PART 2 – Employer's Requirements

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

1. Contents

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 wall, 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 shut down 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 outage plan shall ensure the contract requisite works progress while at the same time power flow through the substation to the distribution feeders is always assured. No outage should last longer than 8 hours.

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)
- Integrated Closed Circuit Television (CCTV) System for the substation buildings and outdoor area
- 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, adequate to serve requirements of control building, staff housing and guard house, automatic level controls shall be provided. Also, 5000 litres elevated water tanks shall be considered near the control building with required pumps to be fed from the main water reservoir.
- 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
- HVAC system shall include Dual Split Units and shall be considered in the control building, guard house and telecom collocation room 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, staff housing shall be constructed, which their design shall be subjected to approval of Client/Engineer.
- Internal access roads to switchyard and to buildings shall be implemented to match existing road 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.

- 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.
- Complete stringing of transmission line slack spans (*between terminal tower and line gantry inclusive of jumpers' termination on the terminal tower*) with all related works for the new 132kV Narok-Bomet double circuit transmission line utilizing ACSR Lynx as well as OPGW both at Narok and Bomet Substation ends.
- Shaded car parking
- Machineries, tools, appliances, instruments and test equipment
- Temporary works, mobilization and de-mobilization

1.2 Site Location

1.2.1 Existing Narok 132/33kV Substation

The coordinates of existing Narok substation land are provided below.

Point No.	SS coordinates (ARC 1960 UTM ZONE 36 S)	
	Easting (m)	Northing (m)
1	825027	9879597
2	825123	9879584
3	825099	9879372
4	825003	9879412

The boundaries of Narok substation land is shown in the below figure.

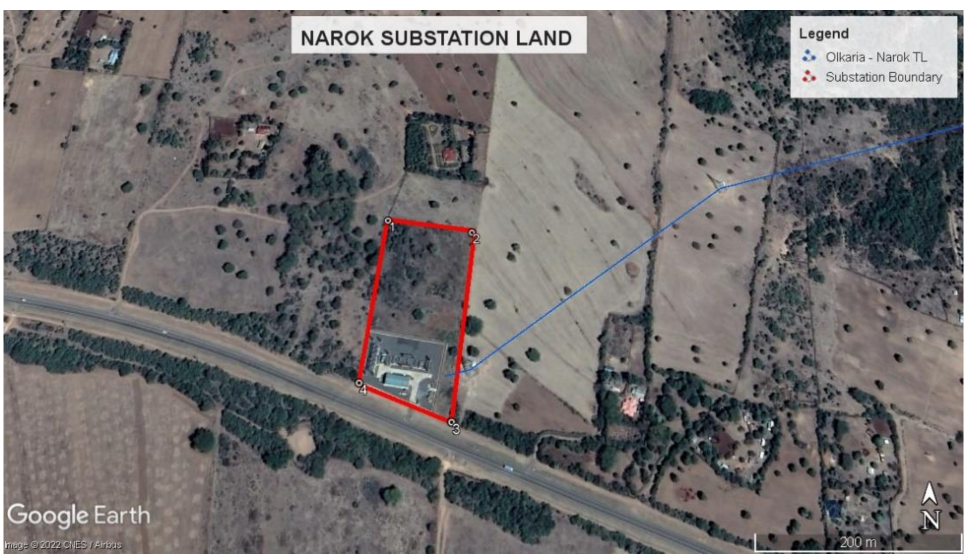

Figure 1: Existing Narok Substation.

1.2.2 Existing Bomet 132/33kV Substation

The coordinates of existing Bomet substation land are as detailed below:

Point No.	SS coordinates (ARC 1960 UTM ZONE 36 S)	
	Easting (m)	Northing (m)
1	753957	9914169
2	754008	9914222
3	754140	9913977
4	754056	9913923
5	754021	9913948
6	754047	9913977
7	754036	9913999
8	754042	9914003

The boundaries of Bomet substation land is shown in the below figure.

Figure 2: Existing Bomet Substation Location.

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 shut down 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 outage plan shall ensure the contract requisite works progress while at the same time power flow through the substation to the distribution feeders is always assured. No outage should last longer than 8 hours.

1.3.1 Extension Works at Narok 132/33 kV Substation

The Contractor shall refer to the existing substation drawings (attached for bidder's reference) and develop SLDs, Equipment layout and other drawings for scope of works of extension of Narok substation with 132kV and 33kV air-insulated switchyards (including supply and installation of 1 x 23MVA 132/33kV Power Transformer).

The works include but not limited to the development / modifications on the following:

a) Extension and modification works at 132kV AIS switchyard:
- Busbar modification from single bus to 132kV double busbar with a bus-coupler. This shall include replacement of existing current transformers to provide sufficient dedicated cores as per the required busbar protection scheme. Bay current transformers shall ensure provision of dedicated two (2) cores for busbar 1 and busbar 2.
- One (1 no.) 132kV bay for bus Coupler
- Modification and reconfiguration of 132 kV Olkaria line bay to fit in double busbar arrangement
- Two (2no.) new 132 kV line bays for the two outgoing circuits to Bomet of Narok-Bomet transmission line
- One (1no) new 132 kV transformer bay for new 132/33 kV transformer
- Modification and reconfiguration of existing 132kV transformer-1 bay to fit in double busbar arrangement.
- One (1no) new Auxiliary transformer and transformer bay
- Associated foundations and civil works.
- Equipment and other support structures installations and associated foundations
- Gantry structures installations and associated foundations

- Supply, installation, testing and commissioning of one (1no.) 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. The new power transformer shall be capable of operating in parallel with the existing power transformer. The parallel method shall be master follower scheme using CAN bus.

b) Extension and modification works at 33kV AIS switchyard:
   - One (1no.) new 33 kV bus
   - One (1no.) new 33 kV bus sectionalizer
   - Three (3 no.) new 33 kV line feeders
   - One (1no.) 33kV transformer bay
   - One (1no) new 33kV Auxilliary transformer bay

c) Supply and installation of One (1) No. 33/0.415kV, 250 kVA, ONAN auxiliary transformer, Dyn11, with 5 taps in step of 2.5% and z =4.5%. The existing transformer shall be decommissioned and delivered to the Client and the new one shall be installed in its place. All related modifications / replacement / relocation / completion work included in the scope of work. Changeover facilities with the generator to be provided. All related modifications/replacement/relocation/completion works shall be included in the scope of work.
d) Supply, installation, test and commissioning of 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.
e) Replacement of energy meters in existing bays and installation of new energy meters in the extension bays.
f) Extension of existing earth mat to cover the entire switchyard (for new and existing equipment)
g) Supply, installation, testing and commissioning of One (1) 0.415kV, 250kVA Diesel Generator
h) Testing, commissioning and training
i) Protection and control, SCADA and telecoms end to end tests with Dispatching Centers
j) Preparation and submission of updated As-built documents approved by the Client/Consultant
k) Complete and functional system integration to existing grid
l) Upgrade/replacement of the entire SAS and SCADA 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.
   - The supplied gateways to be capable of transmitting Integrated Total values totals (telegram with TypeId: <37> M_IT_TB_1) for the Energy meters.
   - Integrate, test and commission the combined SCOPE to the National Control Center including the necessary Data Engineering at the National Control Servers.
   - Old and new Scopes to be integrated to the same redundant HMIs. The servers shall be industrial computers based. The testing and commissioning of the HMIs to be done.
   - Supply and Installation of a pure sine wave Inverter that will draw power from the 110VDC batteries to supply the HMIs.
   - The new network communication protocols to match the existing.
   - Design, Supply, install new LAN network equipment including LAN Switches for the new SCOPE.

m) Upgrade existing Telecommunications Equipment in both substations to achieve the following:
   - Upgrade the link to STM-4/ 2.5 G MPLS-TP with associated functionalities, e.g. WAN etc

- Supply and installation of new cards for Tele-protection signaling for distance protection and differential protection for the two new line bays.
- Create redundancy on existing communications links.
- Implement CCTV for the substations.

n) Modification of the 132kV and 33kV busbar protection scheme from HIGH impedance to a new centralized LOW impedance type considering the number of 132kV and 33kV bays including the new and existing 132kV and 33kV bays.
o) De-commissioning of existing 132kV and 33kV high impedance busbar protection scheme and handing over the protection panels with its accessories to KETRACO.
p) Validation of existing protection settings to achieve the necessary grading with existing systems.
q) Development of new protection settings for extension scope.
r) Modification of the existing protection and control systems including commissioning and testing to achieve protection coordination and grading.
s) The extension/modification scope for protection and control, SAS, SCADA and Telecoms shall match the existing systems.
t) Modification/extension of the remote end stations protection, control and telecommunication and SAS/SCADA systems including commissioning and testing to achieve full system functionality.
u) The LVAC/LVDC systems shall be modified/extended to ensure adequate capacity for the loads associated with the extension works.
v) Provision of additional battery bank with at least 400Ah capacity together with 100A battery changer. 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.
x) Recovery of existing 132kV line bay CT and Transformer Bay CT.
y) 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.
z) Construction of internal access roads to switchyard and to buildings to match existing road standard. Necessary warnings / signage shall also be fixed. Suitable slopes / drains / manholes shall be provided for water to flow to the substation drainage system.
aa) Rehabilitation of existing water supply system and connection 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 shall be via an overhead tank minimum capacity of 5,000L. The main water reservoir of 30,000L (as minimum) capacity adequate to serve requirements of control building and guard house, automatic level controls shall also be provided.
bb) Integration of the existing drainage system with the new drainage system for the extension scope.
cc) Integration of existing sewerage system with the new sewerage system
dd) Removal, modification and completion of existing boundary wall / fencing to approval
ee) Construction of Emergency diesel generator house
ff) Extension/modification of control room building to accommodate additional panels.
gg) Extension of guard house to include collocation room.
hh) Relocation of Olkaria-Narok line to the new gantry to be constructed under this project. This includes all supply and installation of requisite conductors, OPGW, fittings and necessary hardware items to complete the works related to the slack span.

ii) Modification of existing lightning protection and lighting system to cover the entire switchyard.

jj) 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.

kk) Other electrical, mechanical and civil works including complete equipment as per technical requirements and tender drawings to complete the scope of works to ensure substations functionality.

ll) Complete stringing of transmission line slack span (*between terminal tower and line gantry inclusive of jumpers' termination on the terminal tower*) with all related works for the new 132kV Narok-Bomet double circuit transmission line utilising ACSR Lynx as well as OPGW.

mm) Replacement of energy meters in existing bays and installation of new energy meters in the extension bays.

nn) Upgrade existing Telecommunications Equipment in both substations to achieve the following:

   i. Upgrade the link to STM-4 plus 2.5 G MPLS-TP for aggregated network data services with associated functionalities, e.g. WAN etc
   ii. Supply and installation of new/upgrade of cards for transport, control as well as Tele-protection signalling for distance protection and differential protection for the two new line bays.
   iii. Create redundancy on existing communications links.
   iv. Implement CCTV for the substations.

1.3.2 Extension Works at Bomet 132/33 kV Substation

The Contractor shall refer to the existing substation drawings (attached for bidder's reference) and develop SLDs, Equipment layout and other drawings for scope of works of extension of Bomet substation with 132kV and 33kV air-insulated switchyards (including supply and installation of 1 x 23MVA 132/33kV Power Transformer) attached for bidder's reference.

The works include but not limited to the development / modifications of the following:

a) Extension and modification works at 132kV AIS switchyard:
   - Busbar modification from single bus to 132kV double bus bar with bus coupler. This shall include replacement of existing current transformers to provide sufficient dedicated cores as per the required busbar protection scheme. Bay current transformers shall ensure provision of dedicated two (2) cores for busbar 1 and busbar 2.
   - One (1 No.) 132kV bay for bus Coupler
   - Modification and reconfiguration of 132 kV Sotik line bay to fit in double busbar arrangement.
   - Two (2) new 132 kV line bays for the two outgoing circuits to Narok of Narok-Bomet transmission line
   - 1 new 132 kV transformer bay for new 132/33 kV transformer
   - Modification and reconfiguration of existing 132 kV transformer-1 bay to fit in double busbar arrangement.
   - One (1) Auxiliary transformer and transformer bay
   - Associated foundation and civil works.
   - Equipment and other support structures installations and associated foundations
   - Gantry structures installations and associated foundations
   - Supply, installation, testing 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. 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:
- One (1no.) new 33 kV bus
- One (1no.) new 33 kV bus sectionaliser
- Development of new 33 kV line feeders
- One (1no.) No. 33kV transformer bay
- 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 One (1) No. 33/0.415kV, 250 kVA, ONAN auxiliary transformer, Dyn11, with 5 taps in step of 2.5% and z =4.5%. The existing transformer shall be decommissioned and delivered to the Client and the new one shall be installed in its place. All related modifications / replacement / relocation /completion works included in the scope of work. Changeover facilities with the generator to be provided. All related modifications/replacement/relocation/completion works included in the scope of work.
d) Recovery of existing One (1) No. 33/0.415kV, 1000 kVA, ONAN auxiliary transformer, Dyn11 and handover to KETRACO.
e) Supply, installation, testing and commissioning of One (1) 0.415kV, 250kVA Diesel Generator
f) 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.
g) Replacement of energy meters in existing bays and installation of new energy meters in the extension bays.
h) Extension of existing earth mat to cover the entire switchyard (for new and existing equipment).
i) Testing, commissioning, and training
j) Protection and control, SCADA and telecoms end to end tests with Dispatching Centers
k) The extension of existing busbar protection system shall be retested and recommissioned together with all other required modifications.
l) Complete and functional system integration to existing grid
m) Upgrade/replacement of the entire SAS/SCADA 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 totals (telegram with TypeId: <37> M_IT_TB_1) for the Energy meters.
    iii. Integrate, test and commission the combined SCOPE to the National Control Center including the necessary Data Engineering at the National Control Servers.
    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. Supply and Installation of a pure sine wave Inverter that will draw power from the 110VDC batteries to supply the HMIs.
    vi. The new network communication protocols to match the existing.

vii. Design, Supply and Installation of new LAN network equipment including LAN Switches for the new scope.

n) Upgrade existing Telecommunications Equipment in both substations to achieve the following:
   v. Upgrade the link to STM-4 plus 2.5 G MPLS-TP for aggregated network data services with associated functionalities, e.g. WAN etc
   vi. Supply and installation of new/upgrade of cards for transport, control as well as Tele-protection signalling for distance protection and differential protection for the two new line bays.
   vii. Create redundancy on existing communications links
   viii. Implement CCTV for the substations.

o) Modification of the 132kV and 33kV busbar protection scheme from HIGH impedance to new centralized LOW impedance type considering the number of 132kV and 33kV bays, including the new and existing 132kV and 33kV bays.
p) Decommissioning of existing 132kV and 33kV high impedance busbar protection scheme and handing over the protection panels with its accessories to KETRACO.
q) Modification of the existing protection and control systems including commissioning and testing to achieve protection coordination and grading.
r) Modification/extension of the remote end station protection, control and telecommunication and SAS/SCADA systems including commissioning and testing to achieve full system functionality.
s) The LVAC/LVDC systems shall be modified/extended to ensure adequate capacity for the loads associated with the extension works.
t) Provision of additional battery bank with at least 400Ah capacity together with 100A battery changer. 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) The extension/modification scope for protection and control, SAS, SCADA and Telecoms shall match the existing systems.
v) Validation of existing protection settings to achieve the necessary grading with existing systems.
w) Development of new protection settings for extension scope.
x) Extension of control room building to accommodate additional panels.
y) Extension of guard house to include collocation room.
z) Construction of Emergency diesel generator house
aa) 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.
bb) Construction of internal access roads to switchyard and to buildings to match existing road standard. Necessary warnings / signage shall also be fixed. Suitable slopes / drains / manholes shall be provided for water to flow to the substation drainage system.
cc) Construction of approximately 1000m external access road to bituminous standards from the main highway to the substation, including provision for necessary drainage channels.
dd) Demolition and recovery of existing 132kV busbar. Recovery of existing 132kV line bay CT and Transformer Bay CT.
ee) Relocation of Sotik line to the new gantry to be constructed under this project. This includes supply and installation of all requisite conductors, OPGW fittings and necessary hardware items to complete the works.
ff) Modification of existing lightning protection and lighting system to cover the entire switchyard

gg) Removal, modification and completion of existing boundary wall / fencing to approval)
hh) Construction of Emergency diesel generator house
ii) Extension/modification of control room building
jj) 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.
kk) Other electrical, mechanical and civil works including complete equipment as per technical requirements and tender drawings to complete the scope of works to ensure substations functionality.
ll) Complete stringing of transmission line slack span (*between terminal tower and line gantry inclusive of jumpers' termination on the terminal tower*) with all related works for the new 132kV Narok-Bomet double circuit transmission line utilising ACSR Lynx as well as OPGW.

2. Extent of Works

The Contract Works to be supplied shall include all works (at Narok and Bomet substations) 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 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 statements to minimize the shutdown period.
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 (8 hours) 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 Narok 132/33kV and Bomet 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 clamps and fittings at substation side, and the line contractor shall supply the relevant clamps and fittings at overhead line side together with the suitable conductor as jumper.

The detail of terminal points of:

- Extension Substations (i.e., Narok 132/33kV and Bomet 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, testing and commissioning works), and making connection to the upstream/downstream Substations, and Dispatching Centers.
- Termination of transmission line slack spans' downlead conductor on the substation's equipment for the new 132kV double circuit Narok-Bomet overhead transmission line.

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

- 132kV Double Circuit Narok - Bomet overhead transmission line (88km)

Additional to the new transmission line to be developed in another project below transmission lines are terminating at the respective substations:

- 132kV Double Circuit Olkaria - Narok overhead transmission line (Single Circuit only strung with the other to be done later) being terminated at Narok Substation.
- 132kV Double Circuit Sotik – Bomet overhead transmission line (Single Circuit only strung with the other to be done later) being terminated at Bomet Substation.

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.

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	1ºC
Maximum temperature	40ºC
Max. Conductor temperature	80ºC
Annual average temperature	25ºC

(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/m^2 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

(h) Altitude

The height above sea level shall be considered 2000-2500 m (as per each 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.

3. Health and Safety and Compliance with Regulations

3.1 Safety of Personnel

The maximum safety, consistent with good erection practice, must be afforded to personnel directly engaged on this Contract, or who in the normal course of their occupation find it necessary to utilize temporary works erected by the Contractor or frequent the working area. Reasonable measures shall be taken to afford adequate protection against material falling from a higher level onto personnel below.

The works shall be conformed to the requirements of ISO 45001 standard (valid certificate to be submitted).

The Contractor and his representatives shall always comply with KETRACO's Employer's Safety Rules regarding electrical apparatus and the safety of men working thereon.

Particular care shall be taken during work at places where the line runs parallel to other lines that may be energized.

No testing or other work on apparatus which has been delivered to Site and which is liable to be electrically charged from any source shall be permitted except under a "Permit to Work" which will be issued for the purpose by KETRACO's Operating Project Manager.

At the completion of the Contract Works the Project Manager shall undertake an inspection to ensure the operational safety of the overhead electricity transmission lines. For this purpose, the Contractor shall jointly undertake with the Project Manager and KETRACO an inspection of the Contract Works. The cost of any re-inspection occasioned by non-compliance with the Specification by the Contractor shall be borne by the Contractor.

Prior to construction work commencing, the Contractor shall provide a H&S Plan, incorporating the Environmental, Health and Safety Management plan, for review by the Project Manager. This Plan shall cover all activities related to the execution of the Project.

3.2 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.

4. 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.

5. 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).

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.

6. 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.

7. 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.

8. 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.

9. 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.

10. 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.

10.1 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.

10.2 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 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:

   - the duties and responsibilities assigned to staff ensuring quality of work for the Contract;
   - hold and notification points;
   - submission of engineering documents required by the Specification;
   - the inspection of materials and components on receipt;
   - reference to the Contractor's work procedures appropriate to each activity;
   - inspection during fabrication/construction;
   - 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.

10.3 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.

10.4 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.

10.5 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.

10.6 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:

i. Periodic monitoring to confirm the effectiveness of, and the Contractor's compliance with, the established quality plan, system procedures and inspection and test plan.

ii. Witnessing of inspections and tests and/or verification of inspection records to be carried out at the Project Manager's discretion covering:

   - compliance of raw material with specified requirements
   - compliance of manufactured parts, assemblies and final items with specifications, drawings, standards and good engineering practice
   - witnessing of inspection and tests
   - 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 relief 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.

10.7 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.

10.8 Non-Conformances

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.

10.9 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.

10.10 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.

11. Design and Standardization

The design shall be according to International Standards, ISO, IEC, EN, BS or equivalent while local material shall conform to KEBS[1] , 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.

[1] Kenya Bureau of Standards

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.

12. Quality of Material

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

13. 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).

14. 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.

14.1 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 SCADA System
- Telecommunication Equipment
- 110VDCBattery Chargers Pure sine wave inverter and UPS
- Gantries, Steel Structures and Accessories
- Post and String Insulators

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.

15. Erection, Supervision and Checking of Work on Site

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.

16. 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.

16.1 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.

17. 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) Aluminium ladder, 1 set for each substation.

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 = 8**no**.) shall be provided by the Contractor for use by the Employer project implementation team members as well as substation operation and relay configuration.

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.
- Keyboard-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 signalling rate (charging); 1 SuperSpeed USB Type-A 5Gbps signalling 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 signalling 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)

Two (2) 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 x1080), 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 with subscription for a period of six years. The SAS/SCADA software shall have licenses valid for the lifetime of the system. 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
- Gateways configuration Software and licenses.
- IEC 8705-101/104 IEC Simulator Software
- Latest version of AutoCAD suite for Windows,
- Substation Design Suite^{TM} Physical for AutoCAD by SBS
- Substation Design Suite^{TM} Protection and Control by SBS
- STAAD Pro
- PSS CAPE

D. Multifunctional Primary Test System (Full CPC 100 Kit)

The contractor shall supply one (1) CPC 100 Multifunctional primary test system for each bidding package complete with the related software and licenses for all the below listed functionalities.

The CPC 100 kit should include the tan delta test set (CP TD1). This kit enables you to perform power /dissipation factor and capacitance measurements from 15 Hz to 400 Hz.

The CP TD1 includes a high-voltage source, reference capacitor and measurement electronics. It can generate output voltages up to 12 kV, currents up to 300 mA and achieves laboratory precision, even in environments with strong interferences.

The specifications for CPC 100 Omicron test kit shall be as follows:-

<u>Specifications</u>

The functionalities of the CPC 100 should be able to match the following specifications for various equipment.

Current transformer testing

- Multifunctional CT tests
- Primary injection up to 2 kA
- Simple wiring test with handheld polarity checker (CPOL)
- Voltage withstand test up to 2 kV
- CT ratio (with burden) up to 800 A or 2 000 A with CP CB2, 5 kVA output power
- CT burden up to 6 AAC | secondary

- CT excitation curve (knee point) up to 2 kVAC
- Polarity check with CPOL up to 800 A or up to 2 000 A with CP CB2
- Accuracy limiting factor (ALF) test
- CT ratio with voltage up to 130 VAC | bushing CTs
- CT winding resistance up to 6 ADC
- CT demagnetization and remanence
- CT voltage withstand test up to 2 kVAC
- CT ratio Rogowski and CT ratio low power up to 800 A or up to 2 000 A with CP CB2, 5 kVA output power
- Power/dissipation factor test up to 12 kV, 300 mA | with CP TD1
- IEC 61850 Sampled Values testing

Voltage/potential transformer testing

- Ratio testing from 15 Hz - 400 Hz
- Multi-functional VT testing
- Simple wiring check with handheld polarity checker (CPOL)
- VT ratio up to 2 kVAC | polarity and burden
- VT burden up to 130 VAC | secondary
- VT secondary voltage withstand test up to 2 kVAC
- Polarity check with CPOL up to 2 kVAC
- VT electronics up to 2 kVAC
- IEC 61850 Sampled Values testing
- Power/dissipation factor test up to 12 kV, 300 mA | with CP TD1

Power transformer testing

- DC winding resistance (up to 100 ADC)
- Transformer demagnetization (with CP SB1)
- Dynamic load tap changer diagnostics (on load tap changer test) (up to 100 ADC | optionally with CP SB1)
- Transformer turns ratio (TTR) per tap up to 2 kVAC | including polarity and excitation current | IEC 61387-1 support for transformer with unconventional vector groups
- Automatically determination of the transformer's vector group (with CP SB1)
- Leakage reactance / short circuit impedance (up to 6 AAC)
- Transformer, bushing: power/dissipation factor + insulation capacitance up to 12 kV, 300 mA | frequency from 15 Hz to 400 Hz | with CP TD1
- Insulating fluids: power/dissipation factor up to 12 kV, 300 mA | with CP TD1 and CP TC12
- Excitation current per tap (up to 12 kV, 300 mA | with CP TD1)
- Frequency response of stray losses (FRSL) > Surge arrestors: leakage current and watt losses up to 12 kV, 300 mA | with CP TD1
- HV source for voltage withstand test up to 15 kVA | with 3 CPCs + TRC1
- HV source for PD measurements up to 15 kVA | with 3 CPCs + TRC1

Cable and transmission line diagnosis

- Line impedance and k-factor up to 100 A | with CP CU1 > Mutual coupling up to 100 A | with CP CU1
- Positive or zero sequence impedance

Ground system analysis

- Ground grid impedance for large systems up to 100 A | with CP CU1
- Step and touch voltage up to 100 A | with CP CU1 and HGT1

- Ground grid impedance for small systems up to 6 AAC
- Soil resistivity up to 6 AAC > Integrity check of grounding connection up to 400 ADC
- Reduction factor / current split factor > Measure multiple current paths with Rogowski coil

GIS testing
- Withstand test up to 235 kV | max 1.6 nF | with CP RC2
- HV source for partial discharge measurements up to 235 kV | max 1.6 nF | with CP RC2

Switchgear / circuit breaker testing
- Contact resistance up to 400 ADC
- Bushing: power/dissipation factor (tan δ) + insulation capacitance 12 kV, 300 mA | frequency from 15 Hz to 400 Hz | with CP TD1
- Circuit breaker: power/dissipation factor (tan δ) up to 12 kV, 300 mA | frequency from 15 Hz to 400 Hz | with CP TD1
- Insulating fluids: power/dissipation factor (tan δ) up to 12 kV, 300 mA | with CP TD1 and CP TC12

Protection installation testing
- CT ratio (with burden) up to 800 A or 2000 A with the CP CB2, 5 kVA output power
- CT burden up to 6 AAC | secondary
- CT excitation curve (knee point) up to 2 kVAC
- VT ratio up to 2 kVAC | polarity and burden
- VT burden up to 130 VAC | secondary
- Overcurrent relays with primary injection (MV) up to 800 A or 2000 A with the CP CB2, 5 kVA output power
- Polarity check with CPOL up to 800 A or 2 kVAC, 5 kVA output power
- Testing of the entire protection chain by primary fault current injection and live CB tripping

Sampled Values testing
- SV CT ratio test and polarity check up to 800 A or up to 2 000 A, 5 kVA output power | with the CP CB2
- SV VT ratio test and polarity check up to 2 KVAC
- Automatic MU detection
- Automatic voltage / current channel detection
- Frequency selective voltage / current meter
- Noise level measurement
- Amplitude response of the signal processing chain up to 800 A or up to 2 kVAC | frequency from 15 Hz to 400 Hz

<u>Different ways to operate</u>
The CPC 100 should offer the following operating modes, to meet the personal preferences of the user:
- From the front panel: Selecting test cards directly
- From the front panel: Using pre-defined test templates
- Fully automated: Using Primary Test Manager

E. IEC 61850 Simulator

The Contractor shall procure, supply, install, test and commission an IEC 61850 and IEC 60870-5-101/104 amongst other protocols Simulators from a vender approved by the employer. All associated licenses and keys shall be included in the package. These shall be installed on the laptops and tested during commissioning of the project.

The COMPROTWARE: TESTOOL (CPTT) shall have the ability to test and simulate tele control features using the following protocols:

- IEC 61850
- GOOSE Monitoring
- IEC60870-5-104/101
- MODBUS serial
- MODBUS TCP/IP

The system shall be capable of simulating the substation system as well as the control centre with the ability to monitor communication between the two. Remote Control of equipment CBs/Disconnectors and Tap Control shall be possible from the simulation software.

Contractor shall supply a full list of special tools and accessories for each equipment as recommended by the manufacturer for operation and maintenance purpose as described in the general technical specifications. Acceptance of any tools/equipment will not take place before the Contractor has submitted the complete final detailed list of all special tools and equipment.

The finalized special tools and appliances shall be purchased 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 and is not to be used for erection purposes. The prices for all tools and equipment are to be fixed for acceptance up to one year from the last take-over date of the works.

F. Inspection and Monitoring Equipment for E&S

Portable multi-parameter water meters-HACC MP-6p Portable Meter- 2pieces

Simple, robust design allows for rapid testing of pH, ORP (Oxidation Reduction Potential)/Redox, conductivity, resistivity, Total Dissolved Solids (TDS), minerals/salts, and temperature. Probe-free meter enables single-handed operation for high-throughput testing or spot checking. Achieve reliable readings without frequent calibration. Auto shut-off extends battery life to more than 100 hours or approximately 5000 tests for reliable portable use. Meter kit includes MP-6p meter and user manual.

Portable data Loggers for ambient Temp & Humidity- Lascar Temperature & Humidity Data Logger, - 2 pieces

The Lascar EL-USB-2 USB standalone data logger measures and stores over 16,000 temperature and humidity readings between -35°C and 80°C (-31°F to 176°F). It has 0% to 100% RH range at a resolution of 0.5°C (1°F) and 0.5% RH. The user can easily set up the logger and view the downloaded data by plugging the data logger into your PC's USB port and using the free Easy Log software. Data can then be graphed, printed, and exported to other applications for a detailed analysis.

