compressor type			
Condenser coil			
Fin material			
Tube material			
4. EXHAUST FANS			
Manufacturer / country of origin			
Quantity		13	
Model			
International approvals			
Fan Speed	rpm		
Fan impeller material			
Fan Shaft Material			
Voltage/Frequency	V/Hz		
Capacity for Battery room, toilet, pantry, basement	m ³ /hr	2900, 270,770	
Capacity for gas cylinder room, staircase pressurization fans, diesel pump exhaust			
Gas flooded room fan type			
Type			
Basement extract fans			
Battery room fan type		Suitable for hazardous area	

j) HEATING VENTILATION AND AIR CONDITIONING (HVAC)		UNIT	DATA	
			Required	Offered
	Storage warehouse			
	DG house			
5.	EXHAUST AIR FLOW RATES			
5.1	Control Building			
	Telecommunication room	m ³ /s	2	
	Battery room	m ³ /s	15	
	Relay room	m ³ /s	2	
	LVAC/DC room	m ³ /s	2	
	Cable basement	m ³ /s		
	Operator room	m ³ /s	2	
	Office	m ³ /s	2	
	Kitchen or pantry	m ³ /s	12	
	Store	m ³ /s		
	Toilet	m ³ /s	10	
5.2	Guard House and Telecom Room	m ³ /s		
	Main equipment room	m ³ /s		
	Customer equipment room	m ³ /s		
	Battery room	m ³ /s		
	Guard room	m ³ /s		
	Kitchen	m ³ /s		
	Toilet	m ³ /s		
5.3	Staff Housings	m ³ /s		
5.3.1	Technical staff housing	m ³ /s		
	- Bedroom	m ³ /s	2	
	- Living room	m ³ /s	2	

j) HEATING VENTILATION AND AIR CONDITIONING (HVAC)		UNIT	DATA	
			Required	Offered
	- Kitchen	m ³ /s	12	
	- Toilet	m ³ /s	10	
5.3.2	Security staff housing	m ³ /s		
	- Bedroom	m ³ /s	2	
	- Living room	m ³ /s	2	
	- Kitchen	m ³ /s	12	
	- Toilet	m ³ /s	10	
5.4	DG house	m ³ /s		
5.5	Fire pump house	m ³ /s		
6.	SOUND ATTENUATORS			
6.1	Manufacturer / country of origin			
6.2	Model			
6.3	International approvals			
6.4	Main supply air			
6.5	Main return air			
6.6	Pressure drop across attenuators	Pa		
6.7	Main supply air	Pa		
6.8	Main return air	Pa		

17. LOW VOLTAGE CABLES

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
1	<u>Low Voltage Power Cable</u>			
1.1	Manufacturer			
	Name			

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
	Country			
	Type designation			
1.2	Applicable standard			
1.3	Rated voltage	kV rms		
1.4	Number of cores / size			
1.5	Conductor material (Cu/Al) and its class acc. to IEC		High conductivity/plain annealed/copper	
1.6	Type of conductor		Stranded	
1.7	Min thickness & material of insulation	mm	XLPE	
1.8	Type and thickness of inner sheath material	mm	extruded P.V.C	
1.9	Whether shield is provided? (Yes/No)			
1.10	Type and material of armor (wire/tape & Steel/Al)		Galvanized steel wire	
1.11	Type and thickness of outer sheath material	mm	extruded P.V.C	
1.12	High voltage test	kV		
1.13	Short circuit withstand current/time of conductor.	kA/Sec		
1.14	Minimum bending radius at minimum temperature			
1.15	Conductor DC resistance at 20°C	Ω/km		
1.16	Minimum temperature during installation	°C		
1.17	Minimum pulling tension	N		
1.18	Approx. weight of cable	kg/m		

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
1.19	Core identification required	Yes/No	yes	
1.20	Type and routine tests required	Yes/No	yes	
1.21	Distance between cables laid horizontally or in flat		equal to the outer diameter of cables	
2	<u>Control Cable</u>			
2.1	Manufacturer			
	Name			
	Country			
	Type designation			
2.2	Applicable standard			
2.3	Rated voltage	kV rms		
2.4	Type and material of conductor		Stranded/ high conductivity plain annealed copper	
2.5	Diameter of each strand	mm		
2.6	Number and cross section of wires in each cable			
	For CT cable		$\geq 4 \text{ mm}^2$	
	For CVT cable		$\geq 4 \text{ mm}^2$	
	For control cable		2.5 mm^2	
2.7	Insulation material		P.V.C or X.L.P.E	
2.8	Material and thickness of inner sheath	mm	extruded P.V.C	
2.9	Material and thickness of shield	mm	Lead or copper	

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
2.10	Material and thickness of bedding for armor	mm		
2.11	Material and thickness of armor	mm	Aluminium or galvanized steel	
2.12	Material and thickness of outer sheath	mm	extruded P.V.C	
2.13	Type of sheath between shield and armor			
2.14	Short circuit withstand current/time of conductors	kA/Sec		
2.15	Minimum bending radius at minimum temperature			
2.16	Conductor DC resistance at 20°C	Ω/km		
2.17	Minimum temperature during installation	°C		
2.18	Minimum pulling tension	N		
2.19	Core identification required	Yes/No	yes	
2.20	Type and routine tests required	Yes/No	yes	
3	<u>Fiber Optic Cables</u>			
3.1	Manufacturer			
3.2	Type of optical fiber cable			
3.3	Number of cores			
3.4	Mode - field diameter at 1550 nm &	μm		
	Mode - field diameter at 1310 nm			
3.5	Effective core area	μm ²		
3.6	Mode field concentricity error at 1550 nm &	≤ μm		

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
3.7	Mode field concentricity error at 1310 nm			
3.8	Mode field non - circularity error			
3.9	Cut - off wavelength λ_{CC}			
3.10	Attenuation coefficient : in 1550 nm &	dB/K m		
	Attenuation coefficient : in 1310 nm			
3.11	1550 nm bend performance	\leq db		
3.12	Non - zero dispersion region	nm		
3.13	Zero dispersion wavelength	$< \mu\text{m}$		
3.14	Cladding diameter	μm		
3.15	Cladding non - circularity	$\leq \%$		
3.16	Primary coating diameter	μm		
3.17	Primary coating concentricity error	$\leq \mu\text{m}$		
3.18	Primary coating non- circularity error	$\leq \%$		
3.19	Fiber materials			
3.20	Fiber coating material			
3.21	Number of armor			
3.22	Material of outer jacket			
3.23	Color coding of fiber			
3.24	Normal drum length	m		

h) LOW VOLTAGE CABLES		UNIT	DATA	
			REQUIRED	OFFERED
3.25	Proof stress level	≥ Gpa		
4	<u>Cable Gland</u>			
4.1	Cable glands			
	Manufacturer			
	Material			
	Type designation			
5	<u>Cable Tray, Ladder and Accessories</u>			
5.1	Manufacturer			
	Name			
	Country			
	Type designation			
5.2	Material			
5.3	Galvanized thickness			