The measurement ranges between -35°C and 80°C (-31°F and 176°F). Temperature measurement accuracy is ±0.5°C, Humidity measurement accuracy is ±2.25%RH, Logging rates range between 10 seconds and 12 hours, Immediate and delayed logging start, User programmable alarm thresholds for both, temperature and humidity, Status indication via red/green LEDs, Battery life is up to 3 years.

Velocity Meters- Scarlet WR3 Anemometer- 2pcs

Scarlet WR-3 Plus is perfect for work safety, construction, crane operation, and industry. Sick of tangled cords. The wireless anemometer has a 400-m distance for easy installation.

Transmission frequency; 868MHz(default), 915MHz, Battery – sensor: 3.6V 18505 Lithium battery x1, Battery - display unit: 1.5V AA battery x3, Micro USB port, Mounting: Magnetic sensor mounting bracket or 1/4" threaded hole.

Noise/Sound meters. - Reed R8050 Sound Level Meter- 2 Pieces
Measuring Max range 130dB, High accuracy of ±1.4 dB meets Type 2 standards, Dual range measurement (High and Low) A & C frequency weighting, Fast & Slow time weighting, Easy-to-read backlit LCD display, Data hold and Max hold functions, Tripod mount for long-term monitoring, Low battery indicator and auto shut off.

18. 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.

18.1 Submittals during contract period

18.1.1 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

18.1.2 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.

18.2 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.

18.3 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.

19. 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.

19.1 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.

19.2 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.

19.3 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.

19.4 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.

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

20.1 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 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 of permanent construction which can be used by KETRACO after project commissioning.

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.
- Two telephones with international dialling capability
- 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) 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 / Workstation 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.

20.3 Design Review Meeting

The contractor shall arrange for a design review meeting at the contractor's home country's design office or at the designer's offices to be attended by a minimum of four (4) KETRACO Design Engineers and two (2) Employer's representatives (the period exclusive of weekends, considered rest days, shall be at least 10 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.

20.4 Students' Internship and Graduates' Employment

The Contractor shall accommodate four (4) students on internship/apprenticeship for the entire duration of the Contract. The internship shall be for diploma and 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 in line with body regulating the profession in Kenya. 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.

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

21.1 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. The Contractor shall provide the services of one (1) driver mechanic per vehicle whose remuneration shall be not less than KES. 60,000.00 (net amount after statutory deductions) per month per driver for the entire Contract duration and not less than KES. 6,300.00 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 vehicle loaded with a minimum of KES. 150,000 .00 per month.

The vehicles 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 Type 1; while at completion and prior to commissioning for Type 2. 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.

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.

On completion of the Contract, the Type 1 vehicles and all its equipment shall remain the property of the Contractor.

Type 2 vehicles shall be purchased and delivered to the client after completion of construction works but before commissioning of the project.

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:

Medium Truck, 4x2, 7.0-8.0 Ton, Cab Chassis: (4 units): • Purpose: Medium Trucks are essential for transporting materials, machinery, and personnel to different project sites, overhead lines, and substations especially in challenging terrains. • Specifications: • Vehicle Type: Open Cater, suitable for heavy-duty applications. A standard production, 4x2, diesel utility medium truck of latest design in the class, robust construction in current production and marketed in Kenya. Must be supplied new. Control Forward/Normal; Designed for heavy duty specifications, capable of operating in tropical conditions of mud and dust. Most suitable for operating on both "on and off" road conditions. Most suitable for fitting operating high lifting crane and cargo transportation. • Dimensions and Weights: Minimum overall length of 7400mm, Overall width approx. 2400mm, minimum overall height of 2500mm, Wheelbase of 4200mm. Length of chassis after Cab of 5000mm, Kerb weight 3500kg, Max. G.V.W. Aprox.13,500kg, Payload, within range 7,000-8,000kg, Permissible front (steering) axle load, max

5,500kg, Permissible rear (for dual wheels) axle load, max 8,500kg, Ground clearance, min 250mm. • Engine and Powertrain: Engine: Powerful diesel engine with above 4000 - 4600 CC Engine Capacity suitable for heavy hauling; Engine performance curves supplied; Diesel Engine, water cooled, 4 stroke; Mode of aspiration must be Turbo; Piston displacement, within range 7,000 – 8,500cc, Number of cylinders, minimum of six (6), Maximum power output /rpm, min 180hp/3,000rpm, Maximum torque developed/rpm, min 500Nm/1800rpm, disposable Air cleaner type, Disposable Oil and fuel filter type, Average fuel consumption (on full load) should not be below 1000km, Fuel tank capacity, min 200litres, Extra fuel tank fitted capacity Reserve of 100-litres. • Clutch and Transmission: Clutch must be dry single plate; Clutch system actuation, Hydraulic; Gearbox, synchromesh; Number of speeds, min. 5F, 1R; Drive configuration 4x2. • Brakes, and Tires: Brakes, hydraulic-pneumatic assisted; Mechanical parking brake, to act on transmission; Dual Rear tyres; Tyres size locally manufactured, Optimum tyre size as per the Manufacturer. • Steering, Control and Cab; Must be Right Hand Drive steering; power Steering type and fitted with working Seat belts. • Chassis and Suspension: Chassis Type: Robust and durable chassis suitable for heavy-duty use in rough terrains. Suspension: Heavy-duty suspension system to ensure stability and load-bearing capacity. Fitted with Suspension, front and rear heavy duty leaf springs with telescopic shock absorbers at front. • Electrical System/Instruments: Provision of a 24V System voltage, negative earth; Battery capacity and size of between 180 Ah and 240 Ah; Full lighting to conform to Cap 403, subs 23- Kenya Traffic Act; Standard instruments and gauges (or warning lights) for charging circuit, oil pressure, coolant temperature etc • Modifications for Maintenance: The following modifications and features are required to adapt the open canter vehicles for maintenance of electricity transmission lines and substation switchyards: Elevated Work Platform: Type: A hydraulically operated aerial work platform (cherry picker) with a minimum working height of [Specify Minimum Working Height]. Rotation: The platform should be capable of 360-degree rotation for flexible access to transmission lines and equipment. Load Capacity: The elevated work platform should have a safe load capacity for equipment and maintenance personnel. • Body Construction; Low-sided body; Body cross bearers of prestressed channel sections, 100x50x4.5mm equidistantly spaced at a maximum of 500mm apart. Suitable size well-seasoned timber runners, with inverted steel section at top, between body frame and chassis; Body secured to chassis by U-bolts, diameter 16mm, held in position on wooden V-blocks; Body floor fabricated from 3.2mm thick mild steel plate (full width) reinforced at equal distances with box/channel sections; Steel platform body, made from mild steel chequered plate of thickness 3.2mm; Dropped tailgate and sides suitably reinforced; Suitable size toolbox to be fitted under body on the right hand side; Fixed cargo carrier clear of cab to create suitable space for fitting crane machine; Suitable rear mudguards fitted; Stone guards fitted for taillights; Suitable size ladder fitted for the body cargo carrier; Chevrons and reflectors fitted on rear to conform to Kenya traffic act; 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. • Equipment Storage and Securement: Storage Compartments: Adequate storage compartments to securely store tools, equipment, and materials required for maintenance tasks. Securement Devices: Built-in securing mechanisms to prevent equipment and tools from shifting during transit. • Lighting and Safety Features: Work Area Lighting: Bright and adjustable work area lighting to ensure visibility during night or low-light maintenance tasks. Safety Rails and Harness Points: Safety rails around the elevated work platform and harness attachment points for the safety of maintenance personnel. • Auxiliary Power Source: Inverter/Generator: An inverter or generator with sufficient capacity to power maintenance equipment and tools. • Cabin and Comfort: Cabin Type: A comfortable and spacious cabin for the driver and maintenance crew. Seating: Adequate seating for the driver and crew members. Air Conditioning: Air conditioning system for a comfortable working environment. Communication: Two-way communication system between the driver and the crew in the elevated work platform. • Equipment: Heavy duty type front fender; Laminated (safety) windshield; Sun visors supplied; Rear view mirrors (external both sides and internal) supplied; Full size spare Tyre with rim and carrier mounted under truck; Hydraulic (telescopic) jack, wheel brace & manufacturer's standard tools; Any other equipment (or accessories) supplied; Vehicle to be fitted with electronic speed governor; Governor to limit maximum speed to 80km/hr certificate provided; Governor to be tamper proof;

Engine immobilize system fitted; Hazard Triangles metallic, Standard First Aid KS-2094-2007 and 1 Kg fire extinguisher; Supply addition Loose Floor rubber mats • Safety Features: Airbags, ABS, stability control, traction control and any additional safety features as per regulatory requirements. • Accessories: Air conditioning, power windows, and central locking. • Warranty: A manufacturer's warranty with service and maintenance package. Specimen of vehicle warranty to be submitted when tendering; Each vehicle supplied to carry a statement of warranty; Vehicle warranty duration min. 12 Months 40,000Km whichever occurs first; Vehicle Free Service on Labour & Parts. • Compliance: The vehicle must comply with Kenyan road regulations and standards. • Manuals: All literature in the English language; Repair manuals, supplied; Parts catalogue/microfiche/CD, supplied; Driver's handbook supplied; Service schedule supplied. • 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 Employer.

Table 2: Vehicle Description

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	6
2	Type 2: Medium Truck, 4x2, 7.0-8.0 Ton, Cab Chassis; 4000 - 4600 CC Engine Capacity	2

21.2 Project Communication Devices

The Contractor shall also provide at least Five (5) mobile telephone sets per substation (Total = 10) (smart phone, approved by the Employer) per lot 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.

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 mininmum requirements:-

NETWORK	Technology	GSM/CDMA/HSPA/EVDO/LTE/5G
BODY	Dimensions	146.7 x 71.5 x 7.8 mm (5.78 x 2.81 x 0.31 in)
	Weight	172 g (6.07 oz)
	Build	Glass front (Corning-made glass), glass back (Corning-made glass), aluminum frame
	SIM	Nano-SIM and eSIM - International
		IP68 dust/water resistant (up to 6m for 30 min) Apple Pay (Visa, MasterCard, AMEX certified)
DISPLAY	Type	Super Retina XDR OLED, HDR10, Dolby Vision, 800 nits (HBM), 1200 nits (peak)

	Size	6.1 inches, 90.2 cm^2 (~86.0% screen-to-body ratio)
	Resolution	1170 x 2532 pixels, 19.5:9 ratio (~460 ppi density)
	Protection	Ceramic Shield glass
PLATFORM	OS	iOS 16, upgradable to iOS 17.1.1
	Chipset	Apple A15 Bionic (5 nm)
	CPU	Hexa-core (2x3.23 GHz Avalanche + 4x1.82 GHz Blizzard)
	GPU	Apple GPU (5-core graphics)
MEMORY	Internal	256GB 6GB RAM/ 512GB 6GB RAM NVMe
MAIN CAMERA	**Dual**	12 MP, f/1.5, 26mm (wide), 1/1.7", 1.9µm, dual pixel PDAF, sensor-shift OIS 12 MP, f/2.4, 13mm, 120˚ (ultrawide)
	Features	Dual-LED dual-tone flash, HDR (photo/panorama)
	Video	4K@24/25/30/60fps, 1080p@25/30/60/120/240fps, HDR, Dolby Vision HDR (up to 60fps), Cinematic mode (4K@30fps), stereo sound rec.
SELFIE CAMERA	Single	12 MP, f/1.9, 23mm (wide), 1/3.6", PDAF SL 3D, (depth/biometrics sensor)
	Features	HDR, Cinematic mode (4K@30fps)
	Video	4K@24/25/30/60fps, 1080p@25/30/60/120fps, gyro-EIS
SOUND	Loudspeaker	Yes, with stereo speakers
	3.5mm jack	No
COMMUNICA-TION	WLAN	Wi-Fi 802.11 a/b/g/n/ac/6, dual-band, hotspot
	Bluetooth	5.3, A2DP, LE
	Positioning	GPS, GLONASS, GALILEO, BDS, QZSS
	NFC	Yes
	USB	Lightning, USB 2.0
FEATURES	Sensors	Face ID, accelerometer, gyro, proximity, compass, barometer
		Ultra Wideband (UWB) support Emergency SOS via satellite (SMS sending/receiving)
BATTERY	Type	Li-Ion 3279 mAh, non-removable (12.68 Wh)
	Charging	Wired, PD2.0, 50% in 30 min (advertised) 15W wireless (MagSafe) 7.5W wireless (Qi)
TESTS	Performance	AnTuTu: 817125 (v9) GeekBench: 4761 (v5.1) GFXBench: 60fps (ES 3.1 onscreen)
	Display	Contrast ratio: Infinite (nominal)
	Camera	Photo/Video
	Loudspeaker	-25.2 LUFS (Very good)

21.3 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 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.

1) **Power System Analysis (4 Engineers for 2 weeks)**

II.16. Overview of the properties of transmission, distribution and industrial power systems

II.17. Explain the power system dynamic and stable behaviour including the transitions between the different power system states

II.18. Components and general behaviour of the power system from generation over transmission and distribution to consumption

II.19. Basic power flow concepts and system analysis based on some system examples

II.20. Power system modelling and analysis the

II.21. Learn computation techniques for fault calculations

II.22. Power system modelling‹ simulation and analysis (load flow, contingency, switching, shortcircuit, protection, etc as necessary for power line planning, design and operation) using DIgSILENT software

II.23. 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

III) Substation Automation & SCADA System– Application & Design (4 Engineers for 3 weeks)

III.1. IEC61850 standard structure and the– used protocol elements.

III.2. Gateways IEC61850 and IEC104 configuration.

III.3. 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

III.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

III.5. Features of the most common standardized protocol used in communication systems of power utilities and especially in substations.

III.6. List and compare the essential features of all these protocols and explain the use of all these protocols

III.7. System Architecture Design for Substation Automation with IEC61850 – Application & System Design

III.8. Principles for SCS and changing parameters such as database objects, signal texts, measurement scaling and others.

III.9. Create graphic displays in SCS e.g. single line diagrams, overview pictures, system overview picture and Tagging of items with the various variables.

III.10. Configure NCC communication protocols IEC 60870-5-101,104 and configuration of device hardware CPU and interfaces (Ethernet, GPS ...).

III.11. Configuration and interrogation of the energy meters, energy meter software interaction.

III.12. Configuration of the proposed Substation Automation System including IEC 61850 Engineering.

III.13. SNMP configuration and tagging.

IV) Civil/ Structural Design Training (4 Engineers for 3 weeks)

IV.1. Substation civil and structural works design

IV.2. Steel structure design and detailing using Staad Pro or other structural design software

IV.3. 3D modelling in high voltage substations in Substation Design Suite^{TM} Physical for AutoCAD by SBS

IV.4. Structure foundation design

IV.5. Substation drainage design and modelling using appropriate design suites adopted for project works' design.

V) 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.

VI) Telecommunication (MUX) Application and Design (4 Engineers 2 Weeks)

VI.1. Networks and Applications

VI.2. MUX Concept, rack and Backplane, Power Supply and FAN

VI.3. Connection to the MUX: Installation of the MUX configuration software.

VI.4. Configuration of Units, Ports and Cross Connections.

VI.5. TDM Access Modules and TDM Clocking

VI.6. SDH Transport Module and SDH Clocking

VI.7. Management Access

VI.8. Redundancy and Traffic Protection

VI.9. Chassis Switch and LAN Access Applications

VI.10. Teleprotection Fundamentals, Teleprotection Applications and Testing of Teleprotection.

VI.11. Maintenance & Operation.

VI.12. MPLS-TP Network Traffic Engineering and Advanced FOXMAN NMS

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

22. 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 (CO_2, 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

23. 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 less. The cost shall be deemed to cover the entire exercise which shall involve the following:

1. Selection of trees species with 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 trees for a period of 12 months.

To allow for protection and care within the contract period, it is recommended that the tree planting exercise is done early into the project.

24. 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

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1 General Technical Requirements

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

1.1 General Design of Equipment

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 Cleaning and Painting (Other than Civil Works)

1.4.1 General

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.

1.4.1 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.

1.4.2 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

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 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.

1.7 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.

1.8 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.

1.9 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.

1.10 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.

1.11 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.

The thickness of zinc coating shall not be less than 610 gm of zinc per square metre of surface on steel bars, plates, sections and fittings. Threaded work shall have a minimum coating weight of 305 gm of zinc per square metre.

1.12 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.

1.13 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.

1.14 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.

1.15 Cubicles

1.15.1 Basic Design and Construction of Cubicles

All cubicles shall be industrially produced, made by reputable manufacturer and internationally ap-proved 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 refinish 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 retard-ant.

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/s^2, respectively of the application class III with 15 m/s^2 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.

1.15.2 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.

1.15.3 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.

1.15.4 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.

1.15.5 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.

1.15.6 Electrical Equipment

1.15.6.1General 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.

1.15.6.2Reduction 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.

1.15.6.3Power 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.

1.15.6.4Heating 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 cur-rent 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.

1.15.7 Wiring

In selecting cable and wire sizes, 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 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, were 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.

1.15.8 Terminals

1.15.8.1Terminal 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.

1.15.8.2Terminal 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.

1.15.8.3Terminal 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 sup-ply 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.

1.15.9 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).

1.15.10 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.

1.15.11 Control and Selector Switches

1.15.11.1 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 con-tact 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.

1.15.11.2 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.

1.15.12 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.

1.16 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.

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 SF_6 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.Air Insulated Substations

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 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 Bay Control Room

For the housing of the diameter's protection, control, metering and fault recorder cubicles, bay control room (BCR) shall be foreseen in-between the diameters. Each BCR use shall accommodate the cubicles for one diameter. The final size and layout of each BCR is depending on the number of cubicles installed in that BCR. A possible location of the BCRs in the switchyard is shown in the layout and section drawings attached with the tender. The substation control building will house all the superior control, protection, metering and fault recorder equipment. From the cubicles in the BCRs to the superordinate equipment in the substation control building fibre optic cables will run. The fibre optic cables shall be properly protected against physical damage and rodents. For that reason, outside of the BCR and control building they shall be installed in suitable galvanised iron heavy duty conduits. Inside of control building and BCR they may also run in suitable cable ducts. In any case fibre optic cables shall be strictly segregated from the power and control cables. The BCRs shall be equipped with raised floor to house the power, control and signal cabling. To reduce the number and cross-section of cables for the AC and DC power distribution, AC and DC sub-distribution boards shall be installed in the Bay Control Rooms. These sub-distribution boards shall have redundant supply (with automatic switch-over) from the main distribution boards, which are located in the substation control building.

2.4 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).

2.4.1 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.

2.4.2 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:

2.4.2.1 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.

2.4.3 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.

2.4.3.1 Dielectric Tests

The 50 per cent flashover level as well as withstand shall be determined during the impulse and power frequency tests.

2.4.3.2 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.

2.4.4 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:

2.4.4.1 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.

2.4.4.2 Temperature Cycle Test

These tests shall be made on the porcelain complete with all irremovable fittings.

2.4.4.3 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.

2.4.4.4 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.

2.4.4.5 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.

2.4.5 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.

2.4.6 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.

2.4.6.1 Tests

For site tests, the following shall be performed in particular:

- Voltage drop tests during commissioning.
- CT polarity check
- Humidity tests of SF_6 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.

2.4.7 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.

2.4.8 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.

2.5 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 +40ºC, 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

The AIS-open terminal SF_6 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^{o} 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 <u>at least twenty</u> 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 (<<) 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, SF_6 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 SF_6 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.

The 400kV circuit breakers shall equipped with Point on Wave Switch (POW) to open or close breakers at a pre-determined point on the voltage waveform.

The 400kV circuit breakers shall equipped with online monitoring (OLM) system. The OLM system shall monitor following data (but not limited to):

- Internal temperature

- Power supply voltage and current
- Coil circuit and operating currents
- Motor circuit, operation current and time
- Operating times
- Time between operations
- Monitoring equipment functions (watchdog)

The OLM system shall monitor following functions (but not limited to):

- Status signals (circuit-breaker open or closed)
- Closing operation
- Opening operation
- Close-open operation
- Motor operation

The following parameters should derived and supervised from the function categories:

- Operating times
- Operating speeds
- Coil armature time
- Coil peak current
- Damping time
- Over travel and rebound
- Counters recording the number of operations and number of motor operations;
- Motor peak current and spring charging time;
- Internal temperature of the operating mechanism;
- Ambient temperature;
- Power supply voltages and currents (OLM and heaters);
- SF6 density, with trend analysis;
- Contact wear (optional);
- Contact stroke and contact position.

OLM of Circuit breaker shall be designed as per working conditions and installation environment prevailing across KENYA. It shall be suitable to work up to ambient temperature of +50°C and RH 95%;

Circuit breaker monitoring system shall provide continuous online monitoring of the CB by integrating the sensors at the CB and it shall be able to communicate with the central OLM system through the substation OLM data concentrator or otherwise. It shall be able to communicate with available communication protocols at KETRACO and IEC 61850. Contractor shall integrate the same to the KETRACO OLM system.

The software should delivered with the OLM and it contains a feature for automatic update of the software.

Tenderer shall submit specifications / technical details of FO cables, Coaxial cables, fiber optic cables, computers, OLM software, printer and MODEM etc. for approval during detailed engineering stage.

3.2.2 Gas Monitoring and Handling

All circuit breakers shall be filled to the design pressure with Technical Grade SF_6 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 SF_6 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.

SF_6 gas taken from the circuit breaker shall be checked and handled in accordance with IEC 60480.

3.2.3 Gas Handling Equipment

The mobile gas handling plant for filling, evacuating, and processing the SF_6 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 SF_6 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 SF_6 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.

3.2.4 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.

3.2.5 Circuit Breaker Operating Mechanisms

3.2.5.1 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/SF_6 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.

3.2.5.2 Point On Wave Switching relay

Point On Wave Switching relay (or POW relay) that is also known as switching control relay shall be applied to control switching of 132kV circuit breakers for elimination of harmful electrical transients. The contractor shall submit the switching transient study for each line for consultant approval, if it's requested by client. These studies shall be done under manufacturer supervision and if it is necessary, control relay shall be applied for transmission lines.

Controlled energizing and de-energizing of overhead lines shall be considered to minimize the switching transients. Suitable switching control relay shall be considered depending on shunt reactor compensated or uncompensated transmission lines.

Circuit breaker which is selected to apply POW switching relay, shall have stable operating time, which vary only to a limited extent with factors such as ambient temperature and control voltage. The circuit breakers also shall have high and stable dynamic dielectric withstand capability between the contacts, upon making and breaking operations.

Also circuit breakers should have suitable rate of decrease of dielectric strength for closing and rate of rise of dielectric strength for opening.

Closing or opening commands to the circuit breaker shall be adjusted in such a way which making or contact separation shall occur at the optimum time instant related to the phase angle. Therefore by means of switching control relays, both energizing and de-energizing operations shall be controlled with regard to the point-on-wave position, and no harmful transients shall be generated.

Separate output commands shall be given to each pole when a single-pole operated circuit breaker is controlled.

The relay shall be capable of measuring the voltage of both sides of the circuit breaker via voltage transformers.

The reference and control voltage shall be supplied from suitable voltage transformer winding (protection core of current transformer) according to tender drawings.

All switching control relays shall be fully frequency adaptive and shall be designed to work for system frequencies at least between 45 and 55 Hz.

Controller shall have provisions for adaptive input to compensate systematic variations in operating time of the circuit breaker.

Additional predictive compensation sensor inputs e.g. ambient temperature and circuit breaker's control voltage variation shall be considered.

According to high voltage switchgear arrangements of substation, suitable switching control solutions shall be considered and controller arrangements for attaining proper function shall be prepared. In multi circuit Breaker schemes (breaker-and-half, ring arrangement, etc.), special design of control circuits and more than one controller per circuit breaker shall be supplied, as required.

Controller also shall have a data memory that stores information on switching times for condition monitoring of the circuit breaker. For controlled opening (or closing), the contact separation (or touch) instant shall be supervised (and corrected accordingly in the next operation) by detection of voltage onset instant(s), current start instant(s) or circuit breaker precise auxiliary contacts position in the main circuit. it should be noted that, in later condition, only using precise auxiliary contacts position is acceptable. Adaptation control shall adjust the internally created waiting time when needed.

POW Switching relay shall be coordinated with related circuit breaker characteristics by the circuit breaker's manufacturer. The mechanical operating time and pre-arcing behaviour of circuit breaker settings shall be considered in controller.

Controller shall be equipped with heavy duty and high speed close/open power outputs.

Test, configuration, setting and commissioning of the switch control relay at site shall be done by the contractor under manufacturer supervision.

In substation control and protection circuits, one selector switch in related protection panel for by pass the switch control relay shall be considered.

It is important to arrange all fault tripping commands to by-pass the controller.

In installing trip and close circuit supervision, the POW switching relay shall be considered.

These controllers shall have sufficient facilities for remote communication.

3.2.5.3 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.

3.2.5.4 Hydraulic, Spring/Hydraulic, and Spring/SF6 Mechanisms

Hydraulic and SF_6 gas mechanism shall be leak-free. The hydraulic and SF_6 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.

3.2.5.5 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.

3.3 Disconnectors and Earth Switches

3.3.1 Disconnectors

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.

3.3.2 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 SF_6 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 SF_6 encapsulated types when required.
- IEC 60137, IEC 62271-1, IEC 60120, IEC 60305, IEC 60372, IEC60383, 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.

3.4.2 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.

3.4.3 Short circuit tests

Circuit Breaker, Disconnector 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 (<<) 2.5 p.u.

3.4.4 Dielectric tests

Circuit Breaker, Disconnector 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.

3.4.5 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.

3.4.6 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.

3.4.7 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.

3.4.8 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.

3.4.9 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.

3.4.10 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

3.4.11 Circuit Breakers

3.4.11.1 General

For the purpose of the following tests, the operating pressures for hydraulic operating mechanisms and SF_6 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.

3.4.11.2 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.

3.4.11.3 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 (C) 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.

3.4.11.4 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.

3.4.11.5 Short time current test

The short time current test shall be carried out in accordance with IEC 62271-100.

3.4.11.6 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.

3.4.11.7 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 SF_6 gas pressure, rated control voltage and at maximum operating conditions of the mechanism with the agreement of KETRACO.

3.4.11.8Synthetic 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.

3.4.11.9Short 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.

3.4.11.10 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.

3.4.11.11 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.

3.4.11.12 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.

3.4.11.13 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.

3.4.11.14 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.

3.4.11.15 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.

3.4.11.16 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.

3.4.11.17 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.

3.4.12 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.

3.4.12.1Type 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.

3.4.12.2Routine 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.

3.4.12.3Site 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.

3.4.12.4 Sulphur Hexafluoride

Samples of SF_6 from each consignment shall be tested and shall comply with the tests specified in IEC 60376 and IEC 60480, before any SF_6 gas is despatched.

Use and handling of SF_6 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 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).

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 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.

4.2 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.

4.3 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).

4.4 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.

4.5 Type tests

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

4.6 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

4.7 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 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.

5.2 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.

5.3 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/√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.

5.4 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).

5.5 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.

5.6 Type tests

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 tanδ measurement at power frequency
- Short circuit withstand capability
- Lightning impulse test
- Wet test for outdoor type of transformer
- Ferro-resonance test

- Accuracy test

5.7 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 tanδ 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

5.8 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

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 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.

6.3 Testing and Inspection

6.3.1 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.

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.

6.3.2 Routine Tests

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.

6.3.3 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.

6.3.4 Tests on Surge Counters

6.3.4.1 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.

6.3.4.2 Maximum Current Withstand Tests

The maximum rated current stated in the schedules with an 8/20 µsec wave shape shall be applied to the counter ten times without any cooling periods and the counter shall register and withstand without distress.

6.3.5 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 Bay 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 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 CЄ-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.

7.1.3 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.

7.1.4 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.

7.1.5 Constructional Requirements

7.1.6 General

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.

7.1.7 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.

7.1.7.1 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.

7.1.7.2 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).

7.1.7.3 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.

7.1.7.4 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.

7.1.7.5 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.

7.1.7.6 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.

7.1.8 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.

7.1.9 Protection Testing

7.1.9.1 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.

7.1.9.2 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.

7.1.9.3 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.

7.1.10 Environmental Requirements

7.1.10.1Atmospheric 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.

7.1.10.2Mechanical 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.

7.1.10.3Electrical 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.

7.1.10.4Electromagnetic 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 disconnector and earth switch. For mid diameter circuits having no busbar CB then one BCU of the associated CBs shall control the circuit disconnector 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 disconnector 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 disconnector. 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 disconnector 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 disconnector.

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 disconnector 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 disconnector. For each line the contractor hall 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.

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 disconnector 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 1 as distance protection and main 2 as line differential protection. 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. Current Differential Protection Signalling

This current differential signalling shall be reconfigured accordingly for the existing and new line differential protection to be implemented.

f. 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.

g. 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.

h. 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.

i. 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.

j. 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 disconnector and earth switch. For mid diameter circuits with no busbar CB then one BCU of the associated CBs shall control the circuit disconnector 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 disconnector 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 disconnector 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 disconnector 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 disconnector and earth switch. For mid diameter circuits with no busbar CB then one BCU of the associated CBs shall control the circuit disconnector 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 disconnector 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 disconnector 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 disconnector 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. Tertiary Winding protection

The 11kV Tertiary winding is connected to a primary side earthing transformer that supplies the LV services switchboard. The protection comprises the following: -

- Tertiary 3-phase overcurrent and earth fault relay.
- Earthing Transformer 11kV side restricted earth fault protection.
- 11kV side standby earth fault protection
- Earthing Transformer Auxiliary protections (if any).

All tertiary and LV protections trip both the 400kV and secondary side CBs.

j. 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 distributed principle. The bay units shall be installed in the OHL or power transformer protection cubicles, which are located in the Bay 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 diameter. 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 and bay units are located in different Bay Control Rooms.