18. DIESEL GENERATOR

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
1	<u>General</u>			
1.1	Design Ambient Temperature	℃(min) , ℃(max)	According to General requirements document	

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
1.2	Humidity	%	According to General requirements document	
1.3	Installation		indoor	
1.4	ELECTRICAL SYSTEM			
	ALTERNATOR			
	Model			
	AVR Model			
	Rated Cont. Power Output			
	Rated Voltage (no load)	V , %	415 , ±5	
	Alternator Matched to Engine Output		yes	
	Main Exciter(brushless)		yes	
	Earthing		Solidly grounded	
	Over Speed Rating	%	120	
1.5	CONTROL INSTRUMENTS			
	Control Card	Yes/No	yes	
	Auto Start-up , Mains Failure	Yes/No	yes	
	Manual Start-up	Yes/No	yes	
	ALARMS			
	Start-up Failure	Yes/No	yes	
	Battery Change Failure	Yes/No	yes	
	Low Oil Pressure	Yes/No	yes	
	High Engine Water Temperature	Yes/No	yes	
	Low Fuel Level	Yes/No	yes	

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
	Low Radiator Water Level	Yes/No	yes	
	Emergency Stop	Yes/No	yes	
	Over speed	Yes/No	yes	
	PROTECTION DEVICE			
	Emergency Stop Button	Yes/No	yes	
	ATS (optional)			
2	<u>A.C. Generator</u>			
2.1	General			
	Manufacturer			
	country			
2.2	Degree Of Protection For GEN		Ip23	
2.3	Degree Of Protection For Term Box		Ip55	
2.4	Type designation			
2.5	Number of Poles			
2.6	Class of insulation:			
	Stator			
	Rotor			
2.7	Rated voltage	V rms	415 , 3 , ±5	
2.8	Rated current	A rms		
2.9	Rated out put	kVA	250(Kabarnet)/315 (Rumuruti)	
2.10	Rated Power Factor	lag	0.8	
2.11	Total Harmonic Distortion	%	<3	
2.12	Over-load rating and time duration	kW.h		

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
2.13	Short circuit withstand in 1 second (with submission of calculation)	kA (rms)		
2.14	Rated frequency	HZ	50 , ± 2	
2.15	Emergency Standby Duty	Yes/No	yes	
2.16	Time to Accept Full Load After Start up	% step load , sec	100 / 10	
2.17	Load in % of Rated Continuous Power	%	25,50,75,100,110	
2.18	Voltage stability equipment and range			
2.19	frequency stability equipment and range			
2.20	Connection of windings			
2.21	Neutral grounding			
2.22	Is generator brushless?			
2.23	Number of Phases			
2.24	Reactances:			
2.25	Synchronous Xd	%		
2.26	Transient X'd	%		
2.27	Sub transient X''d	%		
2.28	Type of cooling			
2.29	Efficiency at rated voltage and frequency:			
2.30	75% rated load			
2.31	100% rated load			
2.32	Exciter details:			

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
2.33	Manufacturer			
2.34	Power rating	kW		
2.35	Voltage rating	V-DC		
2.36	Max. instantaneous change in frequency for instantaneous load change from zero to full load			
3	<u>Diesel Engine</u>			
3.1	Manufacture			
3.2	country			
3.3	Type designation			
3.4	Number of cylinders		6	
3.5	Speed	r.p.m	1500	
3.6	Type of cooling		Water cooled	
3.7	Compression Ratio		By vendor	
3.8	Coupling			
3.9	Start-up time from initiation until circuit breaker closes	S		
3.10	Number of strokes			
3.11	Compression ratio			
3.12	Efficiency at rated load	%		
3.13	Fuel Type		HSD	
3.14	Rated Overload Power(1hr in 24 hr)	% of Rated Load	110	

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
3.15	Cylinders Wet or Dry		wet	
3.16	Frame		cast	
3.17	Starter Motor			
3.18	Fuel Tank Capacity			
3.19	Fuel injection system			
3.20	Specific fuel consumption at:(Based on generation output)			
3.21	Aspiration (Natural or supercharger)			
3.22	ENGINE SAFETY SHUTDOWN WITH ALARM & INDICATION			
3.23	Engine Over Speed	Yes/No	yes	
3.24	Low lube Oil Pressure	Yes/No	yes	
3.25	High Jacket Water Temperature	Yes/No	yes	
3.26	Fuel Engine Leakage	Yes/No	yes	
3.27	Flow of Air From Fan	m ³ /min		
3.28	Water Jacket Heater	Yes/No	yes	
3.29	LUBRICATION SYSTEM			
3.30	Maximum Oil Consumption (% Fuel Consumption)		0.2	
4	<u>Governor</u>			
4.1	Type	Electric/Hydraulic	Electronic	
4.2	Manufacturer and country			

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
5	<u>Starting system</u>			
5.1	Type of the battery			
5.2	Number of Batteries		1	
5.3	Capacity of the battery	Ah		
5.4	Rated voltage of the battery	V DC	24	
5.5	Type of starter			
5.6	Type of charger			
5.7	charger voltage supply			
6	<u>Control and indication</u>			
6.1	Type of control cubicle (local console or control panel)			
6.2	Number and type of alarms			
6.3	Number and type of alarms			
6.4	Type of remote alarms			
6.5	Metering equipment (manufacturer, type and range):			
	A.C. ammeter			
	A.C. voltmeter			
	Frequency-meter			
	Water temperature indicator			
	Oil pressure indicator			

h) DIESEL GENERATOR		UNIT	DATA	
			REQUIRED	OFFERED
	Running hour-meter			
6.6	Control switches and knobs (manufacturer and type)			
6.7	Protective relaying (manufacturer and type)			
6.8	Circuit breaker (contactor):			
	Manufacturer and type			
	Current rating	A(rms)		
7	<u>Weight and dimension</u>			
7.1	Main fuel tank			

19. TDS-CCTV

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Horizontal resolution		
	in color mode lines	>800	
	in B/W mode lines	>800	
4	Vertical resolution lines	≥600	
5	Minimum illumination Lx		
	in color mode	0.02	
	in B/W mode	0.002	
6	Zoom speed S	Approx. 4.5	
7	Focus speed S	Approx. 6.0	
8	Video out put	1.0V-PAL	
9	Panning range Degree	Composite/75 Ω 360° Endless	
10	Tilting range Degree	0°-180°	
11	Iris	Automatic(Open/Close Id Possible) /Manual	
12	Alarm in	4 Inputs (Alarm IN 1-4)	
13	Alarm out	2Outputs (Alarm/Aux1, B/W/Aux2)	
14	Ambient operating temperature °C	-40°C to +85°C	
15	Ambient operating humidity	max (year):100 min(year):20	
16	Heater yes/no	Yes	
17	Power of heater W	40	
18	Weight kg	To be specified by Supplier	
19	Number of camera's	7	
20	IP protection	IP66/67	