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 atleast 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 66kV circuits' 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). OTB for fibre communication and approach cables shall be 42U free standing fiber cabinets designed for termination of single mode optical fiber's with LC connectors inside equipment enclosure racks located within the Telecom Room. The patch panels shall include the following specifications and accessories for fiber optic cables:

- Minimum 19" width:800mm by depth:800mm cabine
- Glass door
- IP55
- 600kg minimum carrying capacity
- Light grey in colour
- Mounting bolts
- LC/UPC Type receptacle,
- Interconnect sleeve or bulkhead adapter
- Jumper cables
- 48 core fiber drawers
- Storage for fiber
- Cable clamps with strain relief
- Flipcard for easier record keeping

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.

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 Vk) 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

The new telecommunication systems to be provided at the substations shall be designed to transmit and receive data, voice and teleprotection signals. 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.

The new telecommunication equipment shall be based on synchronous digital hierarchy (SDH) technology operating at STM-1, STM-4 or STM-16 transmission level. The final choice will be decided by the Employer/Employer's Representative during the detailed design stage. 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 1550 nm or 1625 nm as appropriate.

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 fiber pairs (i.e. 8 single fibres) shall be made available for use by the telecommunication system.

The existing telecommunication network backbone is based on fiber 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 digital multiplex equipment shall be designed to operate in electrical high-voltage networks and shall be suitable for installations in substations with harsh environment and high electromagnetic interference. It shall be highly reliable and provide secure communications for real time signals such as voice, SCADA, teleprotection and data, including IP/Ethernet and status/control signals. The multiplexing equipment shall offer the possibility for fan less operation in order to ensure maintenance free operation and comply with the environmental conditions in substation environment. Accordingly, it shall comply with substation relevant standards such as IEEE 1613, IEC61850-3.

The equipment offered shall comply with the latest ITU-T and IETF recommendations, ETSI and IEEE standards and be able to be interconnected with legacy multiplexer and other telecommunication equipment.

On PACKET TRANSPORT LEVEL interfaces for optical MPLS-TP based transmission up to 10Gbit/s shall be available. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing VPWS, VPLS and Tree services using the MPLS-TP infrastructure. Activation of MPLS-TP functionality on SDH devices shall be possible without the need to exchange hardware.

On TDM TRANSPORT LEVEL interfaces for optical transmission on STM-1 (155Mbit/s), STM-4 (622Mbit/s) and STM-16 (2.5Gbit/s) shall be available. Additionally, 2Mbit/s DSL interfaces shall be available for connection to copper cables. For connection to higher order transport equipment also Nx2Mbit/s (E1) and STM-1 electrical interfaces shall be available.

MPLS-TP and PDH/ SDH functionality shall be natively integrated (true hybrid functionality).

Static configuration of bidirectional and co-routed communication channels shall be supported using the NMS. Dynamic routing shall be prohibited for all critical data channels. End to end channel supervision should be supported.

The equipment shall be software controlled, of modular design and all modules shall form an integrated part of a 19" shelf.

The platform shall have means to cross-connect, drop and insert individual channels (64kbit/s time slots), 2Mbit/s framed (G.704) and unframed (G.703) signals. It shall also support termination and cross connection of VC-12, VC-3 and VC-4.

Equipment protection and various protection schemes shall be supported. For stations with teleprotection and telecommunication requirements an integrated teleprotection function (distance and differential protection) has to be provided. External teleprotection equipment is only accepted in stations, where existing equipment has to be extended.

Each network element shall be manageable locally as well as from an operation centre. There shall be means available to supervise external/existing equipment. It must be possible to access the platform over a TCP-IP

network as well as other neighbouring platforms in the extensive Kenya Fiber Optic Backbone Telecommunication Network through the specific platform.
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:
Functionality / Interfaces for direct connection to following USER SIGNALS shall be available on hot pluggable plug-in modules for the equipment:

- Analogue subscriber interface: subscriber FXS and exchange side FXO
- 4-wire E&M voice interface
- Programmable data interface V.24, /V.28, V.35, X.24/V.11, RS-485 (2-wire/ 4-wire)
- 64 kbit/s codirectional/ contra directional electrical interface acc. to ITU-T G.703
- Alarm collection interface
- Teleprotection command interface as per IEC 60834-1
- Optical interface module for up to 4 protection relays compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface
- Binary signal (status and control) interface
- 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. to G.703 and G.704
- Circuit emulation function for E1, serial and telephony interfaces
- n x 2 Mbit/s electrical SHDSL ports for TDM services supporting copper pair bonding
- n x 2 Mbit/s electrical SHDSL ports for EFM services supporting copper pair bonding
- Ethernet interface 10/100/1000BaseT, electrical, RJ-45 or SFP based
- Ethernet Interface 100BaseFX and 1000BaseLX/SX, optical, SFP based
- Support of L2 switching functions
- Support of L3 routing functions
- Support of Power over Ethernet
- Ethernet interface supporting Ethernet over SDH (EoSDH, GFP ITU-T G.7041 and LCAS ITU-T G.G.7042 functions)
- Ethernet interface supporting Ethernet over PDH (EoPDH, MLPPP functions)

On TRANSPORT LEVEL the equipment shall support the following connection ports:

- Up to 8 x STM-16 SDH optical ports
- Up to 16 x STM-4 SDH optical ports
- Up to 8 x STM-1 SDH optical / electrical ports
- Up to 8 x MPLS-TP capable transport ports
- Up to 8 x 10 Gbit/s Ethernet (MPLS-TP) ports
- N x 2 Mbit/s electrical E1 ports
- N x 2 Mbit/s SHDSL ports
- Up to 200 x electrical/ optical 1 Gbit/s Ethernet ports

All optical MPLS-TP, SDH and Ethernet ports shall support SFP or SFP+ modules (small-factor pluggable unit) for short, medium, long and extra-long optical communication. ALS (Automatic Laser Shut-down) shall be fully supported.
The Multiservice Platform shall support at least the following Cyber Security features:

- Authentication, Authorization and Accounting
- Secured management communication
- DoS prevention
- Traffic authentication and encryption

The SDH multiplexers shall contain the latest firmware appropriate to manage and handle the services for which it is designed for in the network; such as but not limited to hybrid SDH and MPLS-TP. It 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 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.
The Contractor shall be responsible for the completeness of the telecommunication service. The scope of supply of material necessary in neighbouring substations' telecommunication system for the completeness of the telecommunication services shall form part of this contract.
The contractor shall also provide a VoIP telephone system for each substation as well as two way radio communication devices for coordination of instructions between the operator in the control room and operator in the switchyard.
Details of the existing telecommunication system and OPGW cable may be provided to the contractor by the Employer upon request.

8.2 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 tele protection 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 tele protection 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-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 – 10/100/1000 Base-T interfaces (RJ45) for connection of gateway computers of Substation Automation & 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 system.
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.

8.3 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 fiber operation.
b. Dense wavelength division multiplexing (DWDM).
c. TCP/IP Ethernet networking
d. MPLS-TP/IP

The telecommunication system shall be supplied already equipped with a minimum of 25 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.

8.4 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 fiber optic link.
It is envisaged that at least 4 simultaneous tele protection signalling commands shall be required per circuit.
The Bidder shall include details of the proposed tele protection signalling system in the Tender.

8.5 Telephony

For tendering purpose, the telecommunication system shall be capable of supporting 3 4 simultaneous voice channels at each substation.
Each substation shall be supplied with Four (4) Telephone handsets of modern design and equipped with push buttons for call selection and shall be suitable for desktop installation. The handsets shall be compatible with the existing Telephony Network for Transmission Substations to enable communication with the main Exchange and the neighbouring telephone subscriber units.
The telephones shall be VoIP phone fully configured and integrated into the expansive Kenya Telecommunication Network Telephony System for communication with the neighbouring substations and the National and Regional Control Centres.
The Contractor shall also provide Four (4) portable Digital Mobile Radio units to avail communication between operators in the control building and the switchyard. They shall be slim, pocket- sized and light portable radios with a full keypad and five-line colour screen with customisable display schemes. They shall operate in the UHF 1 band (403-470MHz) on 4FSK digital modulation with a power output of UHF:1W/3W, with up to 14 hours battery life and repeater capable. It shall also contain 1000 channels with 12.5kHz channel spacing. They shall have the following capabilities:

- Integrated accelerometer for optional Man Down
- Bluetooth 4.0: Class 2 Range, 10m
- Indoor location tracking
- Integrated Wi-Fi: IEEE 802.11b, 802.11g, 802.11n
- Environmental Standard: MIL-STD-810D and E compliant

The contractor shall also supply a Digital telephone exchange complete with 50% spare capacity for future extension works use including maintenance software, modem and desktop computer (PC-based Network Management System).
The final design and colour of the telephone handsets including configuration details of both local subscriber unit and the main telephone exchange shall be provided for shall be subject to the approval of by the Employer.

8.6 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 12 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.

8.7 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:

- Existing telecommunication systems.
- 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.

8.8 Fibre optic communication system

8.8.1 General requirements

8.8.1.1 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 fiber 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 fiber optic communication equipment shall be capable of providing proper performance for at least 20 years.

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8.8.1.2 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:

- Mean launch power.
- Receiver sensitivity.
- System design penalties.
- Margin for age degradation and temperature.
- Connector losses.
- 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 Employer/Employer's Representative.

8.8.1.3 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 shutdown 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 Employer/Employer's Representative for approval.

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8.8.2 Functional requirements

8.8.2.1 General

The SDH system shall have the following features:

- High operational security and reliability.
- High quality transmission in accordance with ITU-T recommendations.
- Flexibility for adaptation to the desired transmission capacity.
- Integrated monitoring facilities.
- Comprehensive operation and fault diagnosis.
- Redundancy capability where required.
- Direct and easy access to the transmitted base band signal.
- Direct connection to multiplexing equipment employing pulse code modulation (PCM) techniques.

- Capability of routing TCP/IP traffic.
- Support Q3 interface in accordance with ITU-T G.773.

As far as practicable all fiber 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.

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.

Timing 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 fiber optic communication network shall be included in the Tender***. The existing synchronization scheme applied in the system shall be followed.

8.8.2.2 System capacity and performance

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, the service otherwise called Engineering-Order-Wire.

8.8.2.3 Service channels

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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.

8.8.3 SDH equipment

8.8.3.1 General

The SDH equipment shall perform both multiplexing and optical line terminating functions. 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-1 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:

- Optical line interface.
- Electrical line interface.
- Tributary module.
- Switching unit.
- Control and alarm functions.
- Engineering order wire (service telephone) unit.
- Service data interface.
- Ethernet interface.

The equipment shall be safe to use and shall comply with EN 60950-1.
The equipment shall comply to the following environmental conditions of operation:
Temperature range: -25°C to +60°C
in fan less, configuration: -25°C to +55°C
Humidity: max. 95% (no condensation)

8.8.3.2 Optical line interface

The SDH equipment shall be capable of supporting at a minimum, the following optical interfaces:

- S-1.1, L-1.1, L-1.2 and X-1.2 STM-1 interfaces in accordance with ITU-T G.957.
- S-4.1, L-4.1 L-4.2 and X-4.2 STM-4 interfaces in accordance with ITU-T G.957
- S-16.1, L-16.1, L-16.2 and LR-16.2 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-1 155 Mb/s, STM-4 622Mb/s and STM-16 2.5Gb/s stream. The optical section shall convert electrical signals into an optical signal for transmission over an optical fiber 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 fiber 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 fiber optic link.
The optical source shall have minimum life of at least 50 000 hours at an ambient temperature of +50ºC. 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 fiber 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 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.

8.8.3.3 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 10/100/1000 Mb/s Ethernet LAN interface shall also be supported.

8.8.3.4 Tributary module

The tributary module shall perform the selective extraction/insertion of tributaries to and from the STM-1 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.

8.8.3.5 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.

8.8.3.6 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:

- Loss of incoming signal or loss of frame alignment.
- Optical transmit power low.
- Laser current high.
- Bit error rate (BER) threshold high.
- Optical receive level low.
- Multiplex input fail.
- Loss of clock signal.
- Distance alarms.
- 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.

8.8.3.7 Engineer order wire

8.8.3.8 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. 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 fiber optic communication system.
The number, bit rate and type interfaces available shall be stated by the Bidder.

8.8.3.9 Ethernet interface

8.8.4 The SDH equipment shall be capable of supporting 10/100/1000 Mb/s BaseT interfaces complying with IEEE standard 802. Interfaces on the multiplexers tributary side shall be modular and provide up to four 10/100/1000 Base T interfaces per –card slot. Primary access multiplexing equipment

8.8.4.1 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 fiber 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.

8.8.4.2 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:

- 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.
- Encoding law shall be in accordance with the requirements of ITU-T G.771.
- Jitter characteristics shall be equal to or better than ITU-T G.703.
- The equipment shall comply with the EN 55022 class A, EN 61000-6-2, EN 61850-3, and shall be in conformance with CE.

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:

- 2 Mb/s data interface according to ITU-T G.703.
- 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.

8.8.4.3 Alarm indications

8.8.4.4 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. 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.

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<u>Data Interface</u>

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:

- 64 kb/s data interface according to ITU-T Recommendation G.703.
- Multirate 0.6 to 64 kb/s data interface according to ITU-T Recommendations X.21/V.11.
- Multirate 0 to 19.2 kb/s data interface according to ITU-T Recommendations V.24/V.28.
- nx64 kb/s data interface according to ITU-T Recommendation V.35.
- 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.
- Gigabit Ethernet Interfaces 1000 Base-X/T
- Common LAN – 10/100/1000 Base-T interfaces (RJ45) for connection of gateway computers of Substation Automation & 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.

<u>Teleprotection Signaling Interface</u>

The fiber 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.
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 fiber optic communication system over any fiber 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.

8.8.4.5 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.

8.8.4.6 Power supply requirements

The fiber 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 fiber optic communication equipment from damage in the event of overload shall be provided.
The power supply input to individual items of equipment comprising the fiber optic communication system shall be individually fused.

8.8.4.7 Optical fibre distribution frames

Rack-mount Optical fiber distribution frames shall be provided as necessary by the Contractor to facilitate the termination of fibres, testing and isolation of both the optical fiber cable and fiber 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 fiber distribution frame and shall be properly labelled with fiber identity, destination or source, go or return. It shall be possible to connect each optical fiber to the appropriate point on any terminating equipment. Fixed couplers shall be provided for each fiber comprising a link.
The following basic functions of the fiber distribution frame are required:

- Circuit re-routing/jumpering.
- Circuit disconnection.
- Patching and test connections.
- Bridging measurements.

Plug-in connection shall be used, and the transmit and received direction of the transmission shall be segregated. The optical fiber tail cables and connections shall be substantially protected from possibility of damage due to maintenance or installation activity.
The capacity of the fiber distribution frame shall be chosen to accommodate the maximum capacity of the fiber optic communication system plus 50 per cent spare capacity to cater for any future expansions. All fiber distribution frames shall have an earth connection provided, and shall be protected from corrosion by painting or galvanising.

8.9 Teleprotection signalling equipment

8.9.1 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 fiber optic links. It shall therefore be of a modular design so that it can be readily for direct connection to the SDH fiber 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.

8.9.2 Functional requirements

The teleprotection signalling equipment shall have the following features:

- High equipment reliability.
- Integral monitoring facilities.
- Simple operation and fault diagnosis.
- Direct integration to existing telecommunication systems.
- Wide selection of user interfaces.
- Easy programming for optimum setting of signal processing time, security and dependability.

- Permanent self-supervision.
- Automatic loop checking.

The communication system has to ensure simple, reliable and secure operation of the integrated teleprotection functions using MPLS-TP based Wide-Area Networks (WAN). Therefore, the following features have to be provided.

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8.9.2.1 Contact based Distance Protection application

In order to guarantee correct operation of the distance protection relays the following performance parameters need to be met:

- Guaranteed dependability and security as per IEC 60834-1 for distance protection signals, also in highly disturbed communication networks (e.g. with packet loss or bit errors)
- Guaranteed back to back latency of < 5 ms for high and extra high voltage line tripping
- Availability of communication channel of 99.999%
- Command addressing for teleprotection signal shall be provided to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.
- An automatic and periodic loop test (< 100 ms) has to be provided for a signal delay measurement.
- In case of loss of communication on main path a switch-over of the teleprotection command to the standby path shall be hitless
- Trip counters shall allow the supervision of the teleprotection functionality
- Enhanced channel supervision and warnings and alarming in case of communication channel performance needs to be provided (approaching critical threshold/ critical threshold passed)
- The configuration of the teleprotection has to be integrated into the communication configuration tool of the multiplexer in order to ensure easy maintenance
- The Teleprotection function needs to be fully integrated into the network management system in order to ensure full visibility of the complete communication system
- Authentication of signals to detect data modification in WAN and replay of data

8.9.2.2 Differential protection application

In order to guarantee correct operation of the differential protection relays the following performance parameters need to be met:

- Guaranteed performance for the differential protection interfaces as per the standards (IEEE C37.94, ITU-T G.703, G.712, G.823, V.11)
- Guaranteed maximum end to end asymmetry of ≤ 150 us for IEEE C37.94 channels
- Guaranteed maximum end to end asymmetry of ≤ 400 us for all other legacy PDH interfaces commonly used for differential protection channels
- Enhanced channel supervision as well as warnings and alarming in case of communication channel performance degradation (approaching critical threshold/ critical threshold passed)
- In case of loss of communication on main path a switch-over of the differential protection channel to the standby path shall be hitless
- Guaranteed back to back latency of ≤ 6 ms for high and extra high voltage line tripping
- Availability of communication channel of 99.999%
- Application oriented configuration possibility. Latency as a critical parameter for differential protection application shall be available as a configuration parameter by using the GUI
- Authentication of signals to detect data modification in WAN and replay of data

8.9.2.3 IEC 61850 GOOSE based protection

- IEC 61850 GOOSE transmission module shall be integrated and configurable as part of the substation configuration file
- Possibility to filter specific GOOSE messages and transmit the same to the remote end
- Possibility for solving conflicting GOOSE message fields in wire speed (e.g. VLAN Address, MAC Multicast Group, Application ID)
- Possibility to interconnect redundantly to a PRP redundant substation LAN
- Possibility for trip counters of interested GOOSE messages
- In case of loss of communication on main path a switch-over of the IEC 61850 GOOSE based protection channel to the standby path shall be hitless
- Guaranteed back to back latency of ≤ 3 ms for high and extra high voltage line tripping
- Availability of communication channel of 99.999%
- Authentication of signals to detect data modification in WAN and replay of data

More details on the requirement of the teleprotection features are defined in the corresponding teleprotection interface module chapters.

Distance and differential protection functions shall also be made available for TDM based transport (networks) complying with the established, standard TDM performance parameters.

8.9.3 System capacity

8.9.4 The protection signalling system shall be designed with a minimum of 4 diverse teleprotection command channels operating in full duplex mode. System performance

8.9.5 The protection signalling system performance shall be in accordance with the requirements of IEC 60834 specification.Interfaces

The teleprotection signalling equipment shall provide suitable interfaces for the direct connection to fiber optic communication equipment. .

8.9.6 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:

- Error rate of guard or tripping signal codes too high.
- Loss of synchronisation.
- Alarm indication signal response.
- Bit error rate above the set level.
- Components failure.
- Response of an internal test routine.
- Receive signal low level.
- Loss of guard signal.

The LED alarm displays shall be capable of being reset from the equipment.

8.9.7 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.

8.10**Hybrid Multiservice Platform requirements**

8.10.1 **General requirements**

The equipment shall be capable of operating as a label edge (LER) and label switch router (LSR) in MPLS-TP networks. It shall support packet switched point-to-point, point-to-multipoint and multipoint-to-multipoint topologies. The equipment shall as well support hybrid operation where MPLS-TP and SDH is operational at the same time. Ethernet over PDH/ SDH as well as circuit emulation functionality shall be provided to link the TDM with the PSN domain. In SDH networks the equipment shall operate as a terminal, as an add-drop multiplexer and in transit mode as a regenerator/repeater. First order (2 Mbps), low order (VC-12) and high order (VC-4) multiplexing shall be integrated. Conference for voice channels and point-multipoint functions for data signals shall be supported. The equipment shall be of modular design.

8.10.1.1 **Packet switched capacity**

The design of the backplane shall provide wire-speed GbE connectivity between the different slots and the central (redundant) Ethernet switching matrix slots. Between uplink slot positions a backplane capacity of n x 10 GbE shall be available ($n \geq 2$). For future upgrade purposes a 10 GbE backplane connection from the central Ethernet switching matrix to x different slots shall be available ($x \geq 6$). The central switching matrix shall at least support 64 Gbit/s in full duplex wire-speed switching capacity in a lower scale version and at least 240 Gbit/s in a higher scale version.

8.10.1.2 **Circuit switched capacity**

The digital cross-connect function shall be implemented in such a way that no single point of failure exists. The PDH cross-connect capacity shall be up to 128 x 2 Mbit/s non-blocking with a granularity of 64 kbit/s.

Additionally, the equipment shall offer a scalable high-order SDH cross-connect capacity with at least 80x80 VC-4 and a low order cross-connect for VC-3 and VC-12 in the same equipment with a capacity of at least 48x48 VC-3 and 945x945 VC-12.

8.10.1.3 **Redundancy capabilities**

The equipment shall provide enhanced redundancy features in order to ensure highest availability of the communication network. The following redundancy schemes shall be supported:

- Redundant or distributed cross connect
- Redundant power feeding
- Redundant CPU functionality
- HW redundancy of SDH aggregate interfaces
- HW redundancy of 1 Gbit/s and 10 Gbit/s MPLS-TP aggregate interfaces
- HW redundancy of voice and data conferencing
- HW redundancy of central Ethernet switching matrix
- HW redundancy of routing function
- Enhanced TDM traffic protection schemes
- SNCP/ MSP/ VCAT/ LCAS over redundant TDM aggregate modules
- Enhanced PSN traffic protection schemes
- 1:1 LSP protection switching (< 50 ms switchover time)
- Hitless redundancy for protection data channels using MPLS-TP
- xSTP and ERPS loop prevention
- VRRP for routing function

8.10.2 **Traffic protection**

8.10.2.1 **1:1 Path protection**

1:1 protection of MPLS LSPs shall be supported. Switching from main to backup path shall be automatic, bidirectional and symmetrical. Configuration options shall exist for reversible or non-reversible operation.

8.10.2.2 **1+1 Path protection**

The equipment shall provide means to protect 64kbit/s PDH channels. The protection shall be end to end from one interface (telephone, data, protection signalling) to the other. It shall switch automatically from the main channel to the standby channel. It shall be configurable whether the system switches back to the main channel (reversible switching) or not (non-reversible).

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm. The switching shall be done within the multiplexer without using the Network Management System.

SNCP protection on VC-12, VC-3 and VC-4 level shall be supported. Switching from main to backup path shall be automatically. Configuration options shall exist for reversible or non-reversible switching. Switchover time shall be less than 50 ms.

For utility critical applications symmetrical switching of TX and RX on VC-12 and 64Kbps level shall be supported.

8.10.2.3 **1+1 Section protection**

The equipment shall provide means to protect SDH STM-n sections (MSP). It shall be possible to use two independent links: one as the main and the other as the standby. The system shall automatically switch to the standby connection and generate an alarm if the main connection is disturbed. MSP shall be configurable as intra- and inter-card feature to provide aggregate interface as well as module protection. The switching shall be done within the multiplexer without using the Network Management System.

8.10.2.4 **Hitless protection for teleprotection data channels**

Critical teleprotection data shall not use any LSP 1:1 protection but rather be implemented using a hitless redundancy scheme where critical teleprotection data is duplicated at the teleprotection interface card itself and transmitted via two diverse non redundant LSP's.

8.10.3 Network Topology

It shall be possible to build point to point, linear, ring, T, and meshed networks.

8.10.4 Synchronization

It shall be possible to synchronize the equipment using an external clock source, derived from a network or from an internal oscillator. The synchronization shall be configurable and it shall be possible to distribute the synchronization to other equipment as well. The system shall have the means of switching to select the synchronization source as well as a means of preventing the system from creating synchronization loops.

The equipment shall support synchronous Ethernet and a synchronization selection process based on ESMC (Ethernet Synchronization Message Channel).

The precision time protocol (PTP) as defined by IEEE/ IEC shall be supported for frequency and time of day synchronization.

For teleprotection event recording it shall be possible to synchronize the event recorder of teleprotection interfaces to a GPS. The GPS time shall be available for the Network Element time as well.

Configuration support for SyncE and PTP synchronization shall be available e.g. by means of wizards or guided configuration.

For TDM synchronization the equipment shall be capable of selecting the source of synchronization by means of SSM (Synchronization Status Messaging) on 2 Mbit/s PDH or SDH port or by means of a priority-based sequence.

8.10.5 Alarms

Each module shall supervise its functions and shall have an alarm-indication LED on its front. All alarms shall be collected by the NMS. Each node shall be capable of collecting external alarms.

8.10.6 Maintenance facilities

On hardware level the following maintenance features shall be supported

- Port mirroring
- SNMP based port and traffic class counter statistics (UC, MC, BC)

On MPLS level the device shall support at least the below OAM features

- LSP ping/ traceroute
- Delay measurement
- BFD

Specifically, for teleprotection interfaces the device shall support enhanced monitoring

- Configurable packet loss thresholds with warning and alarming functionality
- Graphical/ tabular performance histograms including 15 min/ 24 hours/ 7 days' statistics

On legacy TDM interfaces the equipment shall provide

- Means to loop signals towards the network and towards the user on 64kBit/s level as well as on 2Mbit/s level. It shall indicate an alarm if a loop is activated.
- Performance monitoring and counters according to ITU-T standards.

8.10.7 Telephony

The equipment shall provide means to interconnect telephony subscribers and PBX systems.

- Digital VoIP subscriber and gateway functionality (SIP)
- Power over Ethernet solutions
- Hotline services

8.10.8 Digital Telephone Exchange

The contractor shall provide (when called for in the Scope of Supply) a Digital telephone exchange complete with 50% spare capacity for future extension works use including maintenance software, modem and desktop computer (PC-based Network Management System).

The exchange shall have the following minimum specifications:

- Dual CPU:
  - Intel Core i3 330E with 2GB memory
  - Diskless storage: 8GB compact flash
  - Combined TP(Proprietary) and SP (Linux) into one CPU

- SIP server embedded
- Redundant Gigabit Ethernet ports

- 19-inch stackable chassis architecture
- Virtualization
- 48VDC power supply
- Operation temperature range of 0°C - 40°C
- Maximum capacity of 6144 IP+TDM ports
- System capacity of up to 4000 IP/TDM stations
- Up to 1524 number of trunks
- Expandable to 24,576 ports
- Up to 192,000 ports in a fusion network

The Exchange shall be configured to manage all KETRACO substations telephone subscriber units through the Multiplexer unit via the Kenya Power System Telecommunications Network.

The design and configuration details of the complete Telephony exchange system as well as the telephone subscriber units shall be provided to the Employer for approval before implementation. The location of the Digital Exchange shall be as advised by the Employer

8.11**KETRACO WAN Integration**

KETRACO has created a KETRACO WAN (Wide Area Network) for the purpose of extending the KETRACO local office network for both data and telephony to KETRACO substations as well as creation of a network for the purpose of CCTV and other tertiary services that may be deployed in the future such as Access Control and Asset Management.

KETRACO WAN is envisaged to support upto 50 substations for all data inclusive of:

- Office Data (30% payload)
- Office Telephony (10% payload)
- CCTV feed (30% payload)
- Asset Management (10% payload)
- Other services (20% payload) such as Fiber Monitoring System data, Amulgamated data, KET systems management network

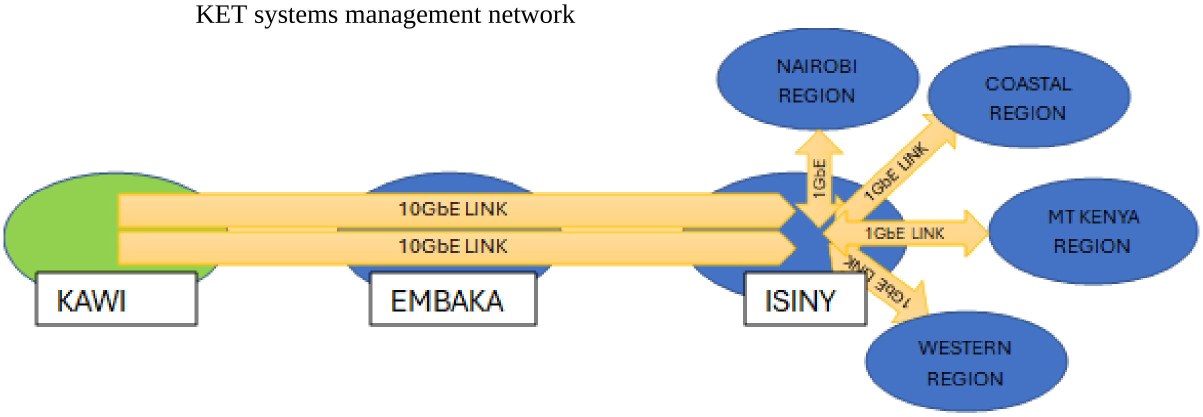


Figure 1: KETRACO WAN OVERALL LINK STRUCTURE

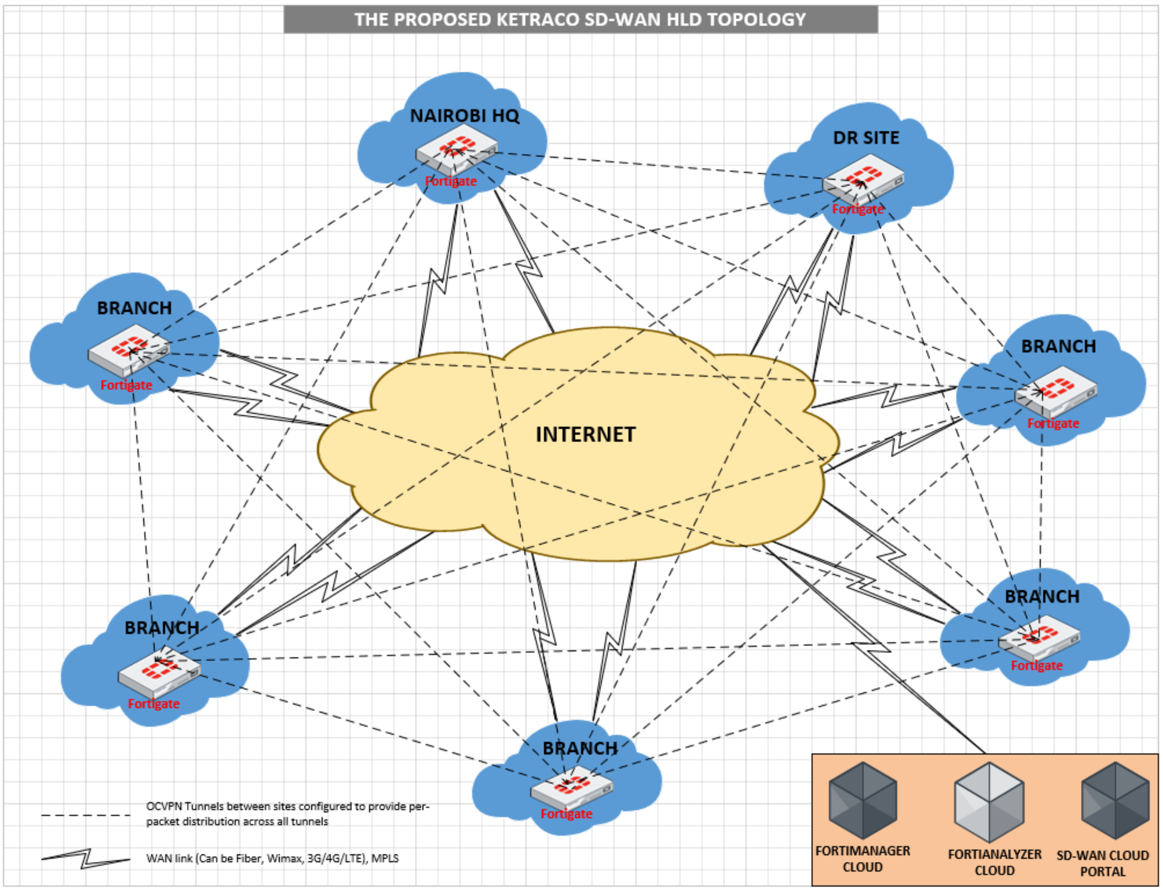
The contractor shall extend this KETRACO WAN network through the telecommunications network and provide routing back to the KETRACO headquarters for extension of this network into each substation in the contract. The contractor shall deploy the KETRACO WAN in the Telecommunication Room in a 42U floor mount panel with proper cable management. The panel should have dual power supplies from both the AC and

DC supply panels from the supply panels for redundancy with the sizing designed with 60% spare capacity. All cabling shall conform to the ANSI/TIA-568-C and ISO/IEC 11801 Ed. 2 standards with proper use of CAT6A SF/FTP cables and RJ45 connectors with boots, patch panels, cable guides, ESD straps and proper grounding made to panel and all equipment.

The system shall also be connected to the AC backup supply within the substation. The contractor shall also design and deploy an SD-WAN Network Solution similar to what is installed in the existing substations. The contractor to design, configure and install the SD-WAN network shall be provide the following equipment to the Employer for approval;

- Certified partnership with the equipment vendor
- Manufacturer Authorization for the firewalls, switches and access points
- Provide evidence of having deployed a similar wide area network

The SD WAN High Level Design is as described below:



The equipment installed for the SD-WAN in other KETRACO stations include:

SD-WAN EQUIPMENT	
FortiGate 60F SKU FG-60F-BDL-811-36	Hardware plus 24x7 FortiCare and FortiGuard Enterprise Protection Onsite Implementation, Maintenance and Support Services/SLA for FortiGate 60F

Rack Mount Tray SKU SP-RACKTRAY-02	Rack mount tray for all FortiGate E series and F series desktop models and backward compatible with SP-RackTray-01. For list of compatible FortiGate products, visit Documentation website.
FortiSwitch 124F FPoE SKU - FS-124F-FPOE	L2+ managed POE switch with 24GE + 4SFP+, 24port POE with max 370W limit and smart fan temperature control Onsite Implementation, Maintenance and Support Services/SLA for Fortiswitches
SKU FC-10-S124F-247-02-36	24x7 FortiCare Contract
FortiAP 433F SKU FAP-U433F-E	Indoor Wireless Universal AP - Tri radio (2x 802.11 a/b/g/n/ac/ax, 4x4 MIMO and 1x 802.11 a/b/g/n/ac Wave 2, 2x2 MU-MIMO), external antennas included, 1x 10/100/1000/2500 Base-T RJ45, 1x 10/100/1000 Base-T RJ45, BT/BLE, 1x Type A USB, 1x RS-232 RJ45 Serial Port. Ceiling/wall mount kit included. For power order: 802.3at PoE injector GPI-130. Optional DC power adaptor SKU SP-FAP43F-PA-X-5. Region Code E Onsite Implementation, Maintenance and Support Services/SLA for FortiAps
SKU FC-10-P433F-247-02-36	24x7 FortiCare Contract
FortiManager VM SKU FC1-10-FMGVS-258-01-36	Subscription license for 10 devices/vdoms managed by FortiManager VM S-series. 24x7 FortiCare support included. Onsite Implementation & Maintenance

8.12 **Cyber Security**

The equipment shall provide means to support integration into a cyber-security architecture enabling cyber secure operation of a communication network.

- Authentication, Authorization and Accounting (AAA)
  - Local management port disabling
  - User roles (privilege-levels)
  - Radius based authentication
  - Security relevant local event logging (audit log)
  - Syslog
- Secured management communication
  - SNMPv3
  - IPSec
  - SSH
- Denial of service (DoS) prevention for device functions and user traffic
  - Rate limiters for different traffic types
  - Firewall towards device management
- Traffic authentication and encryption

The equipment shall be of robust design and hardening shall be done considering cyber security aspects.

8.13 **Quality of service**

Hardware support to ensure device internal and user traffic quality of service shall be provided.

- ≥ 8 hardware queues per physical port
- Configurable scheduling profiles
- Priority mapping tables (DSCP, PCP, EXP, PHB, TC)

- Priority configuration for individual protocols (e.g. PSC, MCC, …)
- Port and service based rate limiting (at least single rate two colour marker (SR2CM))
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port

8.14**SNMP**

The device shall at least provide the following information via SNMPv3 interface.

- Alarms
- Interface counters

8.158.15 Local User Terminal

It shall be possible to connect the craft terminal to any network element in the network using the TCP-IP protocol. The craft terminal shall support configuration, maintenance, and status information. It shall provide a 'windows' oriented user interface.

8.16**Network Management System**

The Multiplexing equipment shall be managed from the National Control Centre via a Network Management System. The contractor shall be expected to provide supervision, monitoring and control of the Multiplexer equipment into the Network Management System located in the National Control Centre.

The Network Management System (NMS) in the NCC has facilities to supervise, monitor, control and configure each equipment and the whole network. It has capabilities of fault, configuration, performance and security management with various graphical views to the network such as geographical overview, logical network structure, and hierarchical view. It allows to define different user profiles.

With the contractors integration of the Multiplexing equipment(s) into the NMS, the NMS shall support end-to-end service provisioning for MPLS-TP as well as for TDM based services for the whole network. For MPLS-TP based services, all service types (VPWS, Tree, VPLS) shall be supported by the end-to-end service provisioning functionality. The NMS shall also perform channel calculations based on various parameters such as available bandwidth, number of hops, provisioned bandwidth/services and channel diversity requirements.

A comprehensive alarm management shall show current alarms such of all the stations' Multiplexers including the Multiplexer(s) installed by the Contractor, with icons of the network elements change their colours according to the alarm level. The alarms shall be categorized as critical, major, minor alarms and warnings. A summary shall indicate the total number of alarms and warnings in the entire network. An alarm list shall list all alarms of the entire network according to the time of their occurrence. It shall be possible to filter alarms with various filter criteria. Operators shall be able to add comments to the alarms.

The NMS shall also provide the following:

- Additional functionality such as centralized ESW handling with the possibility for scheduled ESW distribution and timed ESW activation on a node. Inventory management functionality allowing the upload of all the inventory information of a complete network with detailed information on HW state, serial number or ESW information running on NEs and individual interface cards shall be provided.
- A Graphical User Interface with definable network displays (maps). Icons symbolizing sub-networks, equipment and sections shall be available to be placed on a background image. Drill down to display greater details down to equipment port level shall be possible. An online help shall be integrated in the NMS.
- A graphical shelf view of the devices. Currently installed and configured modules in the network element shall be displayed. Current alarm and status information for the different modules and ports shall be presented with dynamic colouring of the network element.

Security in the NMS with all the stations shall be organized around domains, profiles, and users with defined privileges. Profiles shall define access rights to different NMS functions (e.g. map view, alarm view). User privileges shall be configurable to define user access rights for a defined number of functions.

The NMS shall have a graphical representation of the synchronization status of the complete network elements (for TDM traffic as well as for SyncE).

Main/Standby functionality of all Multiplexer units shall be supported by the NMS. In case of a failure of the main NMS, the standby NMS takes over. Replication of the databases shall be automatically performed.

The DCN's (Data Communication Network) to access all Network Elements are based on TCP-IP and the Contractor shall be expected to consult the Employer on the implementation of the DCN for the Multiplexer(s) provided by the Contractor. The management system shall also be able to offer an SNMP northbound interface for alarm integration into higher order network management systems.

8.17 **Aggregation/ transport interface requirements**

8.17.1 **MPLS-TP functionality**

The following MPLS-TP functionality shall be supported:

- Static configuration of MPLS-TP tunnels via configuration tool or network management system
- Bidirectional MPLS-TP tunnels
- Priority handling using L2 or L3 class of service information
- Special care needs to be taken for mission critical services, required performance parameters for teleprotection applications need to be guaranteed
- Port based MPLS assignment
- VLAN based MPLS assignment

The following topologies shall be supported

- Point to point virtual private wire services (VPWS)
- Tree structures
- Virtual private LAN structures (VPLS)
- Hierarchical VPLS structures (H-VPLS)
- End to end Operation Administration and Maintenance (OAM) channel with at least the following functionality
  - Continuity check messages (CCM)
  - Remote defect indication (RDI)
  - Route tracing (LSP ping/ trace route)
  - 1:1 traffic protection with < 50 ms switchover time
- Management functionality using dedicated MPLS channel
- Circuit emulation of legacy services via MPLS-TP shall be supported

8.17.2 **Scalability of MPLS solution**

A lower scale and a higher scale version of the MPLS function shall be available.

The lower scale version shall support at least

- ≥ 15 x protected hierarchical VPLS networks in parallel in a 200 nodes MPLS network, considering a backbone of 15 devices.
- ≥ 50 x protected point to point links with guaranteed switchover time < 50 ms
- ≥ 100 x protected point to point links with guaranteed switchover time < 500 ms
- ≥ 100 x protected point to point links with guaranteed switchover time < 1 s

The higher scale version shall support at least three times the resources of the lower scale version.

8.17.3 **Ethernet Interface**

Up to 8 x 10Gbit/s optical ports shall be available for Ethernet uplink purposes. The ports shall be available for the synchronization source selection process and support synchronous Ethernet (Sync-E / ESMC) as well as PTP.

1Gbit/s optical / electrical ports shall be available for Ethernet uplink purposes as well.

The uplink 1 Gbit/s and 10 Gbit/s uplink interfaces shall be upgradable to support MPLS-TP encapsulation.

8.17.4 **SDH Interface**

The interface shall be designed for use on single mode fibre (conforming to ITU-T G.652 or G.655). The interface card shall be based on SFP technology and use LC/PC connectors.

The following main functions shall be supported.

- Prepared for STM-1/4/16 SFP's (small-factor pluggable units) for short, medium, long and extra-long optical communications (1310nm, 1550nm or xWDM)
- Prepared for electrical STM-1 (155Mbit/s) SFPs
- Termination of the OS-, RS-, MS- and VC-4 layer
- Extraction and insertion of the SOH communications information
- Through connections of VC-12, VC-3 and VC-4
- Support of MSP (Multiplex Section Protection)
- Support of SNCP (Subnetwork Connection Protection)
- Ethernet over SDH (EoS) functionality based on GFP / VCAT / LCAS
- 1+1 SETS timing protection
- 1+1 hardware protection

The following maintenance functions shall be supported.

- Status indications
- Loops
- Restart after ALS
- Trail Trace Identifier (TTI) monitoring
- SFP inventory and diagnostics

At least the following amount of ports shall be available per module. Twice the amount shall be available in hardware redundant configuration.

- 4 x STM-1
- 4 x STM-4
- 2 x STM-16

8.17.5 **PDH Interface**

A 2Mbit/s E1 module for electrical transport communication shall be supported. Each module shall provide at least 8 x 2 Mbit/s electrical ports according to ITU-T G.703. The ports shall be available for the synchronization source selection process. The interface shall be able to extract the 2.048 MHz clock for synchronization of the multiplex equipment. Support of SSM synchronization signalling shall be supported.

SHDSL Interface

The 2 Mbit/s SHDSL interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to 10 km using G.SHDSL modulations. At least 8 x SHDSL interfaces shall be available on the module. The ports shall be available for the synchronization source selection process. Clock quality level transmission/ reception shall be supported.

8.18**Access/ user interface requirements**

8.18.1 **2/4-Wire Interface (VF interface)**

The module shall provide at least 8 interfaces for voice channels with a bandwidth of 300 Hz - 3.4 kHz and 2 signalling channels (M → E, M' → E') per voice channel. Each voice channel shall be configurable to operate with or without CAS. With CAS it shall use the "a" and "b" bits for the two signalling channels.
The level shall be software adjustable within the following range in 4-wire operation:

- Input: +9.5 to -16dBr
- Output: +7.0 to -16.5dBr

Each voice channel shall be individually configurable with 1+1 path protection. Conferencing functionality of more than 10 parties shall be supported. Stacking of conferences of up to at least 30 participants shall be possible. The conferencing function shall be EQP protected (1:1 hardware protection).

8.18.2 **Voice over IP subscriber media gateway**

The module shall, as a local concentration unit, provide gateway functionality. PSTN (2-wire) subscribers over PSN shall be supported using the SIP protocol. Redundant connection to the VoIP PBX network shall be possible. Local call routing shall be supported in case of connection loss to the PSN network. This unit shall be EQP protected (1:1 hardware protection).

8.18.3 **Party line Telephone System (Engineering Order Wire)**

An engineering order wire (EOW) facility shall be provided at each multiplexer.

- EOW based on Voice over IP (VoIP). The EOW traffic shall be routed over the management channel.
- Alternatively, over TDM the EOW shall be configurable as a party line (conferencing) and use in band DTMF signalling to call another EOW-Terminal. The Terminal shall have an integrated DTMF decoder allowing to program a subscriber call number (1...4 digits), and two group call numbers (1...4 digits each).

8.18.4 **Serial Data Interface**

The following features shall be supported

- Programmable data interface V.24, /V.28, V.35, X.24/V.11, RS-485 (2-wire/ 4-wire)
- Synchronous and asynchronous operation from 0.6 … 38.4kbit/s
- Synchronous operation on 48, 56, N x 64kbit/s (N = 1 … 31)
- 1+1 path protection, Point-Multipoint, Performance Monitoring, Data conferencing

The conferencing function shall be EQP protected (1:1 hardware protection).

8.18.5 Ethernet/IP Interface

For MPLS-TP based networks the Ethernet L2 or IP L3 interface cards shall function as provider edge (PE). Ethernet/ IP modules with the following functionalities shall be available.

- Layer 2 Ethernet switching/ MPLS attachment service access interfaces.
- At least 12 ports per module
- Ethernet electrical connection: 10/100/1000BaseT
- Ethernet optical connection: 100Base-FX and 1000Base-LX/-SX/-EX/-ZX
- Support of VLAN tag stacking
- Protection by means of xSTP, ERPS or L2GP in case of MPLS based networks
- Port and VLAN based rate limiting
- Hard QoS (8 queues per physical port)
- Priority handling (PCP/ TC/ PHB/ EXP) shall be configurable
- Port based access (all traffic is mapped into MPLS-TP services)
- VLAN based access (separation of VLANs into different MPLS-TP services)
- Mix of port and VLAN based access and mapping into VPWS/ VPLS on the same physical port
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port
- Traffic policing/ rate limiting shall be supported
- Traffic type filtering shall be supported (multicast, broadcast, unicast)
- VLAN mapping shall be possible

Ethernet routing modules shall comply with the following specification.

- Low capacity layer 3 routing interface card with access to TDM bus.
- At least 4 ports per module
- Ethernet connection: at least 10/100BaseT
- Routing Protocols: static IPv4 routing, OSPF2 v2, RIP v2
- WAN protocols: PPP, MLPPP
- WAN capacity: up to 16 x 2Mbit/s
- WAN ports: ≥ 30
- Redundancy: EQP (1:1 hardware protection) and VRRP
- Port based rate limiting
- Soft QoS (software queuing)
- High capacity layer 3 routing interface card with access to 1Gbit/s and upgradable to 10Gbit/s backplane.
- At least 12 x FE/ GbE optical/ electrical SFP based front interfaces
- At least 4 x virtual routing functions (VRF/ VPRN)
- Wire speed forwarding on all ports (1GbE or 10GbE backplane access)
- At least IPv4 unicast routing (IPv6 ready)
- OSPFv2 (RFC 2328)/ static routing
- OSPF authentication (Simple/ MD5)
- VRRPv3 (RFC 5798)
- At least 1:1 NAT, one instance per VRF
- At least basic firewalling (ACL rules/ DoS protection/ port and VLAN based rate limiting)
- Layer 3 hardware supported QoS (DSCP/ 8 queues per physical port)
- 1:1 hardware protection (intra-chassis EQP)
- SNMP MIBs (at least IF counters/ alarms)
- Maintenance features (Ping/ trace route)
- At least 128 x VLAN interfaces per module
- At least 128 x VRRP instances per module
- At least 32 x VRRP link tracking per module

For legacy SDH integration the following Ethernet over SDH (EoS) functionality shall be supported.

- At least 12 x logical EoS WAN ports per module

- EoS WAN port capacity of at least 2.4 Gbit/s per module
- Framing according General Framing Procedure (GFP) ITU-T G.7041
- Virtual Concatenation (VCAT) according ITU-T G.707
- Protection by means of Link Capacity Adjustment Scheme (LCAS) according ITU-T G.7042
- A module with Power over Ethernet shall be available to power e.g. camera, telephone set (Voice over IP). MDI / MDIX shall be supported on electrical interfaces.
- At least 12 x PoE ports per module
- PoE and PoE+ standard. At least 2 x PoE+ with up to 30 W shall be supported per card. In case end devices do not need the full PoE+ power capacity the remaining PoE capacity shall be shared among all ports on the same module.
- At least 84 W of PoE power per module

8.18.6 **Alarm Interface**

The module shall provide means to collect at least 12 external alarms, which shall be displayed on the Network Management System. It shall be used to supervise external equipment by the Network Management System. A minimum of 8 outputs, which can be controlled from the Network Management System, shall be available. It shall be possible to connect an input to an output so that if an alarm occurs, the output contact is triggered.
Logical operations among alarm inputs shall be supported.
It shall be possible to label an alarm. The label-text shall be read from the interface module and visible as well on the Network Management System as well as on the local craft terminal.

8.18.7 **Teleprotection Command Interface**

The module shall support the following features related to the protection commands.

- Transmit up to 4 protection commands bi-directionally
- Accept protection command signals in the range of 24VDC … 250VDC
- All inputs and outputs shall be isolated and with EMC immunity for harsh environment (see also table of compliance, emission and immunity)
- Security and Dependability according to IEC 60834-1 shall be fulfilled

It shall also be able to drop and insert commands, transfer commands as a transit station and to realize AND- and OR-combinations between commands. The module shall support T-node configurations.
The teleprotection module shall provide:

- An integrated non-volatile event-recorder, which shall be synchronized to either the PTP information available in the MPLS-TP based WAN, to the node local clock or via local connection to the Global Positioning System (GPS) using the IRIG-B inputs
- A command counter, which counts trip commands
- IRIG-B time of day outputs to pass on time of day information to end devices
- Robust and fast transmission of teleprotection commands by means of direct packetization of teleprotection signals in case of MPLS-TP WAN shall be supported

The teleprotection module shall further support:

- 1+1 path protection. Switching shall be done within less than 4 ms (typical value) for TDM line interfaces and hitless for MPLS-TP networks
- Periodical automatically initiated loop-tests
- Delay measurement and supervision of the teleprotection channel including a warning if a configured threshold is exceeded
- Input debouncing functionality shall be provided
- Input/ output command prolongation functionality shall be provided
- Command addressing: this function shall be used to prevent tripping if the signal is wrongly routed through the telecommunication network

Under no circumstances the module shall cause false trip-commands in case of power supply failure or when equipment is put into or taken out of service.

8.18.8 **Optical Teleprotection Interface**

This module shall have at least 4 optical ports each of them allowing direct connection to protection relays with interfaces complying with ANSI/IEEE C37.94. Each interface shall support all 12 time slots (64 kbit/s – 768 kbit/s) in accordance with ANSI/IEEE C37.94.

The ports shall be configurable to be used also for connection with protection relays using the former interface operate according to IEC 60870-5-1, format class FT 1.2 on 1300 nm, single mode fibre using MCMI (Multi Coded Mark Inversion) line coding.
Symmetry as well as jitter and wander values shall be guaranteed in order to meet application requirements regardless of the transport technology (TDM or MPLS-TP). IRIG-B outputs (optical and electrical) shall be available to pass on time of day information to end devices in case WAN supports transmission of accurate Time of Day information
Redundant communication channels in line with application requirements shall be supported.

8.18.9 **IEC 61850 GOOSE protection interface**

A specific interface for future IEC 61850 based protection applications shall be available. The same shall be part of the IEC 61850 configuration of the substation and act as a gateway IED subscribing to the relevant messages for line distance protection. At least the following functionality shall be provided:

- 4 x FE/ GbE interfaces (SFP based) for direct connection with the station bus of IEC 61850 substations
- Representation of remote IED for inter substation IEC 61850 GOOSE signal transmission
- Filtering capabilities for GOOSE messages
- Translation capabilities of GOOSE messages to resolve potential addressing/ naming conflicts between substations
- Redbox functionality for connection to PRP redundant station bus (one card/ two card solution)
- L2 firewall for access restriction from the WAN to the substation station bus
- Hitless redundancy for GOOSE protection communication channels
- Guaranteed data integrity thanks to authentication of data streams
- 6 electrical IRIG-B outputs for synchronization of end devices to GPS Grandmaster clock
- Optical IRIG-B output for synchronization of end devices to GPS Grandmaster clock
- SNTP master functionality for providing time of day information to IEDs
- SNTP client functionality for full IEC 61850 compliance
- MMS status reporting to substation automation system for full IEC 61850 compliance
- Enhanced traffic supervision features providing full visibility of the communication channel performance
- Full integration in FOXMAN-UN network management system and FOXCST configuration tool
- Providing all optical interconnections from relay to relay through multiplexer without any converter boxes

It shall be possible to connect to up to 8 different remote ends with 1 interface card (or 1 PRP redundant interface card couple)

8.18.10 **Binary Signal transmission interface**

This interface shall provide means to transmit binary signals and support the following features.

- Isolated inputs and outputs (I/O)
- Accepting I/O for 24 … 60 VDC
- Outputs shall be solid-state relays
- The interface shall provide a 24 VDC auxiliary power supply, short-circuit-proof
- Logical combinations of binary signals shall be supported

8.18.11 **E1 Interface**

A 2 Mbit/s E1 module for electrical communication shall be supported. Each module shall provide at least 8 x 2 Mbit/s electrical ports according to ITU-T G.703 and G.704. Support of SSM synchronization signalling shall be supported.
A high density E1 module providing at least 48 x E1 interface ports shall be available. Hardware protection of these E1 circuits shall be supported.

8.18.12 **Circuit Emulation Interface**

This module shall comply with the ITU-T G.703 / G.704 recommendations and also allow transparent 2Mbit/s signals complying with G.703. The module shall have at least 8 x 2 Mbit/s interfaces, each of which may be individually activated. Additionally, the circuit emulation instances shall be available for the other access interfaces, e.g. serial and telephony.

- Impedance of 120 ohms (75 ohms with external balun)

- Supporting CRC-4 multi-frame according to ITU-T G.704 (administrative state configurable by software)
- The CAS signalling according to ITU-T G.704 table 9 shall be activated optionally
- 2 Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals
- Flexible, individual configuration of the 2 Mbit/s interfaces to the circuit emulation instances or to the TDM backplane
- SAToP (RFC 4553) "Structure Agnostic Transport over Packet" circuit emulation method support
- CESoPSN (RFC 5086) "Circuit Emulation Service over Packet Switched Network" circuit emulation method support
- CESoETH (MEF8) "Circuit Emulation Services over Ethernet" method support

8.18.13 **SHDSL Interface**

The 2 Mbit/s SHDSL interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to10 km using G.SHDSL modulations. It shall communicate either with another interface of the same type or with a remote desktop terminal. Remote powering of the desktop terminal shall be available. Up to 8 x SHDSL interfaces shall be available on the module.

In addition, a SHDSL interface complying with Ethernet first mile (EFM) standard as per ITU-T G.991.2 shall be available. The same shall provide at least 8 x SHDSL EFM ports. The capacity shall be up to 22.8 Mbit/s if pair bonding is used. The capacity on 1 pair shall be up to 5.696 Mbit/s.

8.18.13.1 **SHDSL Desktop Terminal Equipment**

The terminal shall provide a SHDSL interface to transmit 2Mbit/s on 1 or 2 pairs of copper wire over a distance of up to 10 km. It shall be housed in a metallic indoor case (desktop).

The following interfaces shall be available

- G.703, 2 Mbit/s, 75 ohms
- G.703, 2 Mbit/s, 120 ohms
- X.21/V11, n x 64 kBit/s (n = 1 to 31)
- V.35, n x 64 kBit/s (n = 1 to 31)
- 10/100BaseT Ethernet

SHDSL Repeater

For distances longer than 10 km a SHDSL repeater solution shall be available including a remote powering solution.

8.19**Synchronisation and Test Equipment**

Recommended list of equipment:

Master clock for the synchronisation of MPLS/ SDH equipment: Type M3000 or similar

Optical Power Meter for 1300nm and 1550nm, handheld: OLP-6 or similar

Digital Communication Analyser: PFA-35 or similar for signal analysis on 64kbit/s / 2Mbit/s level

Optical Time Domain Reflectometer OTDR

Test equipment for Teleprotection Module: Test set or similar

Ethernet test equipment: CMA-3000 or similar

8.20**Spare Parts**

8.20.1 **Mandatory Spare Parts**

The following equipment shall be provided as the mandatory spare parts:

- Ethernet Switches: One for each type of switch provided in terms of its physical hardware and functionality.
- One Teleprotection card - Processing Board
- One Teleprotection card - Voltage acquisition command from 24 to 250Vdc
- One Teleprotection card - Nominal voltage from 48Vdc to 60Vdc
- One Teleprotection card - Digital communication with G703
- One Teleprotection card - 1x Connector Board with built-in VoIP order wire port.

- SDH/PDH STM-1 card - 1x CPU card with 2* STM 1/4 w/o SFP optical modules
- SDH/PDH STM-1 card - 1x Single DC supply (48Vdc)
- SDH/PDH STM-1 card - 1x 16 T1 or 16E1(120) software programmable Tributary Card
- SDH/PDH STM-1 card - 1x 1GBE+8FE interface card w/ L2 switch mapping up to 622Mb
- SDH/PDH STM-1 card - 1x 8-channel Co-directional card
- SDH/PDH STM-1 card - 1x 12 FXS Card w/ Metering pulse and PLAR
- SDH/PDH STM-1 card - 1x STM1/4 add drop interface card w/o SFP optical modules
- SDH/PDH STM-1 card - 1x 8-channel RS232 w/ X.50 subrate module w/ RJ connector
- SDH/PDH STM-1 card - 1x 8-channel E&M module
- One set of Fibre optic splicing kits and consumables
- Configuration licenses for the software for each equipment.
- Fibre optic approach cable drum (km)- 6km

8.20.2 **Recommended Spare Parts**

In order to assist in the ordering of spare parts, the contractor is required to recommend a spare 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, including turnaround times.

The contractor 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 Contractor. The prices shall remain valid for any such variation of quantities, unless stated otherwise.

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.

8.21**Documentation**

The contractor shall provide at least the following information and documents:

- General arrangement drawings of the Telecommunication Layout;
- Overall structure of the Telecommunication System;
- Detailed description of the Telecommunication System;
- Manufacturing Specifications of the Telecommunication System;
- Catalogues, literature and reference lists of the proposed equipment;
- Type Test certificates from an independent testing authority or independently witnessed;
- Quality Management System Manual and ISO Certificate of the equipment manufacturer.

8.2 Substation Control System

8.2.1 General

This section details the supply (hardware and software), Integration, 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. The Substation Automation (SAS) and SCADA will integrate all the new extensions with the Existing using the newly supplied Hardware/Software which will include, the local HMIs servers, Gateways, Local LAN equipment & accessories, Time synchronization equipment, energy metering and printing. 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), Regional Control Center (RCC) and National System Control Center (NSCC). Currently, KPLC operates the electricity network from the NCCDetails 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 Bay 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 centers, GPS and the telecommunication equipment. The bay control units shall be connected via fibre optic cables to the superior automation system.

8.3 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, testing, 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.

8.3.1 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 SAS/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.