TDS for movable camera

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Horizontal resolution in color mode lines in B/W mode lines	>800 >800	
4	Vertical resolution lines	≥600	
5	Minimum illumination Lx in color mode in B/W mode	0.02 0.002	
6	Signal to noise ratio dB	30	
7	Lens mount	To be specified by Supplier	
8	Video out put	1.0V-PAL Composite/75 Ω	
9	Electronic shutter		
10	Alarm out	Yes	
11	Ambient operating temperature °C	-40°C to +85°C	
12	Ambient operating humidity	max (year):100 min(year):20	
13	Heater yes/no	No	
14	Power of heater W	40	
15	Weight kg	To be specified by Supplier	
16	Number of camera's	10	
17	IP protection	IP66/67	

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Manufacturer's model number	To be specified by Supplier	
4	Focal length mm	To be specified by Supplier	
5	Aperture	To be specified by Supplier	
6	Mount	To be specified by Supplier	
7	Image format	To be specified by Supplier	
8	Dimension	To be specified by Supplier	

TDS for fixed camera and lens

Item	Description	Client Request	Guaranteed
A	General		
1	Manufacturer's name and country	Should comply to outdoor	
2	Applicable technical standard	STP-ANSI/TIA-568C, IEC, VDE, BS...	
3	Voltage rating kV	0.6/1KV	
4	Conductor material	Cu	
5	Type of conductor (stranded or solid)	Stranded	
6	Conductor insulation material	PVC	
7	Insulation resistance at 20oC mΩ /Km		
8	Sheath material	PVC	
9	Composition of sheath:		
	a) Lead sheath lead %	To be specified by Supplier	
	Tin %		
	Cadmium %		
	Antimony %		
	b) Other sheath	To be specified by Supplier	
10	Armoring material	Galvanized steel	
11	Number of layers of steel tapes	2-tape	
12	Type of outer sheath and color	P.V.C/Black/Blue	
13	Minimum bending radius x (O.D.)	12*(O.D.)for multi-core & 15*(O.D.)for single core	
14	Test voltage levels kV	3.5KVAC	

TDS for CCTV cable

Item	Description	Client Request	Guaranteed
B 1	Special for each type Manufacture's type and designation	NYRY	
2	No. of cores and core cross section area No./mm ²	At design stage	
3	Normal current carrying capacity (in air), at 30 °C A	At design stage	
4	Thickness of core insulation mm	≥0.8	
5	Color code or numbering code of cores	At design stage	
6	Thickness of sheath mm	≥1.8	
7	Minimum thickness of insulation between core and sheath mm	≥1.0	
8	Armoring thickness mm	To be specified by Supplier	
9	External diameter of completed cable mm	To be specified by Supplier	
10	Weight per meter of completed cable Kg	To be specified by Supplier	
11	Estimated length which will be provided per drum m	To be specified by Supplier	
12	Estimated length of cable to be supplied m	As Req.	
13	Max. current in inter shield (armors or shield) under line ground fault condition A	To be specified by Supplier	
14	Resistance of each core per km at 20°C Ω	To be specified by Supplier	
15	Mean electro - static capacitance of each conductor to earth per km of complete cable	To be specified by Supplier	
16	Estimated length for control & protection cables m	As Req.	

TDS for CCTV power cable

Item	Description	Client Request	Guaranteed
A	General	Should comply to outdoor STP ANSI/TIA 568C	
1	Manufacturer's name and country	Specified by Supplier	
2	Applicable technical standard	BS 6500(1990) similar to IEC (227)(53)	
3	Voltage rating kV	0.3/0.5	
4	Conductor material	Cu	
5	Type of conductor (stranded or solid)	stranded	
6	Conductor insulation material	PVC	
7	Insulation resistance at 20oC mΩ /Km	1000	
8	Sheath material	PVC	
9	Composition of sheath: a) Lead sheath lead %	To be specified by Supplier	
	Tin %		
	Cadmium %		
	Antimony %		
	b) Other sheath	To be specified by Supplier	
10	Armoring material	To be specified by Supplier	
11	Number of layers of steel tapes	To be specified by Supplier	
12	Type of outer sheath and color	PVC / White	
13	Minimum bending radius x (O.D.)	7xO.D ~ 7 Cm	
14	Test voltage levels kV	To be specified by Supplier	

TDS for CCTV data cable-2

Item	Description	Client Request	Guaranteed
11.3.2	Special for each type		
1	Manufacture's type and designation	To be specified by Supplier	
2	No. of cores and core cross section area No./mm ²		
3	Normal current carrying capacity (in air), at 30 °C A	To be specified by Supplier	
4	Thickness of core insulation mm	To be specified by Supplier	
5	Color code or numbering code of cores	At design stage	
6	Thickness of sheath mm	Acc. To IEC...	
7	Minimum thickness of insulation between core and sheath mm	Acc. To IEC...	
8	Armoring thickness mm	To be specified by Supplier	
9	External diameter of completed cable mm	To be specified by Supplier	
10	Weight per meter of completed cable Kg	To be specified by Supplier	
11	Estimated length which will be provided per drum m	To be specified by Supplier	
12	Estimated length of cable to be supplied m	As Req.	
13	Max. current in inter shield (armors or shield) under line ground fault condition A	To be specified by Supplier	
14	Resistance of each core per km at 20 °C Ω	To be specified by Supplier	
15	Mean electro - static capacitance of each conductor to earth per km of complete cable	To be specified by Supplier	
16	Estimated length for control & protection cables m	As Req.	

TDS for CCTV data cable-2

Item	Description	Client Request	
1	Manufacture's name and country	To be specified by Supplier	
2	Type of fixture	Telescopic	
3	Fixture mounting height m	5 ~ 7	
4	Number of fixtures	As Req.	
5	Minimum length of horizontal bracket	At design stage	
6	Type of bracket for movable camera	At design stage	
7	Heater yes/no	in Housing	
8	Power of heater W	40	

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Material of cabinet	To be specified by Supplier	
4	Material of glass	Nano Type	
5	Dimension Length mm Width mm Height mm	To be specified by Supplier	
6	No. of housing for fixed camera	As Req.	
7	No. of housing for movable camera	As Req.	

TDS for camera fixture and housing

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Ambient operating temperature	+10°C-+40°C	
4	Ambient operating humidity	90%	
5	Power Source voltage current	230VAC-9VDC To be specified by Supplier	
6	Controller number	4	
7	Camera number selection	≥24	
8	All of lens functions	Yes	
9	System operation	To be specified by Supplier	
10	Pan/Tilt	To be specified by Supplier	
11	Switching functions	To be specified by Supplier	
12	Type of output data/input data	RS485-P.S-Data	
13	Type of prot. for PC	Via matrix	
14	Accessories	To be specified by Supplier	

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Type of camera inputs	32	
4	Type of camera outputs	1600%	
5	Frequency response (MHZ)	>6	
6	Time of switching interval S	Variable/as setup	
7	Ext. time input	Yes	
8	Ext. time output	Yes	
9	Alarm input	Yes	
10	Number of alarm input	≥8	
11	Alarm buzzer	Yes	
12	Power source	AC/22-230V	
13	Three – position - lever switchers	Yes	

TDS for controller and video switches

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Ambient operating temperature	+10°C-+40°C	
4	Ambient operating humidity	90%	
5	Power Source voltage current	230VAC-9VDC To be specified by Supplier	
6	Controller number	4	
7	Camera number selection	≥24	
8	All of lens functions	Yes	
9	System operation	To be specified by Supplier	
10	Pan/Tilt	To be specified by Supplier	
11	Switching functions	To be specified by Supplier	
12	Type of output data/input data	RS485-P.S-Data	
13	Type of prot. for PC	Via matrix	
14	Accessories	To be specified by Supplier	

Item	Description	Client Request	Guaranteed
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Type of camera inputs	32	
4	Type of camera outputs	1600%	
5	Frequency response (MHZ)	>6	
6	Time of switching interval S	Variable/as setup	
7	Ext. time input	Yes	
8	Ext. time output	Yes	
9	Alarm input	Yes	
10	Number of alarm input	≥8	
11	Alarm buzzer	Yes	
12	Power source	AC/22-230V	
13	Three – position - lever switchers	Yes	

TDS for controller and video switches

Item	Description	Client Request	
1	Manufacturer's name and country	To be specified by Supplier	
2	Manufacturer's type and designation	To be specified by Supplier	
3	Video input	To be specified by Supplier	
3-1	Standard	To be specified by Supplier	
	e) Pal/CCIR, lines, field per second		
	o) NTSC/EIA, Lines, field per second		
3-2	No. of channel	32	
3-3	Resolution		
	e) In quality mode	Min:	
	o) in speed mode	25Im/sec	
		720x576 PAL	
		100Im/sec	
		360x288 PAL	
4	Video output	Min: BNC out/ monitor out	
		RGB/ S video/ RCA	
4-1	Standard	To be specified by Supplier	
	One) Pal/CCIR, lines, field per second		
	Two) NTSC/EIA, Lines, field per second		
4-2	No. of channels	Min: 2xBNC/ 1XRGB/ S video	
5	Type of standalone operation	To be specified by Supplier	
6	Communication	RS485/RS232/R	
6-1	Network	S 985 ,RJ11	
6-2	Concurrent users	10/100 RJ45	
		To be specified by Supplier	
6-3	Web server	Yes	
6-4	Sure link	Yes	
6-5	Modem port	RS 45	
6-5-1	Port	RS 105	
6-5-2	Data bits	RS 232	

Item	Description	Client Request	Guaranteed
6-5-3	Stop bit	100 mbps over Ethernet	
6-5-4	Connection speed	32 ~ unlimited	
6-5-5	Parity	Yes	
6-6	Aux port	To be specified by Supplier	
7	Recording		
7-1	Mode	To be specified by Supplier	
7-2	HD type		
7-3	HD size		
7-4	Max. recording rate	Min: 100 fps per channel Depend on storage EXT.(To 7.5TB)	
8	Event handling		
8-1	Event type	To be specified by Supplier	
8-2	Action type		
8-3	External input		
9	Relay switch		
9-1	No. of channels	Min: 32CH=16CHx2	
9-2	Max. rating	To be specified by Supplier	
10	Power		
10-1	Voltage	240VAC	
10-2	Max. current	To be specified by Supplier	
11	Operating environment		
11-1	Ambient temperature	+10° to +40°	
11-2	Relative humidity	Less than 90%	

TDS for CCTV DVR

C. . Supplementary Information

D. Table of Contents

1.SAMPLE SIGNAL LIST	844
2.COLOR CODES AND BRANDING	855

1. SAMPLE SIGNAL LIST

The sample signals provided as Table 4, for reference only.

Table 4: Sample Signal Lists.

COMMON SIGNALS
AC SUPPLY HEATING, LIGHTING & SOCKET 110V DC CABINET
110V DC SUPPLY FROM BATTERY CHARGER 1
110V DC SUPPLY VOLTAGE MEASURING BB1
110V DC SUPPLY FROM BATTERY CHARGER 2
110V DC SUPPLY VOLTAGE MEASURING BB2
110V DC SUPPLY TFO & OLTC
110V DC SUPPLY RTU
110V DC SUPPLY BUSBAR PANEL
110V DC SUPPLY FEEDER(S) PANEL(S) MPR 1 & MPR 2
110V DC SUPPLY FEEDER(S) PANEL(S) CLOSE & TRIP CIRCUITS
110V DC SUPPLY HV SIDE TRANSFORMER(S) PANEL(S) MPR 1 & MPR 2
110V DC SUPPLY HV SIDE TRANSFORMER(S) PANEL(S) CLOSE & TRIP CIRCUITS
110V DC SUPPLY LV SIDE TRANSFORMER(S) PANEL(S) MPR 1 & MPR 2
110V DC SUPPLY LV SIDE TRANSFORMER(S) PANEL(S) CLOSE & TRIP CIRCUITS
110V DC SUPPLY HV LINE(S) PANEL(S) MPR 1 & MPR 2
110V DC SUPPLY HV LINE(S) PANEL(S) CIRCUITS
110V DC SUPPLY BUSBAR(S) CB, DS'S & DSES
110V DC SUPPLY HV LINE(S) CB, DS'S & DSES
110V DC SUPPLY HV SIDE TRANSFORMER(S) PANEL(S)CB & DS
110V DC SUPPLY LV SIDE TRANSFORMER(S) PANEL(S)CB & DS'S
110V DC SUPPLY FEEDER(S) CB, DS'S & DSES
AC SUPPLY HEATING LIGHTING & SOCKET 48V DC CABINET
48V DC SUPPLY FROM BATTERY CHARGER1
48V DC SUPPLY VOLTAGE MEASURING BB1
48V DC SUPPLY FROM BATTERY CHARGER2
48V DC SUPPLY VOLTAGE MEASURING BB2
48V DC SUPPLY 1 RTU