8.3.2 Modifications at the NCC/RCC/NSCC

The following works are required at the NCC/RCC/NSCC:

The following works are required at the NCC/RCC:

1. Update of NCC/RCC/NSCC databases to incorporate new substations and modified existing substations and data received from the substations.
2. Reconfiguration of NCC/RCC/NSCC applications, as necessary, to utilise the updated database data.
3. Update of the Geographic Map
4. Update of NCC/RCC/NSCC Operator displays to incorporate new / modified single line diagrams.
5. Update of NCC/RCC/NSCC Mimic board to incorporate new / modified circuits.
6. All Data Engineering required to incorporate and integrate the new substations with the existing substations.
7. End to end testing of new controls, indications, analogue and alarms from the substation to both the NCC/RCC/NSCC.
8. Any other facilities required for complete functionality.
9.

8.3.3 Scope of Work for SCS

8.3.3.1 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, RCC and NSCC.

8.3.3.2 New 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, RCC and NSCC.
- Complete Substation Control System (SCS).
- Provision of facilities for a complete integration of the Substation Automation System (SAS) for the extended scope with the existing system.
- Incorporate new substation into the SCADA/EMS System at the NCC/RCC/NSCC.
- Any other facilities required for complete functionality.
- Provision of all works; design, supply and implementation; at the interfacing station(s) necessary for complete functionality of the new or extended stations.
- As built Drawings of the Integrated system.
- Any other facilities required for complete functionality.

8.4 SCS Specification

8.4.1 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.

8.4.2 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/NSCC)
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 industrial 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:

- Two independent RTUs /Gateways for sending substation data to the NCC/RCCs/NSCC using the IEC-60870-5-104 protocol. These should be in form of rack mounted industrial PCs in a panel located in the substation's SCADA and telecommunications room with monitors, keyboard and mouse extended to the operator's desk in the operator's room. They shall be configured to operate on hot standby redundancy mode.

- Two independent IEC 61850 Clients for sending substation data to the HMIs. These shall be in form of rack mounted industrial PCs in a panel located in the substation's telecommunications room with monitors, keyboard and mouse extended to the operator's desk in the operator's room. They shall be configured to operate on hot standby redundancy mode.

- Two independent Operator Workstation(s)/ HMIs for local operations and monitoring of substation alarms, events and status. These shall be rack mounted in a panel located in the telecommunications room with monitors, mouse and keyboard extended to operator's desk.

- 1 independent Engineering Workstation/HMI, this shall be installed in a panel in the relay panel room. It shall be fully equipped with a separate Substation and Automation Control System (SACS) runtime and configuration software licence, and all SACS component configuration files and passwords.

- Rugged peripheral equipment (display units, keyboards, mouse) for each PC supplied.

- Event printer.

- Operator log printer

- Hard copy laser jet colour printer with printing, copying and scanning capabilities.

- 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.

- One GPS clock with antenna to act as the Time Server operating on SNTP for time synchronization. The Time Server shall have the capacity to synchronize all SACS components in each substation. Each GPS clock shall have a spare IRG -B port and a spare antenna.

- Interface for laptop computer for maintenance, information transfer and emergency HMI

- Pure sine wave Inverters whose supply is directly from the 110V DC system supply shall be provided to power the AC powered SAS.

- Communication network equipment [station (system) LAN, Field Communication Network, Various optical couplers, etc.].

- Cable protection (rodent proof conduits) on all laid cables to prevent rodent attack.

- protocol converters where required.

- Audible alarm for annunciation of critical alarms.

  - Integration of the Substation Automation and Control System components into the existing SCADA system at the National and Regional Control Centres.

  - Routing of substation data through the telecommunication network to the NCC and RCC.

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

8.5 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
- Dynamic Colouring of HMIs
- Equipment Interlock Diagrams
- 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/NSCC SCS/BCU/LCC) irrespective of overall substation control authorisation.

NCC/RCC/SCS/BCU/LCC) irrespective of overall substation control authorisation. .

8.5.1 Data Scope

The data scope required for SCS will be determined at design phase in accordance with actually contracted equipment. 25% 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:

- Substation/Bay/Relay
- Signal text including designation of the equipment.
- Signal type; SPI/DPI/SCO/DCO/AMI/MFI/STI/ITI
- Scalling values for Analogs
- 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/ Address
- Transmission to NCC/RCC/NSCC
- IOA Signal address for NCC/RCC/NSCC
- ASDU Address
- Time stamp

8.5.2 Transformer Bays

Control functions shall comprise:

- Bay level control
- Data acquisition
- Bay level interlocking
- Bay level supervision
- Auto-Manual Control
- Station wide interlocking between BCUs

Measuring functions shall comprise:

- Amps
- Volts and Frequency
- MW
- MVAr
- Transformer oil and winding temperature
- Tap changer position.

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 Disconnector open indication *
- Diameter/Bus Disconnector close indication *
- Circuit Disconnector open indication *
- Circuit Disconnector 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, SF_6 alarms etc.

Note: All relevant alarms for Earthing Transformers shall also be included.

* Disconnector status signals as per the substation primary arrangement.

8.5.3 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 Disconnector open indication *
- Diameter/Bus Disconnector close indication *
- Line Disconnector open indication
- Line Disconnector 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
- Lockout Relay Status and Reset
- All other relevant alarms such as Line Differential Protection Trip, Distance Protection Trip, O/C Protection Trip, SF_6 alarms etc.

Note: * Disconnector status signals as per the substation primary arrangement.

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8.5.4 Mid Diameter

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 Disconnector open indication *
- Diameter Disconnector 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 SF_6 alarms etc.

Note: * Disconnector status signals as per the substation primary arrangement.

8.5.5 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 Disconnector open indication
- Bus Disconnector 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, SF_6 alarms etc.

8.5.6 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 Disconnector open indication
- Bus Disconnector 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, SF_6 alarms etc.

8.5.7 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

- Inverter
- GPS Clock
- Fire Protection System
- HVAC system
- Substation Security

8.6 Equipment Requirements

8.6.1 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.

The SAS shall be configured for operation with three ports with capability to communicate with three control centres for pre-determined group of signals. They shall use IEC 60870-5-104 Protocol

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)

8.6.2 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.

8.6.3 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, RCC and NSCC. One for connection to the NSCC another for connection to NCC and one for connection to the RCC as follows;

Gateway 1: Communication Port 1 – NSCC Main

Communication Port 2 – NCC Main

Communication Port 3 – RCC Back- up

Gateway 2: Communication Port 1 – RCC Main

Communication Port 2 – NSCC Back-up

Communication Port 3 – NCC Back- up

The two gateways shall have Independent IP addresses and they shall operate in hot-standby mode. Both gateways shall communicate with the NCC/RCC/NSCC at any given time. In case of failure of one gateway, the second gateway shall be capable of communicating with the NCC/RCC/NSCC.

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/NSCC 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/NSCC.

8.6.4 Substation Level Equipment

8.6.4.1 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:

level equipment shall typically consist of the following:

- Substation computers - IEC 61850 Clients (Industrial PC Based)
- Communication gateways
- Substation Local Area Network(s)
- Operator Workstations /Human Machine interface (Industrial PC Based)
- Time Synchronization clocks
- Color Printers with copy, print and scan capabilities.
- Fully Equiped Engineering Laptop
- Engineering PC (Industrial PC Based)
- Audible Alarm
- External Data storage system

Alternate configurations of hardware shall be considered so long as the functional and separation requirements are met.

8.6.4.2 Substation Computer

The substation computer coordinates the operation of the SCS. The functionality shall include:

- Alarm Grouping
- Event 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.

IEC 61850 Clients

Two redundant IEC 61850 clients operating on hot standby mode shall be supplied to separate substation control system from external networks. This will ensure that a failure in the station HMI will not affect monitoring and control of the substation from NCC/RCCs. The two clients shall report to the station HMIs via the substation's LAN via IEC 61850 protocol. All substation control and Protection IEDs shall communicate directly with the Client via IEC 61850 protocol.

Each IEC 61850 client shall be rugged and mounted in a panel inside the telecommunications room. In the event that an industrial PC is used, all USB ports and software dongles shall be mounted inside the CPU's enclosures such that they can only be detached when the CPU enclosure is opened

8.6.4.3 Communications Gateway

The SCS shall be able to communicate with the NCC, RCC and NSCC 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, RCC and NSCC 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, fall over 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. Downloading of information to or from the SCS to the NCC shall not have any impact on SCS performance including alarm response times.

The Gateways/RTUs shall be capabe of transmitting energy meter import/export values to NCC SCADA via IEC 104 protocol as integrated totals (telegram with TypeId: <37> M_IT_TB_1).

8.6.4.4 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 will be of a dual 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.

8.6.4.5 Operator Workstation

The Operator workstations / HMIs shall consist of high-performance Industrial 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.

8.6.4.6 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.

The printer shall have the following capabilities, subject to the approval of the Employer's representative:

- Functions: Print, copy, scan, send, store.
- Multitasking supported: Yes
- Print speed (BW and colour): Normal: Up to 60 ppm
- Copy Specifications: First page out (ready):
- Black: As fast as 2.9 sec
- Colour: As fast as 4.5 sec
- Print technology: Colour Laser Multifunctional
- Print quality BW and Colour (best): Up to 1200 x 1200 dpi
- Supported Media Sizes:
- Paper Cassette 1: Letter, Executive, Statement-R, Envelope (No.10 (COM10), DL, ISO-C5), Custom Size (3-7/8" *5-7/8" to 11-3/4" *8-1/2")
- Paper Cassette 2: Executive, Statement-R, Envelope (No.10(COM10), Monarch, DL, ISO-C5), Custom Size (3-7/8" * 7-1/8" to 12" *18")
- Stack Bypass: 12" x 18", 11" x 17", Legal, Letter, Letter-R, Executive, Statement, Statement-R, Envelope [No.10 (COM10), Monarch, DL, ISO-C5], Envelope Custom Size (3-7/8" x 3-7/8" to 12-5/8" x 18"), Custom Size (3-7/8" x 5-1/2" to 12-5/8" x 18"), Free Size (3-7/8" x 5-1/2" to 12-5/8" x 18")
- CASSETTE FEEDING UNIT-AM1: 12" x 18", 11" x 17", Legal, Letter, Letter-R, Executive, Statement-R, Custom Size (3-7/8" x 7-1/8" to 12" x 18") HIGH CAPACITY CASSETTE FEEDING UNIT-A1: Letter PAPER DECK UNIT-F1: Letter
- Display: 10.1" TFT LCD WSVGA Colour Flat-panel
- Memory: 4GB RAM
- Hard Disk Drive: 250GB
- Mobile printing capability and Cloud-based Services: HP ePrint, Apple Air Print™, Mopria™-certified Wireless Direct Printing.

- Wireless capability: Yes, built-in Gigabit 10/100/1000T Ethernet, Wireless LAN (IEEE 802.11b/g/n)
- Connectivity, standard:
  - USB 3.0*1 (Host)
  - USB 2.0*2 (Host)
  - USB 2.0*1 (Device)
  - 1 Gigabit 10/100/1000T Ethernet
  - 1 WiFi 802.11 b/g/n
- Network ready: Standard (built-in Gigabit 10/100/1000T Ethernet, WiFi 802.11 b/g/n)
- Compatible operating systems
- The printer shall be compatible with modern operating systems, including but not limited to:
  - Windows: Windows 11, Windows 10, Windows Server (latest versions).
  - macOS: macOS 11 (Big Sur), macOS 10.15 (Catalina), macOS 10.14 (Mojave), macOS 10.13 (High Sierra).
  - Linux distributions: Ubuntu, Fedora, Debian (latest versions).
  - Mobile platforms: iOS, Android (latest versions).
- Full software installations and driver support shall be provided for seamless integration with various operating environments.

8.6.4.7 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

8.6.4.8 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.

8.6.4.9 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.

8.6.4.10 CCTV

8.6.4.10.1 NETWORK SURVEILLANCE AND ACCESS CONTROL

8.6.4.10.1.1 Surveillance & Access Control Solution

Supply, installation, testing and commissioning of a network surveillance monitoring system for monitoring of switchyard and substation area which can be monitored from the Sentry box, Control Room, Regional Control Centre, National Systems Control Centre and the KETRACO’s offices through Closed Circuit Television as well as access control system for all KETRACO facilities shall have the following basic functionality:

- Loitering detection, Intrusion detection, abandoned object detection, removed object detection, target colour recognition, Humans and vehicles distinguish, motion detection, tampering detection capable cameras.
- Capable of easy/seamless integration with the existing surveillance environment in the various surveillance control and/or monitoring centres.
- Cameras should be capable of IR Illumination with clear night vision.
- Solution should include a network based audio-visual entry control system (door station) for regulating main gate entry.
- Solution should also include a centrally supervised and logging access control system with biometric access, card access, key code access measures for all substation and switchyard access gates as well as control room and warehouse access doors.

- Construction and/or modification of Guard Housees at the main station gate to house security guards on duty.
- Fully capable central management system workstation at the main and backup surveillance monitoring stations/centres for video management and recording purposes. This should be scalable to ease addition of more cameras in future. This system should be fully integrated with the access control central system.
- Solution must provide for cameras capable of optical verification identification and logging of persons, vehicle number plates & objects.
- Intruder Alarm & Sirens solution that is capable of being integrated with the surveillance system.
- 24x7 real-time monitoring and alerting: Sends notifications of events real-time via text messages and /or email
- Internet solution for remote connectivity to the main and backup surveillance monitoring stations/centres for remote viewing and archiving of feeds.
- It shall provide adequate resolution for physical monitoring of all the equipment in the substation including ability to clearly view equipment numbers (identifiers).
- The system shall be triplex i.e. it should allow simultaneous recording, playback & network operation.

10.6.4.10.1.2 **Substation Sizes:**

Small substations shall be defined as subtation with upto 4 high voltage (>=132 kV) circuits/bays, Medium substations shall be defined as substations with more than 4 high voltage circuits/bays less than 6 high voltage circuits/bays.

Large substations shall be substations with more than 6 high voltage circuits/bays.

10.6.4.10.1.3 **Site Access**

Effective control of vehicle and pedestrian site access is critical to the employer and should allow for:

- Restrict access to only authorized vehicles and persons
- Provide and audit trail of all traffic that enters and exits site
- Supports incident management
- The system shall be equipped with License Plate Verifier analytics functionality.

A range of barriers will be deployed at site access points to control vehicle and pedestrian entry and exit which will be used in conjunction with the Access Control System.

Site barriers will consist either of:

- Automated Cantilever Sliding Barriers (if called for in the employers requirements)
- Manually Operated Gates/Barriers

10.6.4.11 Automated Cantilever Sliding Barrier Deployment

Automated gates will control all vehicle and human traffic into and out of the site. Automated gates will be deployed at the nominated main access point to the site.

The automated gate should be a cantilevered sliding gate with a minimum length of 6m. Pedestrians should be provided with an alternative entrance or exit controlled with the substations Access Control System.

All automated gates will be controlled by the site Access Control System to allow drivers the ability to access through the gates through their personal access control smart cards. Rugged smart card readers will thus be installed at all site main entry points to allow vehicle entry and exit.

Remote operation of all automated gates will be possible from the Security Control Guard House via the Access Control System. In addition, manual operation of the automated gate will be possible in the event of loss of power to the fate via a manual override facility which must be located on the internal side of the sliding gate and inaccessible from the outside.

All gate control cabinets and related control components must be located on the substation side of the gate. All such control cabinets and manual override facilities must be lockable by a unique key.

The power supply will be a 240v Single phase 50Hz supply with 240v/415v 3 phase option.

The design shall comply to the workplace (Health, Safety and Welfare) regulations 1992, BS EN 12453:2017 and BS EN 12445:2017 standards and thus special attention and inclusion of the following facilities:

- Safety edge to leading edge of gate leaf – to prevent gates closing on a person or vehicle when the gate is activated.
- Additional safety edges to internal and external motor posts
- Weld mesh infill
- Post mounted audible alarm or flashing beacon, alerting people when the gate is in operation
- Gate runback protection. This is to prevent a person, entering that area whilst the sliding gates are operating.
- Safety induction loops cut into the road surface. This will inhibit automatic sliding gates closing on to a vehicle within the aperture, if detected.
- Safety photocells and laser scanners act as additional safety for pedestrians and high lorries.

A maximum of 400N of crushing force is permitted before the gate leaf should start to reverse, for gaps greater than 500mm a maximum crushing force of 1400N is permitted. Regular maintenance and force testing is recommended by a trained technician.

The following are the minimum specifications for the automated vehicle sliding gates:

Construction:

- Cantilever gate with heavy-duty steel square hollow section construction
- Height of gate to match that of the adjacent perimeter compound wall
- Electrified security fence topping
- Short blasted, hot zinc sprayed, primed and finished with final coat of polyurethane paint
- Anti-corrosion protection

Operation:

- Gate with sliding gate drive system including integral logic control panel
- Maximum un-lock and opening time of 20seconds
- Maximum close and lock time of 20 seconds
- Delivers a 75% duty cycle
- Motors enclosed in a dusty resistant housing IP65 minimum
- Operating temperatures up to +45°C

Access Control:

- Microprocessor controlled drive unit which can interface to any standard control system, i.e. card reader, push button console etc.
- Key switch override installed (on internal side) capable of manual operation in the event of total power failure.

Peripherals and Safety Features

- Flashing light when in operation
- Red/Green (Stop/Go) Traffic Lights
- Dual Height Photocells on each leading edge of the gate to ensure safe operation
- Contact safety edge
- Emergency stop button
- Mechanism to stop/block forced entry

Installation

- In accordance with manufacturers instructions
- Meeting all relevant safety codes of practice
- Foundations as per manufacturers recommendations
- Maximum gap between the bottom of the gate and the ground level of 100mm

Equipment Testing

The manufacturer will have fully tested the automatic sliding gate and control system prior to dispatch. These tests will be fully traceable to each unit dispatched and must be transparent. The QA testing will include dimension checks as well as full operation.

Electromechanical Lock gate mechanism should be heavy duty weather resistant to be integrated with the Access Control System, surface mounted fail-secure lock with a hardened steel latch and a mechanical key over-ride, tamper resistant cast housing, latch status monitoring and have a holding force of minimum 900kgs.

Manually Operated Gate Deployment

If there is a secondary vehicle access point within the site, then manual double leaf swing gates will be installed for use by the Employer at specific times such as in an emergency or if there is a requirement to bypass the site main entry point in order to bring large equipment in.

Access though the manual vehicle gate will be controlled by a padlock and mechanical key. The padlock will be protected from attach by a hardened metal shroud that is to be welded to the gate in such a way that the body of the padlock is protected from attach and only the padlock locking mechanism can be accessed by key. The shroud design must allow the padlock to be accessed from either the inside or outside of the site without compromising security.

Design Considerations and Associated Works

All gates must be protected from the environment by appropriate levels galvanization and protective coatings. The design of all gates should offer no hand or foot holds to an intruder. The height of all gates will be level with the adjacent perimeter compound wall or switchyard fence.

All perimeter gates will have a Perimeter Intrusion Detection System topping to prevent intruders from climbing over. The perimeter gate Perimeter Intrusion Detection System topping will be level with the Perimeter Intrusion Detection system topping installed on the adjacent perimeter compound wall.

The maximum gap between the bottom of all manual and automated gate leafs and finished ground level should be 100mm. Gates will be equipped with a range of devices relevant to their location and operation. Devices could include heavy-duty Intruder Detection System alarm contacts, gate disturbance sensors and gate indication sensors.

Where keys and cylinders are required to secure padlocks, gate control cabinets and override facilities, the Contractor is to liaise with the Employer in regards to key design and arrangements for key retention, post-project completion. The contractor is to confirm all gate designs, access control integration details, dimensions, locations and quantities with the employer prior to procurement and commencement of any works.

The contractor will also be responsible for ensuring that all civil works relating to the installation of both automated and manual vehicle and pedestrian gates, access readers and all related accessories is undertaken and completed to the satisfaction of the Employer.

8.7 **Access Control Specifications**

8.7.1 Access Control Solution

8.7.1.1 General

The contractor shall implement access control system for all facilities in which the Network Surveillance surveillance shall be installed. The system shall be completely integratable into the KETRACO Wide Area CMS (Central Monitoring System) as well as the backup locations just as the Network Surveillance network surveillance system with applications for allowing access to sites also provided from remote locations. The access control system shall be installed at the gate and doors of the control buildings (and other buildings as advised by the Employer) in the KETRACO facilities. Access options shall be through biometric, card and code options.

For uniformity purposes, the general classification of substations (as well as facilities such as repeater stations and warehouses) is on size – and thereby the number of access control reader and opening systems to be employed. The number of locations/entry points to be employed will range between 3 and 10 – with one being the main gate and the rest being deployed in the rest of the facility. The classification is as listed below:

- Small Stations – 1 main gate with pedestrian entry, 2 external doors and one internal door in the building
- Medium Stations – 1 main gate with pedestrian entry, 3 external doors and 3 internal doors in the building
- Large Stations – up to 2 main gates with pedestrian entry, up to 4 external doors and 5 internal doors in the buildings.

CLASSIFICATION	**DEFINITION**
Special Station	Any Complex comprised of an amalgam of separate switching switchyard of 500HVDC, 400kVAC, 220kVAC and/or132kVAC voltage levels
Large station	Any substation of or greater than 400kV voltage level or 220kV substations which have more than 6 circuits or all critical stations
Medium station	Any other substation of 220kV voltage level or 132kV substations which have more than 4 circuits but less than 6 circuits
Small station	Any other substations or stations such as repeater stations

KEY:
Criticality assigns to all Evacuating stations, all Switching/Load stations, all Large Customer serving stations and all stations located in areas considered as high security threat areas.

N.B: all other facilities apart from substations are classified as small stations (such as repeater stations, warehouses etc.)
For special substations, the contractor shall be guided by the substation design, with regards to the number of access points.
The contractor shall provide the owner with detailed system design architecture information to demonstrate that the offered system hardware and software is designed for a truly centralized and integrated environment. The proposed Access Control System shall offer a highly efficient and automated solution that allows operators to quickly identify an alarm scenario.
The proposed overall system design and operation shall be user friendly and only require minimum training to allow an operator to perform his daily routine with minimum supervision required. All proposed security field devices installation shall not only to operate functionally, they have also to blend with the interior design of the facilities.
All interfaces within the Network Access Control System shall be based on TCP/IP network protocol connectivity over the corporate intranet/ internet/ LAN/WAN. The contractor shall ensure that the Access Control System must be expandable in the following areas.

- The system shall be designed to allow foreseeable organizational changes and procedural changes beyond current plans,
- Additional hardware units shall easily be added without any modification to the existing hardware, software and network configuration
- All systems shall provide at least 40% spare for future expansion and connection

The Access Control System shall be a multi-tasking and multi-users based head end running on a distributed TCP/IP network. The system shall be designed to provide alarm gathering, monitoring, handling, reporting, full logging including the performance and activities of the operators within the secured areas of the building. It shall also provide monitoring and control of inputs and outputs both locally and remotely (e.g. In different Buildings) The system shall be a flexible and user-friendly workstation providing user(s) with a Graphical User Interfaces (GUIs) for alarm monitoring and control. Such GUIs shall be the core of the entire Access Control System that includes map viewer with alarm list and a Video Verification module for surveillance and recording video streams. The system shall be provided to control access into designated security controlled doors only by personnel with a preregistered biometric identifier, valid access card or Identification-PIN and within valid time schedule. All access cards shall be authenticated against the central and/or local database before granting access. Facility for both online and offline validation shall be incorporated with a log of all activities stored both locally and sent remotely from each station. All door access activities shall be logged into the central database.
The contractor must ensure that expansion of the current Access Control System will provide real time alarm communication to operators within the Security Control Room and/or Guard House in the event of:

- Door forced open
- Door held open (for greater than 30 seconds)
- Door opened under duress (via duress PIN code input)
- Unauthorized access attempt using invalid credentials (Network Surveillance shall also be required to collect photographic evidence on this attempt especially at the main gate and main substation control building entrance)
- Communications or power failure
- Panel/Card reader Tampering
- The basic requirements are that the Access Control System shall:
- Be compatible with third-party hardware and free from lock-in
- Support logical security
- Be in line with local regulations and standards
- Be capable of integrating with surveillance and other security systems
- Be capable of Integrating with existing hardware to reduce capital costs

- Support modern modes of communication like cloud/mobile access and especially the Internet of Things (IoT)
- Should be highly robust with reliable networks
- Support modern wireless and wire-based technologies like Bluetooth, NFC, RFID, PoE, and others
- Support multiple types of authentication input such as biometrics, passwords, mobile apps, cards, key fobs, two-factor authentication, and others
- Latest end-to end data encryption during transmission
- Easy to use and configure
- Affordable and powered by professional-grade customer support
- Support all configurable features, like zoning, time-based access, role-based access, level-based access, count-based access, and other factors.

Any unauthorized attempt or invalid card used shall be reported to the ACCESS CONTROL SYSTEM, including door held and forced opened alarm as priority alarm transactions. With the **Video Verification module**, live images from the camera installed at the door location shall be displayed at Access Control System GUI during door alarm activation and access request. It shall also be possible to select live view of the camera to view the person's face before activating (manually unlocking the door via icon control on the GUI) and granting during door access request. The system shall also include a feature to display the last 5 access requests from a specified entrance with last name, first name, database picture, timestamp and event type (authorized, card is unknown, card is blocked, etc.). Reports shall always be readily available and owner shall be able to request for the reports on exactly what information from the report is required with the use of event filters.

8.7.1.2 Scope

All necessary tools, equipment, hardware, software and software user licenses required as describe in this document for the complete installation of the Access Control System shall be supplied and installed under this contract. All equipment necessary for the Gigabit Ethernet LAN networking installation such as, domain/application servers, PC workstations, fiber optic interfaces, routers, switches, hub, modem, fiber and copper patch cords and the like shall be supplied and installed by the successful contractor under this contract. All equipment supplied by the Contractor shall be installed, configured, programmed, tested and commissioned, as specified herein and shown on the contract drawings and the equipment schedules. The contractor shall supply all materials and services necessary for or incidental to the installation and commissioning of the systems.

The entire Access Control System including all its hardware, peripherals, software and software licenses as specified within this document shall be supplied and provided as part of this contract. All equipment within the Access Control System shall continue to operate for at least 12 hours in the event of main AC power failure. The contractor shall take in consideration the traffic loads and power consumption at each point of installation when determining the size of the Uninterrupted Power Supply (UPS) as backup power for the Network Surveillance and Access control system. Provision of the UPS shall be under the scope of this contract. Works shall also include cabling necessary to interconnect the various security systems central equipment, hardware and devices and the like for it to provide the performance as specified in this contract document.

All cable enclosures including conduits, cable trays, ducts, wall boxes, termination panels and the like that are required to facilitate and complete the installation shall be supplied and installed as part of this contract.

The contractor shall upon completion of the installation provide complete training with documentations on the configuration, operation and maintenance of the systems to the required operators assigned by the owner. At least two (2) training sessions per system covering system operations shall be planned and provided to operators and engineers and two (2) sessions covering system administration and management for system administrators. The contractor shall supply all training materials, operational manuals, as-built drawings, diagram, negatives, printed materials, magnetic and optical storage disk as specific in the contract document.

8.7.2 Access Control System Requirements

The Access Control System shall be of open-architecture, PC-based system based on Windows Server and Azure Arc Operating Systems with the latest available compatible operating/server system taking precedence. The Access Control System shall comply to the strict regulation and adapting state-of-the-art security technologies, the highest level of reliability, and integrate to networking infrastructures such as the Intranet, Internet, LAN/WAN.

The main function of the Access Control System shall be to control and monitor all designated access to the Facility gates, switchyard areas and/or control buildings. The Access Control System shall provide and require a single security license key for system operation. Without or removing of such key (per facility) as well as the central system shall disable the operation of the system upon detection. The Access Control System shall be of modular design providing the flexibility to allow the user to add or remove any components and/or controlled functions or in the event when operating requirements change or as system expands. The Access Control System provided shall contain all the features and requirements specified, but not limited to, in this document. The contractor shall highlight and update the owner of any new or special functionality that are useful and relevant to the user's application but not found in any part of this document.

The proposed Access Control System shall provide the functions and specifications described. In particular, the proposed access controller shall be equipped with all common interfaces such as, Ethernet and RS-485 for connection to the Access Control System server running the management software. The Access Control System shall allow control of door entry access by a biometric identifier, proximity card reader and from the Access Control System workstation. The proximity card reader shall also incorporate a biometric identifier and numeric keypad to be used if fingerprint, Card and/or Pin number access configuration is desired. The Access Control System shall support up to four (4) different card formats of Open Supervised Device Protocol (OSDP) standard simultaneously. The number of each format supported shall be unlimited. A locally mounted door release push button shall be provided for purpose of exiting at access controlled doors as defined by the employer or as indicated on the drawings.

The Access Control System to be deployed as a minimum will have the following characteristics:

Location	**Access Control/Reader Type**	**Comments**
Site Main Entry Point: • Vehicle main gate • Pedestrian entry gate	Master Key-switch controller (for enable/disable control in the Guard House combined with pushbutton open/close/emergency stop control unit	All access control system deployed must be Vandal Resistant, Rugged design, securely installed and sufficiently housed
Building External Doors: • Control Room building (2 doors) • Battery room door • Store Door	Card/Pin/Fingerprint reader	Building External doors shall be supplied and installed with electric locks already fitted. The complete door and lock solution will be provided as part of the main works package. The contractor is to interface the Access Control System with the door locks.
Building Internal Doors: • Control Room • Telecommunications Room • LVAC Rooms • Trans	Card only	The Access Control System will be applied to areas dedicated to Transmission operations when it would be possible for members of the company to gain access. This classification of areas shall be agreed with the Employer
Transmission Switchyard Areas:	Card only	The Access Control System will be applied to areas dedicated to Transmission operations when it would be possible for members of the company to gain access. This classification of areas shall be agreed with the Employer.