COMMON SIGNALS
48V DC SUPPLY MULTIPLEXER PANEL
NORMAL EMERGENCY SWITCH-OVER
110V DC SUPPLY VOLTAGE MEASURING
AC SUPPLY HEATING, LIGHTING & SOCKET AC
AC SUPPLY HV MARSHALLING KIOSKS CABINETS
AC SUPPLY FEEDERS MARSHALLING KIOSKS CABINETS
AC SUPPLY HV PROTECTION CABINETS
AC SUPPLY FEEDERS PROTECTION CABINETS
AC SUPPLY HEATING, LIGHTING & SOCKET AC/48VDC/110VDC CABINETS
AC SUPPLY HEATING & LIGHTING COMMUNICATION CABINETS
AC SUPPLY TRANSFORMERS & OLTC
AC SUPPLY FIRE ALARM PANEL
AC SUPPLY CONTROL BUILDING & GUARD HOUSE
AC SUPPLY 48V DC BATTERY CHARGER 1
AC SUPPLY 48V DC BATTERY CHARGER 2
AC SUPPLY 110V DC BATTERY CHARGER1
AC SUPPLY 110V DC BATTERY CHARGER 2
ETHERNET SWITCH(ES) STATUS
GPS STATUS
DIESEL GENERATOR FUEL LOW
DIESEL GENERATOR BATTERY VOLTAGE LOW

BUSBAR SIGNALS
ALARMS
BUSBAR LINE CIRCUIT BREAKER FAILURE STAGE 1 TRIP (ALL CONNECTED LINES)
BUSBAR TRANSFORMER CIRCUIT BREAKER FAILURE STAGE 1 TRIP (ALL CONNECTED TRANSFORMERS)
BUSBAR BUS 1 DIFFERENTIAL ALARM
BUSBAR BUS 2 DIFFERENTIAL ALARM
BUSBAR CHECKZONE DIFFERENTIAL PROTECTION TRIP

BUSBAR BUS 1 DIFFERENTIAL PROTECTION TRIP
BUSBAR BUS 2 DIFFERENTIAL PROTECTION TRIP
BUSBAR BUS 1 DIFFERENTIAL OUT
BUSBAR BUS 2 DIFFERENTIAL OUT
BUSBAR BUS 1 BREAKER FAILURE OUT
BUSBAR BUS 2 BREAKER FAILURE OUT
BUSBAR TRANSFORMER START CBF 3 PHASE (ALL CONNECTED TRANSFORMERS)
BUSBAR LINE START CBF 3 PHASE (ALL CONNECTED LINES)
BUSBAR RELAY FAIL
BUSBAR RELAY COMMUNICATION FAIL
INDICATIONS
BUSBAR LINE DISCONNECTOR POSITION (FOR ALL CONNECTED LINES)
BUSBAR BAY TRANSFORMER DISCONNECTOR POSITION (FOR ALL CONNECTED TRANSFORMERS)
BUSBAR AWENDO CIRCUIT BREAKER 105 POSITION
BUSBAR LINE CIRCUIT BREAKER 205 POSITION (ALL CONNECTED LINES)
BUSBAR TRANSFORMER CIRCUIT BREAKER POSITION (ALL CONNECTED TRANSFORMERS)
ANALOGUES
BUSBAR LINE CURRENT PHASE B (ALL CONNECTED LINES)
BUSBAR TRANSFORMER CURRENT PHASE B (ALL CONNECTED TRANSFORMERS)

HV LINE SIGNALS
ALARMS
LINE CIRCUIT BREAKER
ALARM
LINE CIRCUIT BREAKER SF6 OPERATING LOCKOUT
LINE CIRCUIT BREAKER CLOSING LOCKOUT DRIVE
LINE CIRCUIT BREAKER POLE DISCREPANCY
LINE CIRCUIT BREAKER PROTECTIVE MOTOR SWITCH TRIP
LINE GROUND DISTANCE ZONE 3 TRIP
LINE CIRCUIT BREAKER HEATING FAILURE
LINE DISCONNECTOR(S) MOTOR PROTECTION TRIP

HV LINE SIGNALS
LINE DISCONNECTOR (S) HEATING FAILURE
LINE BCPU VT SUPPLY FAILURE
LINE CIRCUIT BREAKER 105 BLOCK CLOSE
LINE TRIP CIRCUIT 1 FAILURE
LINE TRIP CIRCUIT 2 FAILURE
LINE MCIRCUIT BREAKER DISCONNECTOR SUPPLY FAILURE
LINE VOLTAGE TFO SIGNAL ENERGY METER FAIL
LINE MCIRCUIT BREAKER VT REFERENCE SIGNAL SYNCHROCHECK FAIL
LINE SYNCHROCHECK ON
LINE SYNCHROCHECK OVERRIDE
LINE INTERLOCK OVERRIDE
LINE PHASE OVERCURRENT TRIP
LINE BCPU GENERAL TRIP
LINE EARTH FAULT TRIP
LINE SYNCHROCHECK OK
LINE F101 DISTANCE PROTECTION INTERNAL FAILURE
LINE MAIN PROTECTION 2 SUPPLY FAILURE
LINE VT SIGNAL LINE DIFFERENTIAL PROTECTION FAILURE
LINE CIRCUIT BREAKER F STAGE 2 FOR DTT
LINE DIFFERENTIAL TRIP
LINE PHASE DISTANCE ZONE 1 TRIP
LINE PHASE DISTANCE ZONE 2 TRIP
LINE GROUND DISTANCE ZONE 1 TRIP
LINE GROUND DISTANCE ZONE 2 TRIP
LINE PHASE UNDERVOLTAGE 1 TRIP
LINE PHASE OVERVOLTAGE STAGE 1 ALARM
LINE PHASE OVERVOLTAGE TRIP STAGE 2
LINE PHASE OVERVOLTAGE TRIP STAGE 3 / DTT SENT
LINE VT FUSE FAIL
LINE PHASE OVERCURRENT TRIP

HV LINE SIGNALS
LINE EARTH FAULT TRIP
LINE DIFFERENTIAL PROTECTION CH1 FAIL
LINE DIFFERENTIAL PROTECTION CH2 FAIL
LINE CIRCUIT BREAKER TRIP 3 PHASE TC1
LINE CIRCUIT BREAKER TRIP 3 PHASE TC2
LINE PHASE OVERVOLTAGE LEVEL 1 TRIP
LINE PHASE OVERVOLTAGE LEVEL 2 TRIP
LINE PHASE UNDERVOLTAGE LEVEL 1 TRIP
LINE SWITCH ONTO FAULT Z2
LINE DIFFERENTIAL PROTECTION RELAY INTERNAL FAILURE
LINE BCPU INTERNAL FAILURE
LINE MAIN PROTECTION 1 SUPPLY FAILURE
LINE CIRCUIT BREAKER HEATING AND LIGHTING TRIP
LINE CIRCUIT BREAKERF STAGE 2 FOR DTT
LINE VT SIGNAL DISTANCE PROTECTION FAILURE
LINE CIRCUIT BREAKER BLOCK AUTORECLOSE
LINE CIRCUIT BREAKER AUTORECLOSE INITIATE
LINE CIRCUIT BREAKER AUTORECLOSE SWITCH OFF
LINE CIRCUIT BREAKER AUTORECLOSE SWITCH 1P
LINE CIRCUIT BREAKER AUTORECLOSE SWITCH 1P+3P
LINE PERMISSIVE RECEIVE 21L
LINE PERMISSIVE RECEIVE 67N
LINE PERMISSIVE SEND 21L
LINE PERMISSIVE SEND 67N
LINE DTT RECEIVE FROM LINE SS
LINE DTT SEND TO LINE SS
LINE GROUND DISTANCE ZONE 1 TRIP
LINE GROUND DISTANCE ZONE 2 TRIP
LINE GROUND DISTANCE ZONE 3 TRIP
LINE GROUND DISTANCE ZONE 4 TRIP

HV LINE SIGNALS
LINE PHASE DISTANCE ZONE 1 TRIP
LINE PHASE DISTANCE ZONE 2 TRIP
LINE PHASE DISTANCE ZONE 3 TRIP
LINE PHASE DISTANCE ZONE 4 TRIP
INDICATIONS
LINE CIRCUIT BREAKER STATUS
LINE DISCONNECTOR(S) STATUS
LINE EARTH SWITCH STATUS
LINE CIRCUIT BREAKER LOCAL/REMOTE STATUS
LINE DISCONNECTOR LOCAL/REMOTE STATUS
LINE DISCONNECTOR 104 IN REMOTE
LINE BCU RELAY LOCAL/REMOTE STATUS
LOCKOUT RELAY STATUS
ANALOGUES
LINE VOLTAGE BC PHASE
LINE CURRENT B PHASE
LINE MW
LINE MVA _r
LINE MVA
LINE POWER FACTOR
LINE HZ
LINE FAULT DISTANCE IN KM
COMMANDS
LINE CIRCUIT BREAKER OPEN/CLOSE COMMAND
LINE DISCONNECTOR(S) OPEN/CLOSE COMMAND
LOCKOUT RELAY REMOTE RESET COMMAND

TRANSFORMER HV SIDE
ALARMS
TRANSFORMER HV CIRCUIT BREAKER SF6 ALARM

TRANSFORMER HV SIDE
TRANSFORMER HV CIRCUIT BREAKER SF6 OPERATING LOCKOUT
TRANSFORMER HV AC SUPPLY FAIL
TRANSFORMER HV CIRCUIT BREAKER POLE DISCREPANCY
TRANSFORMER HV CIRCUIT BREAKER PROTECTIVE MOTOR SWITCH TRIP
TRANSFORMER HV CIRCUIT BREAKER DRIVE LOCKOUT / EXCESSIVE MOTOR RUNNING
TRANSFORMER HV CIRCUIT BREAKER HEATING FAILURE
TRANSFORMER HV DISCONNECTOR(S) MOTOR PROTECTION TRIP
TRANSFORMER HV DISCONNECTOR(S) HEATING FAILURE
TRANSFORMER HV TRIP CIRCUIT 1 FAILURE
TRANSFORMER HV TRIP CIRCUIT 2 FAILURE
TRANSFORMER HV DISCONNECTOR SUPPLY FAILURE
TRANSFORMER HV INTERLOCK OVERRIDE
TRANSFORMER HV MAIN PROTECTION 1 SUPPLY FAILURE
TRANSFORMER HV DIFFERENTIAL PROTECTION INTERNAL FAILURE
TRANSFORMER HV PHASE OVERCURRENT TRIP
TRANSFORMER HV BCPU GENERAL TRIP
TRANSFORMER HV EARTH FAULT TRIP
TRANSFORMER HV LOCKOUT RELAY TRIP
TRANSFORMER HV MAIN PROTECTION 2 SUPPLY FAILURE
TRANSFORMER HV BCPU INTERNAL FAILURE
TRANSFORMER HV MINIMUM OIL LEVEL TRANSFORMER ALARM
TRANSFORMER HV MAXIMUM OIL LEVEL TRANSFORMER ALARM
TRANSFORMER HV MINIMUM OIL LEVEL OLTC ALARM
TRANSFORMER HV MAXIMUM OIL LEVEL OLTC ALARM
TRANSFORMER HV BUCHHOLZ ALARM
TRANSFORMER HV OIL TEMPERATURE INDICATOR
TRANSFORMER HV WINDING TEMPERATURE HV ALARM
TRANSFORMER HV WINDING TEMPERATURE LV ALARM
TRANSFORMER HV BUCHHOLZ TRIP
TRANSFORMER HV OIL TEMPERATURE TRIP

TRANSFORMER HV SIDE
TRANSFORMER HV WINDING TEMPERATURE HV TRIP
TRANSFORMER HV WINDING TEMPERATURE LV TRIP
TRANSFORMER HV PROTECTION RELAY OLTC TRIP
TRANSFORMER HV PRESSURE RELIEF RELAY OLTC TRIP
TRANSFORMER HV MECHANICAL TRANSFORMER TRIP OPERATED
TRANSFORMER HV GENERAL TRIP TO K86-1
TRANSFORMER HV GENERAL TRIP - CIRCUIT BREAKERF TO BB
TRANSFORMER HV CIRCUIT BREAKER FAILURE INITIATE TO MV CIRCUIT BREAKER
TRANSFORMER HV CIRCUIT BREAKER 1T0 TRIP 3 PHASE TC1
TRANSFORMER HV CIRCUIT BREAKER 1T0 TRIP 3 PHASE TC2
TRANSFORMER HV TRANSFORMER PERCENTAGE DIFFERENTIAL TRIP
TRANSFORMER HV TRANSFORMER INSTANTANEOUS DIFFERENTIAL TRIP
TRANSFORMER HV LOW IMPEDANCE RESTRICTED EARTH FAULT TRIP
TRANSFORMER HV (MV TRANSFORMER) CIRCUIT BREAKER FAILURE DIRECT TRIP INPUT
INDICATIONS
TRANSFORMER HV CIRCUIT BREAKER OPEN/CLOSE STATUS
TRANSFORMER HV DISCONNECTOR(S) OPEN/CLOSE STATUS
TRANSFORMER HV CIRCUIT BREAKER LOCAL/REMOTE STATUS
TRANSFORMER HV DISCONNECTOR(S) LOCAL/REMOTE STATUS
TRANSFORMER HV BCU LOCAL/REMOTE STATUS
ANALOGUES
TRANSFORMER HV VOLTAGE BC PHASE
TRANSFORMER HV CURRENT B PHASE
TRANSFORMER HV MW
TRANSFORMER HV MVar
TRANSFORMER HV MVA
TRANSFORMER HV POWER FACTOR
TRANSFORMER HV HZ
COMMANDS
TRANSFORMER HV CIRCUIT BREAKER OPEN/CLOSE COMMAND