All the above building doors where applicable will be equipped with an electronic lock and access control hardware integrated with the Access Control System as the summary below dictates:

Location	Electronic Lock type	Comments
Building External doors	Electric Release Solenoid Locks	Building External doors shall be supplied and installed with electronic locks already fitted. The complete door and lock solution will be provided as part of the main works package. The contractor is to interface the Access control System with the door locks
Building Internal doors	Electric Strike Locks Electric Magnetic Locks	Locks to be provided by the contractor

The contractor is to ensure that all lock installations are carried out to industry standards so that no locks can be accessed from non-secure areas. All Access Control System devices will be connected to intelligent controllers located within the substations buildings. These controllers will then be connected to and intelligent network controller which in turn will be connected to the network switch provided by the contractor for onward signal transmission to the Security Control Room/Sentry.

The site Access control System will integrate with the Network Surveillance: On main gate and external doors, video images of the event must be presented automatically to security system operators.

8.7.2.1 Mapviewer

The Central Systems and backups shall contain a map viewer. This map viewer shall provide a graphical presentation of the premises or object by means of floor plans, object pictures or any desired graphical representation. Navigation links allow navigating from one map to the next. It should be possible to navigate maps horizontally on the same level enabling to cover a larger area with multiple maps next to each other, or vertically up to three levels in which navigation to the next map brings the underlying map e.g. navigate into the room details from the map showing the floor details.

The map structure is given in a map tree of the active map. The tree allows jumping multiple layers or bypassing multiple correlated links by selecting the target map in the tree directly. Back and forward buttons in the top of the map viewer allow navigation between the maps by viewed sequence. On the maps entrances and cameras can be positioned as a graphical icon. These graphical icons will display the location of the device in the map and the actual status of the device. Clicking any of the devices automatically shows the controlling commands available for the respective device. Control commands are automatically linked based on device type. Access events at the door are automatically recorded by one or more mapped cameras for a predefined recording time window. The time window for recording can be programmed. Recordings will be part of the logged event and can be accessed by clicking on the camera symbol in the stored event line.

8.7.2.2 Alarm management**:**

The system shall offer alarm management. The alarm management builds on the map view functionality extended with an alarm list. The alarm list shall support multi handling ensuring when multiple operators are logged in at the same time the event can only be treated by one operator, the operator that treats the event first. In case of alarm the map with the alarm location will automatically get dialog focus and will be displayed accordingly. The device that triggered the alarm will show alarm status on the map to attract attention together with a beeping tone. The alarm shall appear in the alarm list dialog as alarm event. The alarms in the alarm list queue require a manual alarm acceptance from the operator. Alarm events in the alarm list require a written comment entry by the operator before it is possible for the alarm to be accepted. The comments are logged. Accepted alarms are removed from the alarm list. In case the operator navigates trough maps while an unaccepted alarm exists, maps with a direct navigation link to the map with the alarming device, shall display any hyperlink to that map with an a notification. This animated signalling navigation link indicates that behind this navigation link a map exists with an unaccepted alarm. The system shall offer alarm video verification as part of the alarm management. The alarm video verification builds on the alarm management functionality extended with video streaming and recording of alarm events. It shall be possible to map system devices on the map to one or more cameras for alarm video verification. If the respective device reaches the state of alarm the corresponding cameras will automatically start recording the event and show the camera live streams to the operator.

8.7.2.3 Video Verification Access

There shall be possibility by combining with existing video devices to configure dedicated readers for video verification access mode.

Instead of opening the door immediately when an authorized card is presented, the reader/controller shall generate an event at the network access control system. A corresponding alarm dialog displays the stored image

of the cardholder along with a live video image from the corresponding door. The operator shall determine if both images match, he can decide to open the door or to deny the access.
It shall be possible to link up to 5 cameras per door to ensure video verification with optimal situational awareness at the door.

8.7.2.4 Offline Locking System (OLS)

The Access Control System allows the integration of OLS devices.
The personal data will be managed by the Access Control System Online System.
Persons can use the cards they have for the Online System - but only the first one.
There are special access authorizations regarding to the OLS.
There are special time models regarding to the OLS.
There are separate validation limits regarding to the OLS.

8.7.2.5 Elevator Control:

The Access Control System AS provided shall allow the definition of floor access authorizations at designated lift, and assign them to card holders. If a cardholder presents his card at the elevator reader, the system shall activate the elevator floor buttons the cardholder has authorized access.

8.7.2.6 Random Screening

The Access Control System AS shall be able to perform an additional security check by the officer on duty at the site/building exits. The readers at such exits are easily set to that mode by checking a checkbox and setting the frequency. At Random, the selected door should not have opened, but an event shall be triggered at the Access Control System monitoring workstation. Upon receiving the message, shall remind the operator/guard to check the cardholder and his pockets/bags. After which, he can decide to open the door manually by clicking on the door icon inside the location map, release the card reading with a special configured reader, or delete the locking via dialog

8.7.2.7 Time and Attendance Data

Access control readers shall be allowed to be configured additional as time and attendance readers. The booking events are stored in a separate file to export them for use in other applications.
Access Control Management Alarms and Events: The Access Control System AS shall provide a wide range of standard alarm and event states. The following alarms/events, but not limited to, shall be supported:

- Card/Fingerprint unknown
- Card/Fingerprint not authorized
- Card/Fingerprint outside time profile
- Card/Fingerprint anti-pass back
- Access timeout
- Door open time exceeded
- Door opened unauthorized
- Door blocked
- Tamper alarm controller
- Tamper alarm reader
- PIN code error
- Duress alarm code
- Access denied
- Wrong card version
- Card/Fingerprint blocked
- Card/Fingerprint blacklisted
- Card/Fingerprint out route
- Random screening
- Other individual alarm extensions

All alarm/events have to be logged in the central Access Control System event log files together with all assigned alarm documents for a complete reporting. The Access Control System AS provided shall have support for central alarm monitoring and management. It shall provide a graphical user interface (GUI).
The Access Control System AS shall provide practicable the central configuration platform or tool from where everything concerning system behaviour, such as access control cardholder settings, display features, and authorizations are set up. The Access Control System AS shall securely logged all events, alarm activations and operator's actions/responses into the alarm/event log files, so to prevent after-the-fact changes, and to protect

data from any manipulation. The events log files shall include an advanced filter functions such that archive can be kept small and precise. If required, only desired information shall be archived. A device tree and the device names shall be provided for in the GUI. The Access Control System AS shall support any standard laser or inkjet printer that comes with a Windows-compliant printer driver for use as an alarm printer. The printers shall be connectable directly to a workstation or to the network.

8.7.2.8 Graphical User Interface (GUI)

The Access Control System GUI shall support single or multi-screen displays having multiple dialogs separately up to a four (4) to monitors per CMS/backup by using a corresponding video graphics card. The Access Control System shall provide a default GUI that is adequate and ready for used in normal system operation. It shall support at least the following standard resolutions: 1024x768, 1280x1024 (1-monitor operation), 4096x1536 and 5120x2048 (4-monitor operation). The Access Control System GUI shall enable operators to find a specific detector, door, or reader for fast control, such as open door manually, show camera live image, and so on.

In the event of alarm activation, the alarm message shall be displayed at the destined Access Control System operator workstation together with an external audible siren or via PC internal speaker. For the alarm sound generated from the PC internal speaker, standard formats such as WAV, MP3 or WMA shall be supported and selectable for assigning to individual alarm/event or groups of alarms/events during system configuration

8.7.2.9 Alarm Handling Management

The Access Control System shall provide the operator a simple and efficient way to handle any incoming alarms. Only authorized operator with the valid login username and password shall be able to access and operate the system. Once successfully login, the operator shall only see all the alarm and event messages destined to him for monitoring and processing based on his user login access profile.

The operator shall be able at the Access Control System workstation acknowledge/accept, response to incoming alarm or event messages. The location of the alarm shall be displayed by animation on a graphical representation of the premises. All incoming alarms at the Access Control System GUI workstation shall contain a comprehensive alarm message.

The incoming alarm or event message shall provide, but not limited to, the following information:

- Alarm type
- Alarm date and time
- Alarm status
- Current alarm condition
- Alarm location

The operator shall be able to silence the audible alarm sound or buzzer, while he is busy processing earlier alarms. The alarm message shall also show live video images from the Video Verification camera installed at the alarm location such that, the operator can have first time view of the site situation if required. The operator shall be allowed to revert or toggle between all alarms or events messages. The Access Control System operator shall also be able to send remote commands or activate controls manually from the workstation when requested such as, unlocking and re-locking of access controlled door/s, or resetting of detectors. The operator shall be allowed based on his login access profile generate alarm and event reports from his operating workstation.

8.7.3 Access Control Hardware

The Access Control Hardware provided shall conform, but not limited to the following requirements and directives:

- CE
- EN 50130-4:1995
- EN 61000-3-2
- EN 61000-4-2
- EN 61000-4-4
- EN 61000-4-6
- EN 55022:1998
- EN 60950:2000
- EN 61000-3-3
- EN 61000-4-3
- EN 61000-4-5
- EN 61000-4-11

- EN 50131-1

The Access Control Hardware provided shall be of modular design with a download software built-in so that the application program can be easily changed and downloaded without the physically touching the controller itself. The Access Control Server Computer Hardware design shall be of standard 19" rack mountable and also rail mountable for installation in a weather-proofed enclosure suitable for used in outdoor. The connection from the Access Control Hardware to the Access Control System server running the management software shall be by Ethernet 100BaseT. The Access Control Hardware shall have a 16-characters liquid crystal display (LCD), and a button provided for selecting the display to show all its network parameters and actual status to be viewed from the management software (installed in the server/computer) like:

- IP address of the controller
- MAC address of the controller
- DHCP on/off
- Status of all the inputs connected to it
- Status of all the outputs connected to it
- Online and Offline status of the controller
- Firmware version
- Date and Time: A real time clock (RTC) that will adjust itself to leap year computations automatically.

The Access Controller shall contain enough memory for storing user data and access events. In the event of a server failure, the controller shall work seamlessly such that any data required can be down loaded from the server. The Access Controller memory shall under no circumstance loose a single, not even the last transaction when power fails. The Access Controller and all devices connected to it shall continue to operate and control access in off-line mode, even if the computer network fails.
The Access Controller memory shall store database that has a capacity with a minimum of 80,000 cardholders (upgradeable to 400,000), each having a programmable 4 – 8 digits (Personal Identification Number) PIN codes. The cardholder database shall be upgradeable by exchanging the CF card. The system shall automatically detect the size of the CF-card. The Access Controller provided shall support the connectivity of up to maximum of 4 standard OSDP interface readers or 8 serial interface readers operating on RS485 bus technology.
The Access Controller shall provide minimum eight programmable I/O's on board, and shall be expandable to 32 each, using I/O extensions. All inputs provided shall be configurable to provide 2- or 4- status selectable, via End-Of-Line (EOL) resistors, namely:

- Input Closed
- Input Opened
- Input Shorted (provided in 4- status mode)
- Input Tamper (Cable cut, provided in 4- status mode)

EOL resistor's values shall be flexibly selectable in the Access Control System management software during configuration.
The Access Control Hardware and all devices connected to it shall continue to operate and control access in off-line mode, if there is a failure with the computer network. The Access Control Hardware shall support standard CF flash memory card for storing cardholder data and access events. The CF memory card must be formatted with a standard FAT file system, to allow reading them using a standard card reader connected to a computer, if the Access Control Hardware fails.
The Access Control Hardware Firmware is updateable through the Host System via download. The Access Control Hardware memory shall under no circumstance loose a single, not even the last transaction when power fails. UPS shall be provided to continually supply power to the Access Control Hardware and readers for a minimum of 2-hours, in the event of power failure. The Access Control Hardware shall generate a transaction record and save them in its memory for every alarm, they include –

- Time/date of occurrence and restoration
- Location of alarm sensors

Proximity Card Readers Specifications
The proximity card reader provided shall be of ruggedized design, sealed in weatherized polycarbonate enclosure to withstand harsh environments for both indoor/outdoor used and provide a high degree of vandal resistance.

- Power requirement: 10 – 16Vdc.

- Transmit frequency: 125 kHz
- The proximity card readers shall have a read range of at least 3".

The response time to unlock the door after a card is presented to the card reader shall not exceed 1.0 second +/- 0.5 second. The card reader unit shall have an integral keypad with beeper, multi-colour LEDs. The keypad shall have back-light to allow easy viewing, in case of power blackout. It shall light automatically upon pressing any key or when a card is presented to the reader. The overall thickness of the card reader unit shall not exceed 30 mm.

8.7.3.1 Contactless Smart Card Reader Specification

The Smart card reader provided shall be of ruggedized design, sealed in weatherized polycarbonate enclosure to withstand harsh environments for both indoor/outdoor used and provide a high degree of vandal resistance. The smart card reader shall be based on contactless smart card 13.56MHz technology for connection to the Access Control Hardware with OSDP interface. The data transfer between the contactless smart card reader and smart card shall be encrypted.

Power requirement: 10 – 16Vdc.

The contactless smart card readers shall have a read range of at least 2.4".

The response time to unlock the door after a card is presented to the card reader shall not exceed 1.0 second +/- 0.5 second.

The card reader unit shall have an integral keypad with beeper, multi-colour LEDs.

The keypad shall have back-light to allow easy viewing, in case of power blackout. It shall light automatically upon pressing any key or when a card is presented to the reader.

The overall thickness of the card reader unit shall not exceed 30 mm.

The system shall also be able to read the KETRACO staff ID smart cards to allow staff to use their staff cards to access the station.

8.7.3.2 Proximity Card Specifications

The offered proximity cards shall be similar in size and thickness as standard credit cards or bank ATM cards. The proximity cards shall operate on 125 kHz. They shall work with Wiegand protocol and have a short read range of 1-10 cm. CE/UL Approvals

Contactless Smartcard Specifications

The offered contactless smart cards shall be similar in size and thickness as standard credit cards or bank ATM cards. The offered smart cards shall be of contactless technology operating on 13.56 MHz and shall be compliance to ISO/IEC standard 14443A. The read range shall be from one centimetre to one meter and encryption shall be enabled. CE/UL Approvals

8.7.3.3 Fingerprint Biometric Reader Specifications

The Finger-print (FP) biometric reader provided shall be of ruggedized design, having weatherized polycarbonate enclosure or similar protection to withstand harsh environments for both indoor/outdoor used and provides a high degree of vandal resistance. The FP biometric reader shall provide two-factor authentication with the combination of a proximity [/contactless smart] card and a fingerprint biometrics. The FP biometric reader together with the proximity [/contactless smart] card shall support operation with 1:1 verification mode or 1: N, identification mode.

The FP biometric reader shall continue to operate to control access in off-line mode. When the network connection restored, the reader shall automatically upload and synchronize its database with the server. The FP biometric reader shall include a FP scanner that uses capacitive verification techniques for the live finger recognition and resistance of the human skin. The FP biometric reader provided shall have a read tolerance of at least +/-30 degree and a displacement of about +/- 5mm from the FP scanner. The same FP biometric reader provided shall be able to be used for both access control and as an enrolment station. The specifier shall supply and install the necessary software to manage the FP enrolment for all users and configuration of the FP access control operations. The software provided shall be integrated to the Access Control System for access control and monitoring.

During enrolment process, the FP biometric reader and software used for capturing the finger-print shall provide, but not limited to the following: The FP image shall have a minimum size of 256 x 360 pixels. Provide full visibility of the ridge details including texture, continuity, edges and pores. Allow for real-time on-screen preview of the FP image while performing the FP capture. FP captured shall have resolution of at least 500dpi. Minutiae file size of at least 256 bytes. The FP enrolment process shall support a percentage estimation of the image quality such that the operator can accept or reject the enrolled FP. Up to a maximum of 10 FP templates shall be allowed to be assigned to a single user. The enrolled FP templates shall be stored in the Access Control System centralized database as well as within the reader's memory storage. The FP templates stored shall incorporate a date stamp and shall record the number and/or name of the finger taken. The FP images captured shall be stored in an open format such as jpeg or bmp for the purpose to export for further use by another application when required.

8.7.3.4 Locking Hardware

The contractor shall ensure that the locks are compatible with doors and shall be responsible for the correct installation of each lock according to the manufacturers instructions. The locking mechanisms shall be:

- Electromagnetic lock
- Electric Strike locks

Door entries shall be configured with electric strikes, electromagnetic locks, push bars, or other electrified hardware.

The locking systems shall be provided with anti-tampering switches with alarm indication should the magnet become unsecure from the lock. They shall be provided with a magnetic bond sensor to detect the correct bond between magnet and armature as well as door position sensor. For double leaf doors, both leaves shall be secured individually using the locking system.

The electromagnetic lock shall have a minimum holding force of 600kg for steel doors and 12/24VDC supply.

The electric strike lock shall have minimum holding force of 850kg for steel doors, 2hour fire rating, 12/24VDC supply, Field selectable fail locked/fail unlocked operation, latch status output and cast stainless steel body.

Design Considerations and Associated Works

All access control doors must be equipped with locks that allow lock monitoring so that the Access Control System receives a signal that indicates when the lock has engaged or not.

All access control doors and access control gates must be equipped with door contacts to indicate to the Access Control System when the door/gate us closed or open.

An alarm should be generated within the Access Control System when an access controlled door/gate is opened using a manual key override.

Audible alarm sounders are to be fitted to an external building door as well as the pedestrian gate at the main access point. Sounders will omit an audible alarm when an access controlled door or gate is not closed within a pre-determined period. Sounders will also omit an audible alarm when a fire exit door is opened. Sounders will be connected to the local door controller/input module.

All smart card readers that are installed in external areas must be suitably IP rated and protected from sun by sunshades constructed from glass reinforced plastic material.

The contractor will supply and install information signage for any access controlled gates and doors as designated by the Employer. All signs should be in A5 in size. All sign lettering will be in dark green with a white background using English text. Signs must be long lasting and weather resistant with anti-fade inks. Sign wording will be confirmed with the Employer during the Final Engineering Design.

As part of their Final Engineering Design, the Contractor will complete and Access Control System schedule.

8.8 Perimeter Intrusion Detection Systems (Pids)

A PIDS will be installed around the entire perimeter of each substation in order to provide automatic detection of potential intrusions, thereby removing the need for constant monitoring of the perimeter via Network Surveillance or guarding.

The Employers standard for PIDS should be based on Electrified Security Fence (ESF) technology. However, the contractor must take into consideration local site and environmental conditions when selecting PIDS solutions and this should be confirmed with the Employer during the design process.

The PIDS will provide detection along the entire length of the perimeter sequentially identifying the precise point of intrusion.

The EFS PIDS shall be capable of deterring and detecting potential intruders by means of electric shock and detecting the following types of attack:

- Cutting or disconnecting any wire
- Shorting any wire to ground or the support posts
- Shorting adjacent but different polarity wires
- Shunting the wire with and electrically conductive material to reduce the pulse voltage

The ESF PIDS will be installed along the top of the substation perimeter wall as well as on top of all perimeter pedestrian and vehicle gates. It will be minimum of 1200mm high from the top of the perimeter compound wall or perimeter gate.

The ESF PIDS will consist of a horizontally spaced grid of conductive wires supported by a specially made carrier fence. This will comprise of insulated components and support posts fitted to the substation existing perimeter wall and gates.

The maximum length of any PIDS zone must not exceed 100m. One PIDS processor will control each PIDS zone. The contractor is to produce a drawing showing all proposed PIDS zones with an accompanying Cause and Effect matrix as part of the Final Engineering Design, but not as part of this tender return.

All vehicles gates will be configured as individual PIDS zones. For automated vehicle gates, PIDS zones must be interlinked to the gate control system, in order that, on receipt of a correct 'open (initiation)' signal, the PIDS zone will deactivate on receipt of a correct 'closed (completion)' signal, the PIDS zone will reactivate.

Where ESF is installed on top of the site gates, the contractor must ensure that the gaps between the ESF on the gates and on the adjacent perimeter wall are minimized as much as possible to prevent any person attempting to gain entry through the site perimeter by climbing through the gap in the ESF.

It must also be possible to isolate individual PIDS zones in order to allow occasional access to the perimeter wall and adjacent areas for maintenance works. This function should be available from the Security Control Room/Sentry as well as through on-site Remote Alarming Terminal, which is to be installed within the substation control building.

Disturbance sensors will be fitted to all perimeter pedestrian and vehicle gates. The sensors must be installed on the actual gate leaf and will provide an alarm should an intruder attempt to cut through or attack the gate fabric or cladding.

In addition, a gate indication sensor will be fitted to all manual vehicle gates. The sensors will be connected directly to the gate ESF topping and will short the ESF topping when the gate is opened more than 50mm. thus in turn will create an alarm alerting system operators that the gate has opened.

The contractor shall ensure that no conductive materials are installed within 500mm of the ESF wires.

It is the contractor's responsibility to follow all necessary installation standards and manufacturer recommendations in implementing the most suitable ESF installation method according to local conditions on each substation. Thus, may involve providing additional strain relief, welded supports, brackets and intermediate posts are required.

8.8.1 PIDS Signal Transmission

Data transmission form the field based PIDS processor units will be transmitted via RS485 serial communications cable to and ESF intelligent network controller located within the substation building.

All such field based PIDS processor units will be installed within ventilated enclosures that will allow optimum system performance regardless of internal or external temperature. These enclosures will be protected from the elements on three sides (from above, left-side and right-side) by appropriate sun shades contracted from glass reinforced plastic.

All gate disturbance sensors will be connected to the ESF intelligent network controller via RS485 serial communications cable.

The ESF intelligent network controller will be connected to a network switch for onward transmission to the Security Control Room/Sentry.

8.8.2 PIDS & Network Surveillance Integration

The PIDS will be fully integrated with the Network Surveillance system -Network Surveillance System – via high level software integration with the video management system. This will provide automatic image switching to the point of alarm.

As a minimum each PIDS zone must be covered by at least two PTZ cameras and nearest fixed cameras, wherever applicable such as the main entry gate. This will allow the location of any PIDS alarm to be accurately displayed on GUIs located within the Security Control Room/Sentry and the substation control room and provide automatic image switching of Network Surveillance cameras to the point of alarm. Subsequently operators will be able to rapidly verify the cause of alarm by viewing images from PTZ camera units.

All alarm information will be interfaced with the respective security management systems at the Security Control Room and displayed on a common GUI with custom mapping individual to the substation site.

8.9 Additional Requirements

Signage: The contractor will supply and install warning signs for the ESF as a minimum every 10m along the perimeter. Signs should be visible on both sides of the ESF and should be located beside each access gate, and at each change in direction along perimeter. Additional large warning signs are to be located on each perimeter wall with text in English and Kiswahili.

ESF signs should be procured from the ESF manufacturer. All sign lettering will be in black with a yellow background.

All wall signs are to be locally manufacture and final design and text is to be confirmed with the Employer.

6. Intruder Detection System (IDS)

The IDS will consist of the following devices:

- Standard door contacts for all identified building external/fire exit doors
- Heavy duty magnetic alarm contacts for roller shutter doors and gates
- Internal PIR (passive infrared)-based volumetric sensors
- Glass Break Detectors
- Input/output modules
- Keypads for IDS setting and un-setting

IDS devices will detect intrusion into the substation site and subsequently identify the precise location.

All IDS devices will be cabled back to local input/output modules which in turn will be connected to intelligent access controllers located within substation buildings allowing full integration with the Access Control System which will eliminate the need for a separate IDS solution.

It is important that the contractor understands that all new Employer sites that are constructed, and any new extension works to existing Employer sites must be equipped with IDS hardware that allows full integration with the existing IDS system.

IDS devices will be deployed as follows:

Device Type	**Locations**	**Function**	**Comments**
IDS Alarm Keypads	At all main entry points to substation buildings	Allow the IDS to be armed and disarmed locally	
Magnetic Alarm Contacts	Access controlled doors Fire exit doors	Provides an alarm if a door is forced	
Glass Break Detectors	Installed internally near fixed glass windows providing complete coverage of the glazed area	Provides an alarm if window glass is broken or device is tampered with	To be installed within vulnerable areas where it might be possible to gain building entry through a window
Heavy Duty Magnetic Alarm Contacts	Roller shutter doors Switchyard entry gates Emergency escape gates Secondary vehicle gates	Provides an alarm if door/gate is forced open	
Internal PIR based Volumetric Sensors	Wall mounted units installed internally with corners of rooms 360degree units mounted within ceiling tiles Both devices providing complete coverage of the area to be protected	Provides an alarm if motion is detected or device is tampered with or masked	To be installed within vulnerable areas where it might be possible to gain building entry through a window

As part of their final Engineering Design the Contractor will complete and IDS schedule. Arming and disarming the IDS shall be possible through the use of smart card readers and alarm keypads. In addition, the IDS design will allow for both remote arm and disarm via the Access Control System GUI located in the Security Control Room/Sentry.

The following IDS devices will be 24hrs 7days a week, so that regardless of whether the IDS is set or not, IDS alarm activation will occur triggering Network Surveillance camera switching:

- Fire-exit door contacts
- Glass break detectors
- All roller shutter door heavy-duty contacts

The setting of all other IDS devices will be confirmed by the Contractor with the Employer. All input/output units will have local battery providing a minimum of 8hrs operation.

All IDS alarm circuits will be cabled back to local input/output modules which in turn will be connected to intelligent controllers located within the substation. These controllers will then connect to the network switch provided by the Contractor for onward signal transmission to the Security Control Room/Sentry via the Employers Networks.

8.10 IDS and Network Surveillance Integration

The IDS will be integrated with the network surveillance system. Where Network Surveillance coverage is available, video images of an IDS alarm event will be presented to security system operations whenever an IDS alarm activity. This will be an automated process, and cameras covering the specific alarm zone will be displayed on a separate monitor screen to operators. The contractor is to produce a drawing showing all proposed IDS with an accompanying cause and effect matrix as part of the Final Engineering Design.

All IDS information will be interfaced with the Access Control System at the Security Control Room/Sentry and displayed on a common GUI with custom mapping individual to each substation site.

Signage: The contractor will supply and install warning signs for all fire exit doors equipped with door contacts and set all the time. Signs should read 'Fire Exit Only. This door is alarmed.'

All signs should be A4. All sign lettering will be in white with a red background, using English text. Similar signs should be provided in Swahili and local area vernacular. Signs must be self-adhesive type.

NOTES:

- In the event of an emergency such as fire, a facility to unlock all doors automatically shall be included.
- Coordination of the Access Control System with the external doors as well as the emergency doors shall not inhibit normal operation of either of the doors. For example, in emergency evacuation circumstances (external of an alarming situation), the use of the Panic devices (such as panic cross bars on emergency doors by application of pressure on it) shall not be inhibited by any Access Control Device or application but rather the access control system shall alarm and appropriate coordination with the surveillance system made to effectively capture the emergency event.

8.11 Network Surveillance Particulars

8.11.1 General Specifications

All new Employer sites that are constructed, and any new extension works to existing Employer sites, must be equipped with a Network Surveillance hardware that allows full integration with existing Video Management System installed in Suswa substation which is based on Axis Camera Station for multi-station connection. This system to be implemented must be compatible with this system. In addition, all software licensing that is required to expand the current system should be compatible with that already in operation.

The network surveillance camera systems are to be grouped as follows:

- Site Main Entrance Fixed Cameras
- Perimeter PTZ Cameras
- Transformer Bay PTZ Cameras
- Building Access Point Cameras
- Internal Operational Cameras

The Network Surveillance systems will be required to work on a continuous basis both day and night and under all anticipated weather conditions dependent on their locations. Further operational requirements for each of the camera systems are detailed below.

A range of IP based Network Surveillance camera systems will be deployed at Employer sites. The table below summarizes the minimum requirements for each subsystem:

Camera type	**Location**	**Function**
Site Main Entrance Fixed Cameras	Close to site main entrance	Identify the License Plate Number of all vehicles as they enter or exit the site Identify persons as they enter through pedestrian entrance
Perimeter PTZ Cameras	Site Perimeter	Provide Monitoring of perimeter and site external areas Allow system operators the ability to zoom in and focus on specific areas of interest
Equipment PTZ cameras	In switchyard	Provide monitoring of major equipment i.e Circuit breakers, Disconnectors, earth switches, instrument transformers and surge arrestors
Transformer Bay and reactor bay PTZ Cameras	Near transformer bays and reactor bays	Provide monitoring of the transformer bays and reactor bays

		Allow system operators the ability to zoom in and focus on specific areas of interest.
Building Access Point Bullet Cameras	Main access points to substation building	Identify persons as they enter through building main entry doors
Internal Operational Cameras 1 – Dome Cameras	Within substation operational areas	Provide Fixed Camera Monitoring of selected areas of interest such as front and rear of panels in control and protection relay rooms, switchgear rooms.
Internal Operational Cameras 2 – Dome cameras	Within substation operational areas	Provide PTZ Monitoring of selected internal operational areas such as control and protection relay rooms, GIS buildings and switchgear rooms. Allow system operators the ability to zoom in and focus on specific areas of interest.

The indicative positions of all Network Surveillance camera systems will be shown in drawings provided by the contractor as part of their tender submission. Following their appointment, the contractor will be required to finalize camera positions in consultation with the Employer. As part of their Final Engineering Design the contractor will complete a Network Surveillance schedule.

8.11.2 Site Main Entrance Fixed Cameras

Two external fixed cameras will 24hr dedicated coverage of the main entry point to the sit encompassing the automated vehicle gate and pedestrian entrance.

The external fixed cameras will provide coverage of persons entering through the pedestrian entrance at the site main entrance. In addition, it shall be possible through the use of a digital zoom for the face of the person entering through this entrance for easy identification (Achieving IDENTIFICATION) at any time day or night.

The same external fixed cameras will provide coverage of vehicles entering and exiting through the automated vehicles gate at the site main entrance. In addition, it shall be possible using digital zoom for the vehicle number plate to be easily read (Achieving IDENTIFICATION) at any time day or night.

8.11.2.1 Perimeter PTZ Cameras

These shall be installed at the substation perimeter to provide 24-hr coverage of the entire site perimeter in all weather conditions and will be fully integrated with the design and function of the PIDS and IDS.

At times other than during alarm events, the PTZ cameras can be used for functions such as monitoring of the perimeter and external areas, and guard force patrols. However, the system will automatically override user input in the event of an alarm.