TRANSFORMER HV SIDE

TRANSFORMER HV DISCONNECTOR(S) OPEN/CLOSE COMMAND

TRANSFORMER LV SIDE**ALARMS**

TRANSFORMER MV AVR INTERNAL FAILURE

TRANSFORMER MV TRIP CIRCUIT 1 FAILURE

TRANSFORMER MV TRIP CIRCUIT 2 FAILURE

TRANSFORMER MV INTERLOCK OVERRIDE

TRANSFORMER MV MAIN PROTECTION 2 SUPPLY FAILURE

TRANSFORMER MV DISCONNECTOR(S) SUPPLY FAILURE

TRANSFORMER MV VT SIGNAL ENERGY METER FAILURE

TRANSFORMER MV VT SIGNAL BCU FAILURE

TRANSFORMER MV VT AVR INTERNAL FAILURE

TRANSFORMER MV HEATING, LIGHTING & SOCKET FAILURE

TRANSFORMER MV CIRCUIT BREAKER SF6 ALARM (0,54MPA)

TRANSFORMER MV CIRCUIT BREAKER SF6 OPERATING LOCKOUT (0,51MPA)

TRANSFORMER MV CIRCUIT BREAKER CLOSE LOCKOUT DRIVE

TRANSFORMER MV CIRCUIT BREAKER MOTOR PROTECTION TRIP

TRANSFORMER MV CIRCUIT BREAKER EXCESSIVE MOTOR RUNNING

TRANSFORMER MV CIRCUIT BREAKER HEATING FAILURE

TRANSFORMER MV DISCONNECTOR(S) MOTOR PROTECTION TRIP

TRANSFORMER MV DISCONNECTOR(S) HEATING FAILURE

TRANSFORMER MV FEEDERS CIRCUIT BREAKER FAILURE STAGE 2 FROM OUTGOING FEEDERS

TRANSFORMER MV CIRCUIT BREAKER FAILURE INITIATE FROM HV TRANSFORMER

TRANSFORMER MV CIRCUIT BREAKER FAILURE STAGE 2 FROM 132KV BB BAY

TRANSFORMER MV VT 33KV BUSBAR FAILURE

TRANSFORMER MV PHASE OVERCURRENT TRIP

TRANSFORMER MV BCU GENERAL TRIP

TRANSFORMER MV EARTH FAULT TRIP

TRANSFORMER MV CIRCUIT BREAKERF INITIATE TO RT01

TRANSFORMER MV AVR UNDER VOLTAGE BLOCK
TRANSFORMER MV AVR OVER VOLTAGE BLOCK
TRANSFORMER MV AVR OVER CURRENT BLOCK
TRANSFORMER MV TAP CHANGER MOTOR DRIVE RUNNING
TRANSFORMER MV TAP CHANGER CC FAILURE
TRANSFORMER MV TAP CHANGER HEATING FAILURE
TRANSFORMER MV TAP CHANGER VOLTAGE MONITORING FAILURE
TRANSFORMER MV MAIN PROTECTION 1 SUPPLY FAILURE
TRANSFORMER MV BCU INTERNAL FIALURE
INDICATIONS
TRANSFORMER HV CIRCUIT BREAKER OPEN/CLOSE STATUS
TRANSFORMER HV DISCONNECTOR(S) OPEN/CLOSE STATUS
TRANSFORMER MV CIRCUIT BREAKER LOCAL/REMOTE STATUS
TRANSFORMER MV DISCONNECTOR(S) LOCAL/REMOTE STATUS
TRANSFORMER MV BCU IN LOCAL STATUS
TRANSFORMER MV AVR IN LOCAL / REMOTE
TRANSFORMER MV AVR IN MANUAL / AUTOMATIC
TRANSFORMER MV AVR IN INDEPENDANT / PARALLEL
ANALOGUES
TRANSFORMER MV VOLTAGE BC PHASE
TRANSFORMER MV CURRENT B PHASE
TRANSFORMER MV MW
TRANSFORMER MV MVA _r
TRANSFORMER MV MVA
TRANSFORMER MV POWER FACTOR
TRANSFORMER MV HZ
TRANSFORMER MV TAP CHANGER TAP POSITION
COMMANDS
TRANSFORMER MV CIRCUIT BREAKER 1T0 COMMAND
TRANSFORMER MV DISCONNECTOR(S) 1T3 COMMAND
AVR MANUAL / AUTOMATIC CONTROL

AVR INDEPENDENT / PARALLEL OPERATION

TAP POSITION RAISE / LOWER

FEEDERS SIGNALS

ALARMS

FEEDER BCU INTERNAL FAILURE

FEEDER MAIN PROTECTION 2 SUPPLY FAILURE

FEEDER VT SIGNAL DISTANCE PROTECTION FAILURE
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FEEDER AUTORECLOSE SWITCH ON

FEEDER AUTORECLOSE SWITCH OFF

FEEDER BLOCK AUTORECLOSER

FEEDER AUTORECLOSE INITIATE FROM BCU

FEEDER CIRCUIT BREAKER 1L5 TRIP TC1

FEEDER CIRCUIT BREAKER 1L5 TRIP TC2

FEEDER CIRCUIT BREAKER 1L5 AUTORECLOSE
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FEEDER PHASE DISTANCE ZONE 1 TRIP

FEEDER PHASE DISTANCE ZONE 2 TRIP

FEEDER GROUND DISTANCE ZONE 1 TRIP

FEEDER GROUND DISTANCE ZONE 2 TRIP

FEEDER MAIN PROTECTION 1 SUPPLY FAILURE

FEEDER DISTANCE PROTECTION INTERNAL FAILURE

FEEDER INITIATE CIRCUIT BREAKERF DISTANCE PROTECTION
--

FEEDER HEATING & LIGHTING SUPPLY FAILURE
--

FEEDER VT SIGNAL BCU FAILURE

FEEDER BCU INTERLOCK OVERRIDE

FEEDER CIRCUIT BREAKER SF6 ALARM (0,54MPA)
--

FEEDER CIRCUIT BREAKER SF6 TRIP LOCK OUT (0,51MPA)
--

FEEDER CIRCUIT BREAKER CLOSE LOCKOUT DRIVE
--

FEEDER CIRCUIT BREAKER EXCESSIVE MOTOR RUNNING
--

FEEDER CIRCUIT BREAKER MOTOR PROTECTION TRIP
--

FEEDER CIRCUIT BREAKER HEATING FAILURE
--

FEEDER DISCONNECTOR(S)(S) MOTOR PROTECTION TRIP

FEEDER DISCONNECTOR(S) (S)HEATING FAILURE

FEEDER DISCONNECTOR(S) SUPPLY FAILURE

FEEDER VT SIGNAL ENERGY METER FAILURE
FEEDER TRIP CIRCUIT 1 FAILURE
FEEDER TRIP CIRCUIT 2 FAILURE
FEEDER PHASE OVERCURRENT TRIP
FEEDER BCU GENERAL TRIP
FEEDER EARTH FAULT TRIP
FEEDER TRANSFORMER MV CIRCUIT BREAKERF STAGE 2 TRIP
FEEDER LOCKOUT RELAY STATUS
INDICATIONS
FEEDER CIRCUIT BREAKER OPEN/CLOSE STATUS
FEEDER DISCONNECTOR(S)OPEN/CLOSE STATUS
FEEDER EARTH SWITCH OPEN/CLOSE STATUS
FEEDER CIRCUIT BREAKER LOCAL/REMOTE STATUS
FEEDER DISCONNECTOR(S) LOCAL/REMOTE STATUS
FEEDER BCU IN LOCAL/REMOTE STATUS
ANALOGUES
FEEDER VOLTAGE BC PHASE
FEEDER CURRENT B PHASE
FEEDER MW
FEEDER MVar
FEEDER MVA
FEEDER POWER FACTOR
FEEDER HZ
FEEDER FAULT DISTANCE IN KM
COMMANDS
FEEDER CIRCUIT BREAKER OPEN/CLOSE COMMAND
FEEDER DISCONNECTOR(S)OPEN/CLOSE COMMAND
FEEDER LOCKOUT RELAY REMOTE RESET COMMAND

2. COLOR CODES AND BRANDING

The following requirements for color, painting and branding shall be maintained.

Table 2: Color Scheme Schedule.

Item	Color	Code	Description
Roof cladding	Green	C=58, M=26, Y=99, K=7	Pre-painted sheets
Rain water gutter	Green	C=58, M=26, Y=99, K=7	Concrete/ Metal sheet
Fascia Board	Green	C=58, M=26, Y=99, K=7	
Berg board	Green	C=58, M=26, Y=99, K=7	
Gable	Green	C=58, M=26, Y=99, K=7	
Ring beam	Red	C=0, M=100, Y=100, K=0	
Lintel beam	Red	C=0, M=100, Y=100, K=0	
External wall (main)	White/ Light green		80% of total height
External columns	To match main wall and skirting color		
Skirting	Green	C=58, M=26, Y=99, K=7	20% of total height
Ceiling	White		
Doors and door frames	Grey	C=0, M=0, Y=40, K=0	
Window frames	Grey	C=0, M=0, Y=40, K=0	
Gates	Green	C=58, M=26, Y=99, K=7	
Interior walls	Warm/ soft white		

Table 3: Paint Codes Roofing Sheets Suppliers.

Supplier	Roofing Sheet	Walls, Doors, Skirting, Gutters Paints	Paint	Contact person
Mabati Rolling Mills (SAFAL GROUP)	KETRACO Green Box profile sheets. Must make prior order of at least 3000m ² Alternatively use Forest Green	-	Both Galaxy and Sadolin paint will provide the KETRACO Green	Ask for Steve Kiruthi 0735 511196
Rafiki Mabati (City Engineering works Ltd.)	KETRACO Green Box profile sheets. Alternatively use Forest Green	-	Both Galaxy and Sadolin paint will provide the KETRACO Green	Ask for Jamil 0701 100001
Maisha Mabati (Devki Group)	KETRACO Green Box profile sheets. Must make prior order of at least 5 tonnes Alternatively use Forest Green	-	Both Galaxy and Sadolin paint will provide the KETRACO Green	Ask for Pandeet 0756 020000
Galaxy Paints	-	Ask for: Green – KETRACO Green Red - KETRACO Red Grey – KETRACO Grey	Manufactures paints and supplies MRM, RM, MM.	Ask for Tom 0722 358654
Sadolin Paints	-	Ask for: Green – KETRACO Green Red - KETRACO Red Grey – KETRACO Grey	Manufactures paints and supplies MRM, RM, MM.	Ask for Juliet 0732 888826
Duracoat paints	-	Ask for: Green – Beaumonde 2623C Red - Adventure 2189C Grey – Color Plus C138	Manufactures paints	-
Crown paints	-	Ask for: Green – Climbing vine 102A Red – Geranium 04E53 Grey – Granite 00A09	Manufactures paints	-

Substation Outdoor Recommended Colors illustrated in Figure 1 and Figure 2.

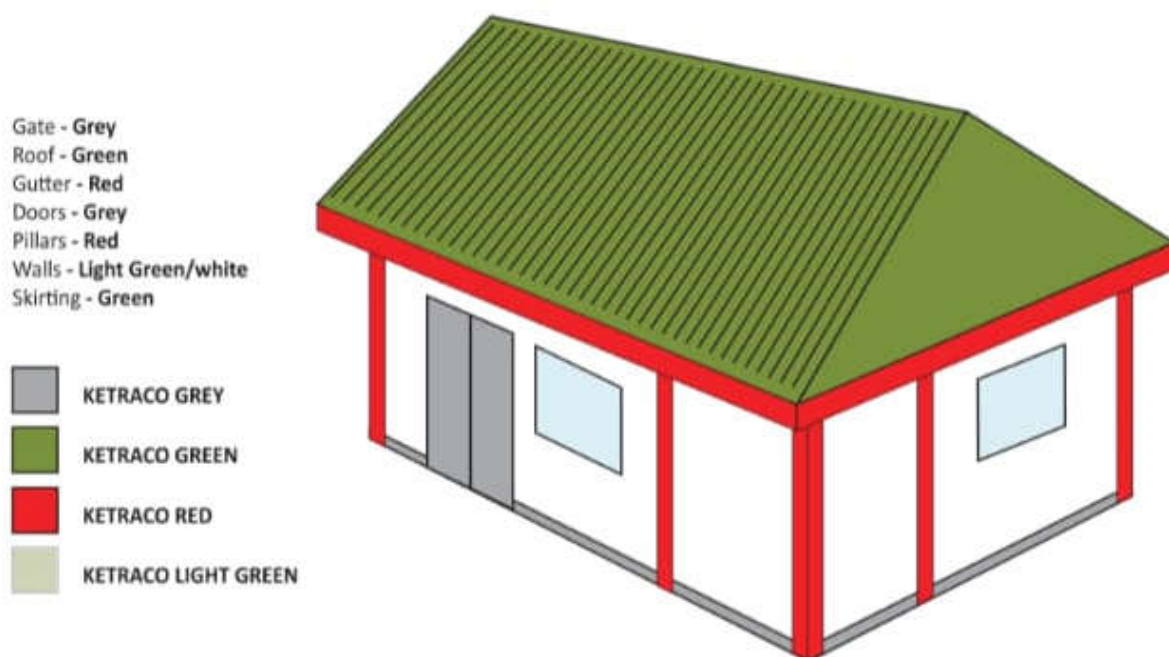


Figure 1: Substation Building Recommended Colors



Figure 2: Substation Main Gate Recommended Colors and Branding.

Substation signs contents and dimensions shall be according to Figure 3 and Figure 4.



Figure 3: Substation Sign Single Sided (20 x 10.6 Ft).



Figure 4: Directional Sign Double Sided (8 x 4).