During all alarm events the security operator must be able to view an intruder located within such any section of the alarmed PIDS zone. In addition, the security system operator must be able to view camera images at their alarm pre-set positions or at optimum zoom and clearly determine what is happening in the scene (achieving RECOGNITION). Examples of recognition:

- Whether a person is present in the scene
- Whether that person poses a threat to the site or not
- Which direction a person is moving in
- Whether designated building doors have been opened

All PIDS alarms will be verified via automatic image switching of the two PTZ cameras adjacent to the detection zone in which the alarm reporting segment initiates.

Perimeter PTZ cameras will also be used to verify designated IDS alarms such as opening of substation building fire exit doors and any emergency escape gates.

8.11.2.2 Equipment PTZ cameras

The contract will include the installation of a number of external PTZ cameras to provide dedicated coverage of the substation major equipment i.e. Circuit breakers, Disconnectors, earth switches, instrument transformers and surge arrestors.

When designing the Network Surveillance system, the contractor shall note that all sides of the equipment should be viewable to site cameras. However, site Perimeter PTZ cameras may also be able to assist with this task thereby reducing the number of dedicated transformer bay and reactor bays PTZ cameras.

If there is a requirement for a PTZ camera to view equip,emt the security system operator must be able to view images when the camera is at its optimum zoom and clearly determine what is happening in the scene (Achieving DETECTION). Examples of detection include:

- Whether a person is present in the scene
- Whether there is smoke or fire present
- When a circuit breaker, earth switch or disconnectors have been operated

8.11.2.3 Transformer Bay and Reactor Bay PTZ Cameras

The contract will include the installation of a number of external PTZ cameras to provide dedicated coverage of the substation transformer bays and reactor bays. When designing the Network Surveillance system, the contractor shall note that all sides of the transformer bays and reactor bays should be viewable to site cameras. However, site Perimeter PTZ cameras may also be able to assist with this task thereby reducing the number of dedicated transformer bay and reactor baysPTZ cameras.

If there is a requirement for a PTZ camera to view the transformer bays and reactor bays the security system operator must be able to view images when the camera is at its optimum zoom and clearly determine what is happening in the scene (Achieving DETECTION). Examples of detection include:

- Whether a person is present in the scene
- Whether there is smoke or fire present
- Whether fire suppression systems have activated

8.11.2.4 Building Access Point Cameras

These will provide dedicated coverage of persons entering substation buildings. Building Access Point cameras field of view will be such that the face of the person entering through the access controlled door can be easily identified (Achieving IDENTIFICATION) at any time day or night.

8.11.3 Internal Operational Cameras

A combination of Fixed and internal PTZ cameras will be installed in designated rooms within substation buildings to provide coverage of operational areas. When viewing operational areas, the security system operator must be able to view fixed and PTZ camera images and clearly determine what is happening in the scene (Achieving DETECTION). Examples of detection include:

- Whether a person is present in the scene
- Whether there is smoke or fire present

Where internal PTZ cameras are installed they should also be used whether possible to view access controlled doors and roller shutter doors on an Access Control System event or IDS alarm.

8.11.3.1 Performance Criteria

A series of performance evaluation tests shall be conducted prior to system hand over and project sign-foo. Examples of such tests are outlined below:

- Coverage test to include correct field of view
- Target visibility tests under all lighting conditions
- System resolution test
- Automatic image switching speed
- Recording, compression and frame rate test

8.11.4 Network Surveillance Supporting and Lighting

The contractor will supply and install cameras with integrated IR lighting units as detailed below:

- Perimeter PTZ cameras must be supported by integrated IR lighting to ensure the clarity of night-time Network Surveillance images.
- All external PTZ cameras covering the site perimeter are to be mounted on 6m high tri-axial lattice towers using suitable mounting brackets to achieve the operational requirements.
- All external PTZ cameras covering transformer bays are to be mounted on the adjacent building or pole mounted using suitable mounting brackets, to allow proper moniroting of the Transformer.
- All internal cameras are to be mounted using suitable wall or ceiling mount brackets as required, in order to achieve the cameras operational requirements. It is the contractor's

responsibility to select and install the most appropriate camera mount/bracket/pole according to each camera location.

8.11.5 Network Surveillance System Transmission

All cameras supplied by the contractor will be connected to a KETRACO WAN (Wide Area Network) which, for full integration with existing Video Management System installed in Suswa substation which is based on Axis Camera Station for multi-station connection, which will transmit video signals over the Employer's Network to enable remote access and management from the KETRACO Headquarters and later connectivity to Remote and National Control Centers system.

8.11.6 Network Surveillance Camera Towers, Posts and Brackets

Camera Towers: They will be tilt-over tri-axial lattice towers with a 6m height. The structural steel work shall be to BS EN10210-1:2006, BS EN 10210-2:2006, BS EN 10219-2:2006 and general steelwork to BS1449:1991, BS EN 10255:2004, BS EN 10025:2004. They shall have a hot dipped galvanized finish for maximum weather protection, with a galvanizing to BS EN ISO 1461:2009. They shall be constructed to wind loading according to BS EN 1993-3-1:2008 and able to withstand minimum wind speeds of 40m/s, 3 sec gusts with a head load not exceeding 40kg. they shall be connected to an earth spike or mat to earth any lightning strike. They shall be wind-down type using a detachable winch to enable cameras to be serviced at the ground level (one detachable winch is to be supplied per site). The lowering and raising of tower shall be easily carried out by a single person. These units must be tamper proof. Foundation dimensions shall be consistent with manufacturers recommendations, taking into account local ground conditions.

Camera Columns: They will be high fixed tubular structures of varied lengths according to design application and limited to this guide – 20ft to 30ft for PTZ cameras, 8ft to 12ft for Bullet cameras and 8ft to 10ft for Dome camera supports. Structural steelwork to BS EN 10210-1:2006, BS EN 10210-2:2006, BS EN 10219-2:2006 and general steel work to BS1449:1991, BS EN 10255:2004, BS EN 10025:2004. They shall have a hot dipped galvanized finish for maximum weather protection, with a galvanizing to BS EN ISO 1461:2009. Cameras column will be supplied with a lockable access door and backboard for terminations. They must be constructed to design wind loading in accordance with CP3 chapter V pt 2 and BS EN 1991-1-4:2005+A1:2010 and able to withstand minimum wind speeds of 40m/s with a head load not exceeding 40kg. They shall be connected to an earth strike or mat to earth any lightning strike. They shall be built-in cable entry and exit points, as well as pole clamp adaptors for mounting cameras. Foundation dimensions will be consistent with manufacturers recommendations, taking into account local ground conditions.

Camera Brackets: They shall be structural steelwork to BS EN 10210-1:2006, BS EN 10210-2:2006, BS EN 10219-2:2006 and general steel work to BS1449:1991, BS EN 10255:2004, BS EN 10025:2004. All bracket fasteners will be to Grade 8.8, BS 3692:2014, BS 4190:2014 DIN931 and DIN934. They shall have a hot dipped galvanized finish for maximum weather protection, with a galvanizing to BS EN ISO 1461:2009. They must be constructed to design wind loading in accordance with CP3 chapter V pt 2 and BS EN 1991-1-4:2005+A1:2010.

Network Surveillance Room mounted Camera Brackets: They shall be of two types:

- Parapet wall mount swing arm
- Parapet corner wall mount swing arm

They shall be structural steelwork to BS EN 10210-1:2006, BS EN 10210-2:2006, BS EN 10219-2:2006 and general steel work to BS1449:1991, BS EN 10255:2004, BS EN 10025:2004. All bracket fasteners will be to Grade 8.8, BS 3692:2014, BS 4190:2014 DIN931 and DIN934. They shall have a hot dipped galvanized finish for maximum weather protection, with a galvanizing to BS EN ISO 1461:2009. They must be constructed to design wind loading in accordance with CP3 chapter V pt 2 and BS EN 1991-1-4:2005+A1:2010. They must be constructed to design wind loading in accordance with CP3 chapter V pt 2 and BS EN 1991-1-4:2005+A1:2010. They shall be connected to and earth material to earth any lightning strike. All brackets should extend horizontally over roof parapet approximately 400mm. Parapet corner wall mount swing arms should extend vertically above the roof parapet by approximately 200mm. Parapet corner wall mount swing arm brackets should be equipped with swept dome adaptors for mounting PTZ Dome cameras.

8.12 Video Management and Video Recording Systems

The contractor will supply and install a Network Video Recording system (NVR) that supports high-definition recording and playback, compatible with the latest video compression standards to ensure efficient storage use.

A network video recorder (NVR) shall have a capacity for 8 channels, designed to integrate seamlessly with high-definition network cameras. It must feature an embedded Linux-based operating system specifically optimized for surveillance purposes and requires an integrated Power over Ethernet (PoE) switch to directly power connected cameras, minimizing installation complexity. It should come with a pre-installed surveillance-grade hard drive, with a minimum capacity of 4TB, specifically designed for 24/7 video recording. The device must support H.264 and H.265 video compression codecs to ensure efficient storage use without compromising video quality and needs to include advanced security features such as secure boot, encrypted storage, and the capability for complex password protection to ensure system integrity and data security. The system should also offer an intuitive, user-friendly interface that provides easy setup and management without requiring specialized IT knowledge. It shall also supports direct connection to a monitor through HDMI for live viewing and playback without needing an additional computer.

The NVR shall be connected to a server at the substation for connection to the Central Monitoring System Server for a decentralized server-based solution for connectivity to the Axis Camera Station system. The server shall be equipped with dual processors, each with at least 10 cores, providing sufficient computational power for video processing and analytics. It shall also have a minimum of 64GB RAM and 16TB of storage in a RAID configuration for data redundancy and must support additional storage expansion. It shall also include at least four Gigabit Ethernet ports for network redundancy and high-speed video data transmission and have dual, hot-swappable power supplies to ensure uninterrupted operation.

The contractor will also supply and install required licenses and all related software upgrade plan licenses for connecting the substation cameras to the Security Control Room/Sentry and the Central Monitoring System to be in the remote locations such as Remote Cotrol Center, National Control Center and HQ.

The Network Surveillance system in Suswa is designed to provide recording of video images from each and every substation camera in line with the following minimum requirements:

- Under normal conditions all Network Surveillance cameras will be recorded continuously at a minimum of 1 frames per second (fps) and at the resolution shown in the Network Surveillance Camera schedule that will be provided for each substation:
    - Cameras providing automatic coverage of pedestrian and vehicle activity at site access control points will be recorded at a minimum of 25fps for 2 minutes' pre-event and 5 minutes' post-event
    - During a PIDS alarm, cameras providing primary and secondary coverage will record automatically at 25fps for 5minutes pre-alarm and 15minutes post-alarm
    - During an Access Control System alarm (door forced/held open, tamper alarm or unauthorized access attempt) those doors with dedicated camera coverage, will record automatically at 25fps for 5min pre-alarm and 15min post alarm
    - During an IDS alarm (fire exit door forced, motion detector alarm etc.) where camera coverage is available, those cameras will record automatically at 25fps for 5min pre-alarm and 15min post-alarm.
- Recorded video will be sorted locally for a minimum of 30days before being overwritten. It will be possible to set the recording parameters in terms of images per second and resolution individually for all cameras.
- All video images that are recorded locally will be stored for a minimum of 30days.
- All video images of substation alarms and access control events that are recorded locally are to be transmitted over the Employers Network and achieved centrally at the Central Monitoring System. These video images will be stored centrally for 90 days.
- The contractor is required to liaise with the Employer to ensure that there is sufficient storage capacity within the Central Monitoring System location for all the archived video storage requirements. The contractor shall give the design details with storage requirements for the Central Management System for all footage from the substation. Any additional centralized storage required, and all associated devices such as switches will be provided by the contractor.
- The contractor will be responsible for ensuring that adequate recording and storage capability to achieve the above parameters across all cameras is provided under this contract. The contractor is to provide a detailed storage calculation as part of the tender submission as well as Final Engineering Design.

8.13 Cabling Works, Enclosures and Power System Specifications

The contractor will be required to ensure that all necessary trenching, ducting, conduiting and all other methods of containments as required for the security and associated systems are provided as part of the project.
Where a containment is shared, the contractor should ensure that the security and associated systems are laid along with other Extra Low Voltage systems such as Fire Alarm System only in order to avoid any degradation in performance due to interferences such as Electro Magnetic Interference.
Excluding the Employers transmission network, the contractor will be responsible for all security and associated systems related cabling works such as Ethernet/RS485/RS232 communication cables, and all other cabling between field devices and system controllers etc. and their proper termination and ferruling.
Route markers are to be installed along external security system cable routes at maximum intervals of 50m.
All CAT-6 F/UTP cables will be tested to the ISO/IEC 11801 Channel EA specification. Automated testing such as Fluke test or equivalent will be used for these tests. The contractor will submit all such test results and reports for the approval of the Employer or their nominated representatives.
The contractor will be responsible for the production of up to date transmission drawings as part of the Final Engineering Design and on completion of all works.
The contractor will provide sufficient equipment racks and cabinets to house all system PIDS processing units, network switches, path panels, inverters and all associated security system peripherals. The contractor will provide a tamper monitoring facility for all equipment racks installed.
The contractor will ensure that all the racks are adequate in size and quantity (preferably 26U UPS-Depth Wall-Mount Rack Enclosure Cabinet, Hinged Back with at least 3 Nos of 16" Deep Vented Cantilever Universal Tray for 19" Equipment Rack and Cabinet of Heavy Duty Cold Rolled Steel) appropriately and securely installed as per the system requirements. Full allowance shall be made to ensure adequate airflow and ventilation is provided to this equipment, in line with manufacturer’s recommendations.
The contractor will ensure that sufficient power supplies and distribution systems are provided for the security systems and related equipment installed under this contract regardless of their location.
This will include the installation of separate Electrical Distribution Boards dedicated to the powering of the installed security systems. The contractor will ensure that the sufficient power cables are run between the security systems distribution board and all others security equipment as well as step-down transformers, junction boxes and all associated civil and electrical works. The contractor must submit their finalized distribution scheme to the Employer or their nominated representative for approval prior to commencing any works.
The contract will also include the supply and installation of an inverter unit for the security systems, which will convert the 110VDC supply to 230VAC output. The 110VDC input supply will be supported by the substations battery bank.
The following security devices will be fed from the Inverter unit:

- Site Main Entrance Fixed Cameras
- Perimeter PTZ cameras
- PIDS field processors
- PIDS network controllers
- Access Control System/IDS controllers
- Local NVR
- Network switch

The contractor is to provide a power load estimate for the above systems as part of their tender submission as well as ensure that the power demands of the system will be included in the backup power supply system sizing for the protection and control systems for the backup power supply duration specified in the protection and control backup supply specifications.

8.14 Device Specifications

The specifications of the surveillance equipment to be deployed is as listed below:
Surveillance Cameras

8.14.1 Outdoor Wireless IP Bullet Camera

The Cameras shall have the following specifications:

- Image Sensor: 1/2.8” 2.0-megapixel progressive scan CMOS sensor,
- Resolution: 1920*1080 resolution,
- Day/Night Mode: Auto/Colour/Monochrome (removable infrared-cut filter) mode,
- Electronic Shutter speed: 1/100000s to 1s electronic shutter speed,

- Wide Dynamic Range: 128dB wide dynamic mode,
- Backlight Compensation: Supported
- Digital Noise Reduction: Self-adaptive to 2D or 3D DNR,
- Defog: Automatic/Manual,
- Image Stabilization: Electronic Image stabilization,
- IR coverage: Up to 80meters
- Angular field of view: Horizontal: [43° Wide 14°(Tele)] and Vertical: [22° (Wide) 9° (Tele)],
- Video Compression: H.265/H.264/MJPEG,
- Multiple streaming: Double Full HD streams and Treble streams (30fps or 25fps),
- Audio compression G.711a/G.711u/G.726/OPUS,
- Network protocols: (TCP, UDP, IPv4, IPv6, DHCP, DHCPv6, DNS, ICMP, SIP, RSP, SSL, NTP, SNMP, 802.1x, QoS, DDNS),
- Steaming Transmission: Unicast/multicast,
- Stream encryption: AES 128/192/256 encryption algorithm,
- Intelligent analytics: (Loitering detection, Intrusion detection, abandoned object detection, removed object detection, target colour recognition, Humans and vehicles distinguish, motion detection, tampering detection),
- Alarm actions: [Alarm output, SD card recording and snapshot],
- Ethernet interface (1xRJ-45 10/100Base-T self-adaptive Ethernet port),
- Serial Interface: At least 1*RJ-45 10/100Base-T self-adaptive Ethernet port,
- Alarm Interfaces: 2 channel input and 2 channel output,
- Audio interfaces: 1 channel input and 1 channel output,
- Memory card slot: Built in 32G memory slot,
- Power Supply: [DC12V±25%, DC24V±25%, AC24V±25%, POE(IEEE802.3at)],
- Power Consumption: Maximum power consumption 20W,
- Surge Suppression: 6kV surge voltage protection IEC61000-4-5 compliant,
- Vandal Proof Class: IK10 vandal-proof metal casing IEC62262 compliant,
- IP Protection class: IP66 minimum, complies with IEC61000-4-5,
- Anti-corrosion specification: 10-day salt spray test IEC60068-2-11 compliant.

8.14.2 IP Pan Tilt Zoom Camera

The Cameras shall have the following specifications:

- Image Sensor: 1/2.8" 2.0-megapixel progressive scan CMOS sensor,
- Resolution: 1920*1080 resolution,
- Day/Night mode: Auto/Multicolour/Monochrome,
- Electronic Shutter Speed: 1/100000s to 1s,
- Iris Diaphragm: Automatic iris diaphragm,
- Gain Control: Automatic/Manual,
- Wide Dynamic Range: 120dB wide dynamic mode,
- Backlight Compensation and highlight Suppression: supported,
- Digital Noise Reduction: self-adaptive to 2D or 3D,
- Defog: Automatic/Manual,
- Image stabilization: G-Sensor Unit Electronic Image stabilization,
- Focal Length: 4.5mm-135mm,
- Zoom: 30X Optical zoom and 16X Digital zoom,
- Angular field of view: Horizontal: [60.89° Wide 2.67°(Tele)] and Vertical: [37.34° (Wide) 1.51° (Tele)],
- Rotation angle: (Horizontal:0° to 360°, Vertical: -20° to +90°),
- Horizontal Rotation Speed: [Manual: 0.1°/s to 450°/s, Preset≥450°/s],
- Vertical rotation speed: [Manual: 0.1°/s to 400°/s, Preset≥400°/s],
- Preset positions: 256,
- Tour scan: 8 scan lines each with 32 preset positions,

- Pattern scan: Max of 5 scan lines each 10minutes,
- Park Action: [Home position, preset position tour, pattern scan, horizontal scan, vertical scan, random scan, frame scan and panoramic scan],
- ISP Packages: 5 defined scenarios (outdoor, indoor, motion capture, lowlight, and backlight modes),
- Video Compression: H.265/H.264/MJPEG,
- Multiple streaming: Double Full HD streams and Treble streams (30fps or 25fps),
- Communication Interface: One RJ-45 10/100/1000Base-TX self-adaptive Ethernet port,
- Network protocols: (TCP, UDP, IPv4, IPv6, DHCP, DHCPv6, DNS, ICMP, SIP, RSP, SSL, NTP, SNMP, 802.1x, QoS, DDNS),
- Alarm interface: (4-channel alarm input and 1-channel alarm output(pigtail),
- Unicast/multicast steaming transmission and stream encryption capable,
- Event Triggers: (motion detection, covering detection, alarm input, intelligent analytics alarm and network disconnection),
- Ethernet interface: (1xRJ-45 10/100Base-T self-adaptive Ethernet port),
- Storage interface: Micro SD cards in 64GB maximum memory slot of Speed class≥6,
- Media security: AES128/192/256 encryption algorithm,
- Power supply: [DC12V±25%, DC24V±25%, AC24V±25%, POE(IEEE802.3at)],
- Maximum power consumption 45W,
- EMC Compatibility: Complies with EN 55022 Class B, EN 55024, EN 50130-4, EN61000-6-1/3/2, EN 61000-3-2/3 and FCC Part 15 Subpart B Class B.
- Lightning Surge Suppression: 6kV surge voltage protection IEC61000-4-5 compliant,
- Vandal-proof Class: IK10 vandal-proof metal casing IEC62262 compliant,
- Anti-Corrosion: 10-day salt spray test IEC60068-2-11 compliant.

8.14.3 IP Dome Camera

The Cameras shall have the following specifications:

- Image Sensor: 1/2.7" 2.0-megapixel progressive scan CMOS sensor,
- Resolution: 1920*1080 resolution capable and lower,
- Day/Night mode: Auto/Colour/Monochrome (removable infrared-cut filter),
- Electronic Shutter Speed: 1/100000s to 1s,
- Automatic Iris: DC Iris,
- Gain Control: Automatic/Manual,
- Wide Dynamic Range: 120dB wide dynamic range,
- Backlight Compensation: supported,
- Digital Noise reduction: self-adaptive to 2D or 3D DNR,
- Defog: Automatic/Manual,
- IR coverage: 30m,
- Focal Length: 2.8-12mm F1.4max,
- Angular field of view: Horizontal: [106° Wide 36°(Tele)] and Vertical: [57° (Wide) 20° (Tele)],
- Camera angle adjustment: (Pan:0° to 356°, Tilt: 0° to 75°, Rotation: 0° to 356°),
- Video Compression: H.265/H.264/MJPEG,
- Multiple streaming: Double Full HD (1080p) streams and Treble streams (30fps or 25fps),
- Audio Compression: G.711a/G.711u/G.726/OPUS,
- Network protocols: (TCP, UDP, IPv4, IPv6, DHCP, DHCPv6, DNS, ICMP, SIP, TRSP, SSL, NTP, SNMP, 802.1x, QoS, DDNS),
- Unicast/multicast steaming transmission, stream encryption capable,
- Intelligent detections: (motion detection, covering detection),
- Event actions: [Alarm output, SD card recording and snapshot],
- Ethernet Interface: One RJ-45 10/100Base-TX self-adaptive Ethernet port,
- Alarm interface: (1-channel alarm input and 1-channel alarm output,

- Event Triggers: (motion detection, covering detection, alarm input, intelligent analytics alarm and network disconnection),
- Communication Interface: 1xRJ-45 10/100Base-T self-adaptive Ethernet port, 1*RS485 serial port,
- Built in 64GB maximum memory slot,
- Media security: AES128/192/256 encryption algorithm,
- Power supply: [DC12V±25%, DC24V±25%, AC24V±25%, POE(IEEE802.3at)],
- Maximum power consumption 9W,
- EMC compatibility: EN 55022 Class A, EN 55024, EN 50130-4, EN61000-6-2, EN 61000-3-3 and FCC Part 15 Subpart B Class A.
- Lightning Surge Suppression: 4kV surge voltage protection IEC61000-4-5 compliant,
- Vandal-proof Class: IK10 vandal-proof metal casing IEC62262 compliant,
- Anti-Corrosion: 10-day salt spray test IEC60068-2-11 compliant

8.14.4 Digital Video Recorder and Monitoring System.

8.14.4.1 Monitoring Screen

The monitoring screen(s) colour display shall be suitable with the standards of the selected cameras. They shall be solid state and modular in design. They shall provide a bright, clear and well-defined picture display on the screen. All controls for brightness, contrast etc. shall be provided on the rear panel for readily adjusting the levels of the video signal. The rear panel shall also be provided with input and output connectors for coupling the video output to other Monitors.

Specifications:
32" Monitor
Display Type: LED
HDTV: Yes
TV Type: Standard TV
HD Type: Full HD
Display Resolution: 1920x1080
Colour: Black
Resolution: 1920x1080
Inputs: 2 HDMI, 1 USB (minimum)
Not flash high brightness, ratio 16:9, colour 16.7M with interface of VGA, HDMI, USB and TV CVBS;
60 Hz NTSC /PAL/SECAM 1080P;
Brightness (typical): LCD panel 250 nits;
Response time: 5 m sec;
Power supply: AC (100 V~235 V);
Contrast ratio: 20000000:1(D C R);
Viewing angle: 178*178;
LED back light.

The screens shall have a rack able steel/aluminium stand designed to securely support them,
A control keyboard, optical mouse with pad shall also be provided
PTZ control system shall be provided and shall be from the same manufacturer as the PTZ cameras.

8.14.4.2 Video Surveillance Server

A video surveillance central monitoring system characterized as a 8-channel network video access which provides a wide assortment of services such as live video surveillance, video retrieval and playback, Pan-Tilt-Zoom (PTZ) controls, alarm detection and linkage, voice intercom, and electronic map.

Specifications:

- 16 maximum video access channels, 16 video playback and download channels,
- Video input bandwidth: 128Mbit/s,
- Video forwarding channels: 32,
- Video output bandwidth: 256Mbit/s,
- Video formats: H.264/H.265,
- Decoding performance: (1-channel 4K or 8-channel 1080p or 16-channel 720p),

- Preview modes: 1/4/8/9/16 panes,
- Stacking function: 2 to 16 such modules, 2 number if storage disks with Hot-swappable SATA3.0,
- Disk Type: 4TB enterprise-level hard disk,
- RAID Level: non-RAID mode/RAID1,
- Recording modes: (supported manual recording, scheduled recording, and alarm-triggered recoding), Query by time or events option, Batch download or download by time segment options,
- Media encryption: supports multiple encryption algorithms such as AES256,
- Compatibility: Supports access of devices that comply with the GB/T 28181, ONVIF 2.4, or ONVIF Profile S protocol, DHSDK, also supports connection to other platforms that comply with various protocols such as GB/T 28181 to implement diverse functions such as live video viewing and PTZ control and alarm reporting,
- Protocols supported (TCP, UDP, IPv4, HTTPS, RTP, RSTP, RTCP, AIP, SSL, NTP, HTTP),
- External Interfaces: at least 1*HDMI 2.0, 1*VGA, 2*10/100/1000Mbit/s Ethernet ports, 1* USB3.0, 1*USB2.0, 1*BNC Audio input, 1*BNC Audio output, 2*input Alarm channels, 1*output Alarm channels,
- Power consumption (including disks): <60W,
- Power Supply:100VAC to 240VAC (50Hz/60Hz),
- Standard 19-inch 9U cabinet.

8.14.4.3 Network Video Recorder

A 2U shall be provided for software defined storage, as well as act as a virtual desktop infrastructure with the following specifications :

- Processor : Up to two 2nd Generation Intel® Xeon® Scalable processors, up to 28 cores per processor
- Memory : Must support 24 DDR4 DIMM slots, and RDIMM /LRDIMM,with speeds up to 2933MT/s, and offer a maximum capacity of up to 3TB to accommodate the high volume of data generated by the surveillance cameras. 24 DDR4 DIMM slots, Supports speeds up to 2933MT/s, 3TB max Up to 12 NVDIMM,
- Storage controllers : A minimum internal storage capacity of 20TB, expandable and configurable for redundancy. The system should support a mix of NVMe SSDs for high-speed data access and HDDs for bulk storage, ensuring optimal balance between performance and capacity. RAID configurations (PERC H740P) are required for data protection and continuity.
- Network Specifications: Must include options for at least four high-speed network interfaces (1GbE or 10GbE) to support the substantial data throughput required for high-definition video surveillance.
- Power Supply and Physical Specifications: Equipped with dual, hot-plug, redundant power supplies (750W/1100W options) to ensure continuous operation. The form factor should be Rack (2U), providing an efficient use of space in a data center environment.
- Security and Management: The server must incorporate advanced security features to protect against unauthorized access and cyber threats, including TPM 1.2/2.0, cryptographically signed firmware, and Secure Boot capabilities. An integrated management module (such as iDRAC9) for streamlined setup, monitoring, and maintenance of the server hardware.
- Environmental and Operational Conditions: Designed to operate efficiently within a wide range of environmental conditions, ensuring reliability and longevity of the server in different substations' environments.
- Scalability and Compatibility: The system architecture should support scalability, allowing for future expansion as surveillance needs grow. Compatibility with major video management software platforms is essential for seamless integration into the existing surveillance ecosystem.
- Embedded management : iDRAC9, iDRAC Direct, iDRAC RESTful API with Redfish
- Integreations and connections : Integrations: Microsoft® System Center, VMware® vCenter™, BMC Truesight, Red Hat® Ansible Modules

- Securtiy : TPM 1.2/2.0, TCM 2.0, Cryptographically signed firmware, Secure Boot
- I/O and ports : Network daughter card
    - 4 x 1GbE or 2 x 10GbE + 2 x 1GbE or 4 x 10GbE or 2 x 25GbE
    - Front ports: 1 x Dedicated iDRAC Direct Micro-USB, 2 x USB 2.0, 1 x USB 3.0 (optional) 1 x VGA
    - Rear ports: 1 x Dedicated iDRAC network port, 1 x Serial, 2 x USB 3.0, 1 x VGA
    - Video card: 2 x VGA
- Supported operating systems : Canonical® Ubuntu® Server LTS, Citrix® Hypervisor, Microsoft Windows Server® LTSC with Hyper-V, Oracle® Linux

8.14.5 Guardhouse screen and network video decoder with desk and chair

8.14.5.1 The Network Video Decoder

The Network Video Decoder (Media Display Server) shall be characterized by the following specifications:

- Maximum resolution: Local up to 2MP, Remote up to 12MP
- Applications: Digital Signage, Video Decoding, Public Viewer
- Maximum number of cameras: 16 for Small Medium and Large Substations, and 48 for special substations
- Maximum number of Video Devices: 16
- Maximum number of clients: Local-1, Remote-2
- Maximum Display Resolution: 1080p
- Live View Display Layout Modes: 1,2,4,9,12,16,1+5,1+7,1+12,2+4,2+8
- Live View Digital zoom: Enabled
- Event Status: Network loss, Motion, DI
- PTZ Control: PTZ control, Speed Control, 32 preset points, 32 preset tours
- Video sources: Live video streams from IP cameras
- H.264 compression
- Maximum frame rates vs resolution: 30 fps at 1920 x 1080, 30 fps at 720 x 480, 25 fps at 720 x 576, 30 fps at 640 x 480
- Network Protocol & Service: TCP, UDP, IP, HTTP, HTTPS, DHCP, PPPoE, RTP, RTSP
- Ethernet Port: RJ-45 connector
- Password protected user level security
- Client PC Operating System: Windows 8.1, Windows 7 SP1
- Server Operating System: Embedded Linux
- USB Port USB 2.0
- System Status Monitor: Real time status reports on remote browser
- ONVIF Profile S compliant
- HDMI Output Type A
- Analog Video Output: CVBS, BNC connector
- External Storage Interface: USB (Support Digital Signage function from external USB drive)
- Local Access: HDMI monitor, USB keyboard & mouse
- Power Source: DC 12V, PoE Class 3 (IEEE802.3af)
- Power Consumption: 8.5 W (PoE), 7 W (DC)

The Screen to be installed (including a mouse and trackpad) shall be characterized as specified:

- Resolution pixels: 1280*1024 (5:4)
- Video Standard: PAL/NTSC
- Display contrast ratio: 2,000,000:1 (DCR)
- Response time: 5ms
- Brightness: 250cd/m^2
- Viewing Angles: 160deg vertical and 170deg horizontal
- 17" display size
- Comb filter: 3D comb with de-interlace
- Video Inputs: VGA. HDMI, Composite (CVBS)

- Audio inputs: RCA jack
- Mount: VESA standard 100*100mm
- Power consumption:25W
- Supply voltage: 12VDC with PSU 100~240VAC

The screen shall be accompanied by an appropriate sturdy desk and chair

8.14.5.2 Computer Desk and Chair

Computer Desk Specifications:

Width: 750mm, Depth: 400mm, Height: 750mm

The desk table shall be supplied with steel members duly welded and rigidly fixed table top and provided with a slidable keyboard tray, modesty panel and footrest.

The frame shall comprise of hollow rectangular M.S. section of size 50x25x1.6 mm thickness. Two side members of the frame identical in shape shall be joined with welding at bottom with a footrest (hollow rectangular M.S. section of size 50x25x1.6mm thickness) angularly welded, and at the top in front side welded with an angle size 17x17x3mm. And at the back on the top side of the frame, a modesty panel of size 200x17x0.8mm thick CRC sheet shall be welded. Thus, making the frame rigid in construction.

The keyboard tray shall be of size 710mm (front width) x 300mm(depth) approximately is to be provided with end fittings mad from minimum 2mm thick MS steel mounted on either side and the keyboard tray shall be easily slidable, provided with two telescopic channels with balls.

Modesty panel of size 200x17x0.8mm thick of length made from CRC sheet conforming to IS:513/2008 covering full backside of the said frame & shall be suitably welded with two sides members of the frame, in such a way that it's top surface having 17mm width, flushes with top surface two side members and joining front angle member.

Four level screws, having smooth bottom flat surface of minimum 50mm diameter, shall be welded under the bottom of two said side members of the frame; capable to adjusting level up to 10mm in height.

All exposed steel sections shall be painted with black in colour with powder coating 40-50-micron thickness.

Table top shall be of MDF board or pre-laminated particle board having dimensions as specified in the description(750x400) with tolerance of+/-5mm in length and width. The top shall be extended 50mm approximately on all sides over the steel frame. Height of the table shall be 750mm+/-10mm from the floor of the top surface.

The MDF board used for top, keyboard tray should be of minimum density of 750kg/m3 and shall be of 18 mm thickness with laminated sheet of 0.6mm thick. The top shall be of grey colour. Bottom side of the board should have balancing sheet of requisite thickness of white or of same colour as top laminate.

Only ISI marked MDF board and laminate should be used. Pasting of laminates should be done with the help of post forming machine having air pressure & temperature control.

8.14.5.3 Computer Chair Specifications:

SEAT/BACK ASSEMBLY: The seat & back is made up of 1.2 cm thick hot pressed plywood are upholstered with contoured lumbar support for extra comfort.

BACK SIZE :39.0 cm (W) X24.0 cm (H)., SEAT SIZE: 44.0 cm (W) X 41.0 cm (D)

POLYURETHANE FOAM: The polyurethane foam is moulded with density=45 +/-2 kg/m3and hardness = 20 +/-2 on Hampden machine at 25% compression.

SEAT/BACK COVERS: The upholstered seat is covered on the underside with black polypropylene non-woven fabric and the upholstered back is covered with a back cover injection melded in black Co-Polymer Polypropylene.

ARMRESTS: No Armrests.

ADJUSTABLE BACK MECHANISM: The adjustable back mechanism is designed with the following feature: 360o revolving type Provision for backrest tube (3.5 cm X 168 G). Back height adjustment 9.0 cm, Ub finite locking of back height.

PNEUMATIC HEIGHT ADJUSTMENT: The pneumatic height adjustment has an adjustment stroke at 9.0 cm

PEDESTAL ASSEMBLY: The pedestal is fabricated from 0.2 cm. Thick CR steel, power coated and fitted with an injection moulded black Polypropylene hub cap and 5 nos. Twin wheel castors. (castors wheel dia. 5.0 cm). The pedestal is 55.0 cm pitch-centre dia. (65.0 cm with castors)

THE WHEEL CASTORS: The twin wheel castors are injection moulded in Black-Nylon.

8.14.6 Battery Backup Supply

8.14.6.1 3KVA Battery Backup

Shall be installed in the small and medium stations

- Output Power capacity: 2.7kW/3.0kVA
- Nominal Output voltage: 240V, configurable for 220V, 230V, or 240V nominal output voltage
- Output voltage distortion: less than 5% at full load
- Output frequency: 47 - 53 Hz for 50 Hz nominal, 57 - 63 Hz for 60 Hz nominal
- Output Connections: (8) IEC 320 C13 (Battery Backup), (2) IEC Jumpers (Battery Backup), (1) IEC 320 C19 (Battery Backup)
- Nominal Input Voltage: 230V, 220V or 240V
- Input frequency: 50/60 Hz +/- 3 Hz (auto sensing)
- Input Connections: IEC-320 C20, Schuko CEE 7 / EU1-16P, British BS1363A
- Input voltage range for main operations: 160 - 286V
- Battery type: Maintenance-free sealed Ni-Ca leak proof batteries.
- Typical recharge time: 3hour(s)
- Interface Port(s): USB
- Control panel: Multi-function LCD status and control console
- Audible Alarm: Alarm when on battery, distinctive low battery alarm, configurable delays
- Surge energy rating: 365Joules
- Filtering: Full time multi-pole noise filtering, 0.3% IEEE surge let-through, zero clamping response time, meets UL 1449
- Operating Temperature: 0 - 40 °C
- Audible noise at 1 meter from surface of unit: 53.0dBA
- Online thermal dissipation: 375.0BTU/hr.
- Certification: CE, CSA, EAC, EN/IEC 62040-1, EN/IEC 62040-2, RCM, VDE

8.14.6.2 5KVA Battery Backup

Shall be installed in the Large stations and the main and backup CMS centres.

- Output Power capacity: 3.5kW/5.0kVA
- Nominal Output voltage: 230V, configurable for 220V, 230V, or 240V nominal output voltage
- Efficiency at full load: minimum 92%
- Output voltage distortion: less than 5% at full load
- Output frequency: 47 - 53 Hz for 50 Hz nominal, 57 - 63 Hz for 60 Hz nominal
- Output Connections: (8) IEC 320 C13 (Battery Backup), (2) IEC Jumpers (Battery Backup), (1) IEC 320 C19 (Battery Backup)
- Nominal Input Voltage: 230V, 220V or 240V
- Input frequency: 50/60 Hz +/- 5 Hz (auto sensing)
- Input Connections: IEC-320 C20, Schuko CEE 7 / EU1-16P, British BS1363A
- Input voltage range for main operations: 140 - 280V
- Battery type: Maintenance-free sealed Ni-Ca or Gel type leak proof batteries.
- Typical recharge time: maximum 3hour(s)
- Interface Port(s): USB
- Control panel: LED status display with load and battery bar-graphs and On Line: On Battery: Replace Battery: Overload and Bypass Indicators
- Audible Alarm: Alarm when on battery, distinctive low battery alarm, configurable delays
- Surge energy rating: 555Joules
- Filtering: Full time multi-pole noise filtering, 0.3% IEEE surge let-through, zero clamping response time, meets UL 1449
- Operating Temperature: 0 - 40 °C
- Audible noise at 1 meter from surface of unit: 55.0dBA
- Online thermal dissipation: 1057.0BTU/hr.

- Protection Class: minimum IP 20
- Certification: CE, EN 50091-1, EN 50091-2, EN 55022 Class A, EN 60950, EN 61000-3-2, GOST, UL 1778, VDE

8.14.7 Network Switch

A layer 2 stackable Ethernet switch in racks and outdoor fiber connection (OFC) shall be used. The technical characteristics and protocols are: IEEE 802.1D, IEEE 802.1p, IEEE 802.1Q VLAN, IEEE 802.1s, IEEE 802.1.w, IEEE 802.1x, IEEE 802.3ad, GBIC – 100 Base FX, SNMPv2, RMON I y II, IEEE 802.3 at / af, SSH. We use a core layer 4 Ethernet switch for main switch in control building. The technical characteristics added to the core switch are: Support for IP routing protocols, Two Redundant power of supply, GBIC: 100 base FX, 10/100/1000 base TX ports
Minimum 8* 10/100/1000 Mbps Gigabit Ports, Auto MDI/MDIX Crossover for all ports,
Store-and-forward Switching Scheme,
Full/half-duplex for Ethernet/Fast Ethernet Speeds,
IEEE 802.3x Flow Control,
Plug-and-play Installation,
RoHS Compliant,
IEEE 802.1p QoS (4 Queues, Strict Mode),
Supports Cable Diagnostics,
Supports 9720 Kbytes Jumbo Frames,
60Wmax 24VDC power supply.

Ethernet Cable and Accessories
The cameras and modules for each station shall be wired using at, a minimum, the following:
150ft (50m) CAT5e EXTERNAL (outdoor use) & INTERNAL cable (100% SOLID COPPER, Ethernet, Network Surveillance System, 10/100/1000mb, Networking & Patch Cable, DATA/LAN, BLUE),
20* SHD RJ45 Connectors Shielded RJ45 Ends 8P8C FTP STP Network Plug for CAT5E CAT6 Stranded Cable each with blue strain relief boots.
PVC Conduit of heavy grade (ISI mark) with 20 mm dia as well as appropriate sweep bends and bell mouth couplings will be used for laying Video links throughout each station. The length of the PVC conduit shall be customized for each station depending on the design layout of the entire surveillance system.
All other cables shall conform to the specs below:

Cable Application	**Cable Description**
Network Cables	CAT5e
Patch cords	CAT5e
Card Reader	4C,18AWG, OA shielded
Door lock power	4C, 16AWG, stranded, shielded, multi-conductor
Door contact	2C, 18AWG, stranded, shielded, multi-conductor
Emergency break glass	4C, 18AWG, stranded, shielded, multi-conductor
PIR	6C, 16AWG, stranded, shielded, multi-conductor
RG-6 co-axial cable	18AWG Solid stranding, Non-plenium
Lightning control networking cable	24AWG, 3 pair, stranded, non-plenium
Building Management system (BMS) e.g. fire alarm and HVAC system	2C, 18AWG, shielded, twisted pair, multi-conductor
Fiber optic cable	Single mode fiber optic cable, zero water peak, metallic loose tube, armoured, in accordance with ITU-T G.655c

8.14.8 System Protection and Consumables

The complete system shall be appropriately protected complete with disconnector switches and MCB's as appropriately designed and sized for each station. The system shall be powered from each station supply as available or a supply system designed for locations without this supply system. The system as well as its

protection facilities to be implemented shall be designed in conjunction with and approved by the employer before installation.
All cameras and modules shall take advantage of the PoE powering capability. The contractor shall be responsible for supply of all components necessary for the powering of the units; inclusive but not limited to voltage converters for 48VDC to 24VDC systems as well as AC to DC converters.

8.15 Readiness for Connection to WAN Network Requirements

The contractor shall design system for readiness of connection to an extended WAN network guided by the Kenya power system telecommunication network owed by both KETRACO and Kenya Power.
The contractor shall also be expected to utilize industrial-grade firewall and ruggedized network switch and implement cybersecurity measures to protect the integrity of the Network Surveillance data.
The contractor shall define and configure one VLAN (guided by the Employer) for Network Surveillance traffic and for Access Control System traffic. Inside Network Surveillance VLAN all components belonging to Network Surveillance must be included while for the Access Control System VLAN, all components belonging to Access Control System must be included. The switches ports dedicated to connect VoIP devices will be defined inside VoIP VLAN. The contractor shall also do a proposal for the station wide IP addressing for the Network Surveillance VLAN for consultation with the Employer for coordination with respect to the nationwide IP addressing.

8.15.1 Fiber Optic Cable (Patch Cords)

25m FC-LC Single Mode, Duplex 9/125micron fiber optic patch cable
The patch cables shall have high-grade connectors with ceramic ferrules for increased durability and accuracy and shall also cables feature OFNP Plenum-Rated jackets. They shall have a maximum allowable loss of 0.02dB and optical return loss - 55dB.
The cables shall abide to the standard specifications according to:

- ITU-T Recommendation G.655 (Tables A, B, C and D)
- IEC Specifications 60793-2-50 Type B1.3
- ISO 11801 OS2

8.15.2 Industrial-grade Firewall

The contractor shall be expected to provide a high-performance, industrial-grade network firewall capable of ensuring the highest level of security for critical power system substation networks, withstanding industrial environmental conditions and providing advanced threat protection and network traffic management.
A high-performance industrial-grade network firewall and a ruggedized network switch shall be added to the network surveillance system to provide layered security over GbE corporate SD- WAN connections combined with enhanced security solutions which comply with utility and industrial standards. The firewall has to be compliant with the IEEE 1686 cybersecurity standard, IEC 60068-2-27 on Shock, IEC 60068-2-6 on Vibration.
The contractor shall provide the firewall for the station as well as the remote station for end-to-end cybersecurity protection.
The contractor shall also provide after sale services as part of the hardware, which include; Hardware Unit, 24x7 Comprehensive Support, Advanced Hardware Replacement, Firmware and General Upgrades, VPN, Traffic Management, Threat protection bundle Services Bundle (Application Control, IPS, AV, Botnet IP/Domain, Mobile Malware Service, Web Filtering, Antispam, Cloud support services including Virus Outbreak and Content Disarm & Reconstruct Services) for 5 years.
The firewall shall have the following minimum specifications:

- Performance Requirements:
  - Capable of delivering a minimum of 10 Gbps firewall throughput with VPN capabilities exceeding 3 Gbps to manage high-volume, encrypted traffic efficiently to support real-time HD video streaming.
  - Must include advanced security functionalities such as deep packet inspection (DPI), intrusion prevention systems (IPS), and Advanced Threat Protection (ATP) with real-time threat intelligence updates, application-aware controls, and encrypted traffic inspection capabilities.
  - VPN Capabilities: Support for various VPN configurations, including IPSec and SSL, with advanced encryption to ensure secure remote access across distributed networks.

  - Should offer comprehensive protocol support to ensure compatibility with industrial communication standards.
- Environmental Hardening:
  - Designed to operate reliably within an extensive temperature range, ideally from -40°C to +75°C, suitable for deployment in harsh industrial environments.
  - The enclosure should be rated at least IP30, offering protection against dust and operational interference.
  - Standards Compliance: Certification under IEC 62443 or equivalent industrial cybersecurity standards is mandatory, ensuring suitability for critical infrastructure protection.
- Management, Scalability, and Integration
  - Network Management: Features an advanced, user-friendly management interface for configuration, monitoring, and reporting. Must support integration with Multi-Factor Authentication (MFA) and Identity and Access Management (IAM) frameworks.
  - Scalability: Modular design preferred to support network growth and adaptation to evolving security requirements without extensive hardware changes.
- Security Features:
  - Equipped with state-of-the-art cybersecurity capabilities including intrusion detection and prevention, application-aware firewalling, and advanced threat intelligence to protect against evolving cyber threats. Compatibility with industrial control systems and SCADA protocols is a must.
- Compliance and Standards:
  - Designed to operate reliably within an extensive temperature range, ideally from -40°C to +75°C, suitable for deployment in harsh industrial environments.
  - The enclosure should be rated at least IP30, offering protection against dust and operational interference.
- Scalability and Flexibility
  - Must support scalable configurations to adapt to growing network demands without significant hardware changes.
  - Should allow for flexible rule creation and traffic management policies to accommodate diverse network architectures and changing security needs.
- Virtual Private Network (VPN) Support
  - Comprehensive VPN support, including site-to-site, remote access, and SSL VPN, with strong encryption standards to securely connect remote sites and mobile workers.
- Reporting and Analytics
  - Advanced reporting capabilities, providing insights into traffic patterns, threat intelligence, and system performance.
  - Real-time analytics and threat detection to quickly identify and respond to security incidents.

8.15.3 Ruggedized Network Switch

The contractor shall acquire a state-of-the-art, ruggedized, and highly reliable Layer 3 managed network switch designed for critical surveillance applications within industrial settings, ensuring high performance, security, and environmental resilience. The ruggedized network switches shall be characterized by the following minimum specifications:

- Network Performance and Management
  - A Layer 3 managed switch offering a robust switching capacity of at least 20 Gbps of bandwidth to facilitate real-time surveillance video streaming without latency, equipped with a minimum of 24 Gigabit Ethernet ports, including 12 ports with PoE+ support according to IEEE 802.3at for powering surveillance cameras other PoE devices directly through the network cabling.
  - Must support advanced network segmentation through VLANs and have quality of service (QoS) prioritization to ensure critical surveillance data is prioritized across the network.
- Durability and Environmental Hardiness

  - Must withstand extreme industrial conditions with an operating temperature range from -40°C to +70°C and a high ingress protection rating of IP67 or better to ensure protection against water, dust, and other environmental elements.
  - Designed for high vibration, shock resistance, and compliance with electromagnetic interference (EMI) standards suitable for substation environments.
- Reliability and Redundancy
  - Features such as redundant power supplies and network redundancy protocols like Rapid Spanning Tree Protocol (RSTP) to ensure continuous, uninterrupted operation.
  - The equipment should have a high Mean Time Between Failures (MTBF) rating, indicating superior reliability and longevity in operation.
- Advanced Network Security Features:
  - Comprehensive security features including Access Control Lists (ACLs), port security, DHCP snooping, and advanced threat detection mechanisms. Support for secure VPN connections for remote monitoring and management is also required.
- Network Management and Scalability:
  - Easy-to-use, comprehensive management capabilities via a web-based interface, CLI and SNMP for efficient setup, monitoring, and maintenance. The solution should be scalable, allowing for future network expansion without significant reconfiguration.
- Industrial Protocol Support:
  - Capability to integrate seamlessly with industrial protocols and automation systems, ensuring that the switch can communicate effectively within a broader industrial control system environment.
- Certifications and Compliance:
  - Must meet industrial standards for vibration, shock, and electromagnetic interference (EMI) resistance. Compliance with international standards such as IEEE 1613 and IEC 61850-3 for utility automation applications is essential.

8.16 **Scope of Works**

8.16.1 General Conditions for Scope of Installation, Commissioning and Testing

The Equipment and its Auxiliaries must be designed corresponding to the Technical Specifications and Employers requirements. The Equipment must be of the proper capacity type and quality to perform successfully the functions and specified service conditions for which it is specified. Accessories are included in the scope of supply and must be adequate to meet specified requirements.

The scope of installation, commissioning and testing includes all components down to small details required to ensure safe and proper operation and maintenance of the equipment or required by Codes and Rules applicable. Also, individual parts which are not explicitly mentioned but which are necessary for proper operation must be included in the scope of supply. Any other equipment, material, document and / or service not specifically indicated but necessarily for a reliable and safe operation of the equipment will form also part of the supply.

The Equipment and its auxiliaries must also be designed with provisions for easy and safe access for inspection, cleaning, maintenance and repair.

The Equipment must be designed, manufactured assembly and inspected in accordance with the terms and conditions of this specification and its annexes. The supply must follow the recognized international codes, regulations or instructions by the authorities whenever deemed to do so. When there is not any explicit Directive the Codes and Standards listed in the Technical Specification must be applied.

The equipment must have the appropriate Certificates of Conformity. Compliance with this specification must not relieve the contractor from his responsibility of supplying a group of appropriate design and correct construction, fully adaptable to the specified operating conditions and also reliable as regards its mechanical, electrical and operating performances.

Any contradiction between this document and the data sheet and with the applicable standards to comply with the Object of this document shall be communicated to the Contractor. Subcontractor will assume any changes in the project reference specifications.

The contractor must be responsible for the following supply; therefore, Bidder's proposal must include:

- Selection and design of the Equipment, as specified, including coordinated design of auxiliary equipment as required. Design must guarantee for a safe and trouble-free operation and maintenance

- Supply shall include the following equipment and components; A Network Surveillance System shall be provided.

All equipment / accessories included in the scope of work shall be designed and manufactured for a design life of 25 years. The contractor shall guarantee that all the material in this supply up to the definitive delivery date against any design material, manufacturing or assembly defect that may occur due to normal use under the conditions stipulated in the Technical Specifications.

The contractor shall provide appropriate name tagging of all cables and equipment installed. The contractor shall abide by the requirements in the ANSI/TIA-606-B labelling standard as well as ISO/IEC IS 11801 Ed. 2.1. Information technology – Generic cabling for customer premises and ISO/IEC IS 14763-2 Information technology – Implementation and operation of customer premises – Part 3: Acceptance Testing for Optical Cabling. The contractor shall guarantee that the data mentioned on the name plate of the equipment or the nametag/cable marker and given in the data sheet will not deteriorate during the life of this equipment under the specified operating and maintenance conditions.

The contractor shall guarantee the values in the technical data schedule. The employer reserves the right to reject any equipment that does not respect these values. Unless explicitly defined in the particular contractual forms the Guarantee period of the complete system as well as the respective subsystems shall be a minimum of 3 years.

Definitive reception will be carried out as indicated in particular contract terms. If any components or device were observed to be faulty during the guarantee period, the contractor will be obliged to repair or replace it, leaving the material in perfect operating conditions again at its expense and risk, and in the shortest possible time. A new guarantee period will be established, like the first one, for any repaired or replaced component, as well as for all remaining material that have been affected.

The contractor shall upon completion of the installation provide complete training with documentations on the configuration, operation and maintenance of the systems to the required operators assigned by the owner. At least two (2) training sessions per subsystem covering system operations shall be planned and provided to operators and engineers and two (2) sessions covering system administration and management for system administrators. The contractor shall supply all training materials, operational manuals, as-built drawings, diagram, negatives, printed materials, magnetic and optical storage disk as specific in the contract document.

After installation and configuration of each and every subsystem, integrating various systems and providing various services, tests shall be conducted for each subsystem performance as well as the complete system performance as a whole.

Commissioning shall mean end-to-end commissioning of the complete Network Surveillance, Access control and WAN system with testing of live applications. Test parameters, commitments etc. shall be submitted by the contractor along with implementation plan, which shall be approved by the employer. Upon Testing and Commissioning in the presence of the employer, the system shall be handed over to the employer for inspection.

The contractor shall prepare an inspection schedule with details of each activity which shall be reviewed and approved by the employer before implementation.

8.17 Scope of Supply and Works in Stations Devoid of Network Surveillance Camera System

The contractor shall implement in stations without Network Surveillance cameras, a complete Network Surveillance system complete with local (in station), at gate and remote view and operation facilities. The cameras shall be appropriately placed in the respective stations to ensure full coverage area of all critical equipment in the station i.e. control building, switchyard and driveway as well as general view of the perimeter areas around the station.

Supply per station shall include the following equipment and components including hot dip galvanized outdoor perforated cable trays and outdoor conduits for all systems:

1. Network Surveillance system
   - Network Surveillance video Server/ Controller
   - Remote Operator Station facility
   - Cameras
   - Operator station at the Guard House with a 19" surveillance monitor
   - Client Operator station in the operator room in the station

- Indoor and Outdoor Wiring
- Power wiring from cabinets to outdoor fiber cabinets
- Power wiring from outdoor fiber cabinets to field boxes
- Brackets for cameras
- Software and integration into existing CCTV system
- Testing

2. A UPS/Inverter Unit system
3. 26U UPS-Depth Wall-Mount Rack Enclosure Cabinet, Hinged Back with at least 3 Nos of 16" Deep Vented Cantilever Universal Tray for 19" Equipment Rack and Cabinet of Heavy Duty Cold Rolled Steel
4. WAN-ready Network requirements as well as firewall.
5. Tools and accessories for assembly and maintenance.

Scope of works and services shall include:

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1. Engineer and design the Network Surveillance system for each station Engineering and design of the Network Surveillance system for each station. Define the WAN requirements as per the system design.
2. Integration of the Network Surveillance surveillance system with the Access control system in a single security system.
3. Develop a station-wise extensive commissioning and testing schedule to be provided to the employer for approval.
4. Implement the Network Surveillance surveillance system according to the approved designs of the systems.
5. Provide the technical support for the supplier of the surveillance systems.
6. Provide extensive documentation related to the scope of works comprising descriptions, calculations, drawings, lists, manuals (included manual and procedure for field erection and for Operation and Maintenance as described in this specification, Manuals and Documents shall be issued in two soft copies (Flash Drive) and two hard copies formats.
7. Provide the entire configuration of the Network Surveillance system per station including definition of pre-sets and alarms configuration in two Disk Drive formats as well as one flash drive format.
8. Training component of the new system to be provided to the Employers operators and engineers.

8.17.1 Scope of Works in Stations with Network Surveillance Camera System

The contractor shall implement in stations already equipped with Network Surveillance cameras, the complete integration of the Network Surveillance system complete with local (in station), at gate and remote view and operation facilities. The placing of the existing cameras shall be resigned with optimum placement in the respective stations to ensure full coverage area of all critical equipment in the station i.e. control building, switchyard and driveway as well as general view of the perimeter areas around the station.

Supply per station shall include provision of the following equipment and components including hot dip galvanized outdoor perforated cable trays and outdoor conduits for all existing and new systems:

1. Network Surveillance system
   - Revision of Network Surveillance camera layout and positioning
   - Operator station at gate house with a 19" surveillance monitor
   - Redoing of Indoor and Outdoor Wiring
   - Revision of Power wiring from cabinets to outdoor fiber cabinets
   - Revision of Power wiring from outdoor fiber cabinets to field boxes
   - Supply of new Software and integration with existing equipment
   - Testing
2. A UPS/Inverter Unit system
3. 26U UPS-Depth Wall-Mount Rack Enclosure Cabinet, Hinged Back with at least 3 Nos of 16" Deep Vented Cantilever Universal Tray for 19" Equipment Rack and Cabinet of Heavy Duty Cold Rolled Steel
4. Define the WAN Requirements: WAN-ready Network requirements as well as firewall.

5. Tools and accessories for assembly and maintenance.

Scope of works and services shall include:

1. A complete survey of the KETRACO stations already equipped with Network Surveillance facilities for inventory and design purposes. To revise, optimize and redefine the extents of coverage area and enable optimum design of layout and positioning of cameras per station.
2. Design and implementation of solar power supply systems for the facilities without available and expandable powering systems such as repeater stations and warehouses.
3. Define the WAN network requirements per station.
4. Engineer and design the Network Surveillance system for each station
5. Integration of the Network Surveillance surveillance system with the Access control system in a single security system.
6. Develop a station-wise extensive commissioning and testing schedule to be provided to the employer for approval.
7. Implement the Network Surveillance system according to the approved designs of the systems.
8. Provide the technical support for the supplier of the access control and surveillance systems.
9. Provide extensive documentation related to the scope of works comprising descriptions, calculations, drawings, lists, manuals (included manual and procedure for field erection and for Operation and Maintenance as described in this specification, Manuals and Documents shall be issued in two soft copies (Flash Drive) and two hard copies formats.
10. Provide the entire configuration of the Access control and Network Surveillance system per station including definition of pre-sets and alarms configuration in two Disk Drive formats as well as one flash drive format.
11. Training component of the upgraded system to be provided to the Employers operators and engineers.

In the event that there will be need to reinstall some components of the Network Surveillance system in the stations with already existing Network Surveillance facilities – for reasons such as inoperability of the existing systems or inability to integrate existing system with the new software – the contractor shall make use of the spares in the contract for these works.

8.17.2 Scope of Supply for Spare Parts

The contractor shall include supply as spare parts 10% of all equipment and materials installed under this contract, with a minimum of 1 unit, in case the number of items are less than 10. All material left unused at the end of the contract shall be handed over to the Employer. As part of the bid, the contractor shall provide a complete detailed Bills of Quantities, which includes a list of spare items.

8.17.3 Installation

A. The Contractors or subcontractor's main resources within the project shall carry proper professional certification issued by the manufacturer and verified by a third Party organization to confirm sufficient product and technology knowledge.

B. The Contractor shall carefully follow instructions in documentation provided by the manufacturer to ensure all steps have been taken to provide a reliable, easy-to-operate system.

C. All equipment shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.

D. All firmware found in products shall be the latest and most up-to-date provided by the manufacturer, or of a version as specified by the provider of the Video Management Application (VMA) or Network Video Recorder (NVR).

E. All equipment requiring users to log on using a password shall be configured with user/site-specific password/passwords. No system/product default passwords shall be allowed.

8.18 **Quality Assurance**

A. The Contractor or security contractor shall be a licensed security Contractor with a minimum of five (5) years' experience installing and servicing systems of similar scope and complexity and evidence that is completed at least three (3) projects of similar design and is currently engaged in the installation and maintenance of systems herein described.

B. All installation, configuration, setup, program and related work shall be performed by electronic technicians thoroughly trained by the manufacturer in the installation and service of the equipment provided.
C. The contractor or designated contractor shall submit credentials of completed manufacturer certification, verified by a third-Party organization, as proof of the knowledge.
D. The Contractor shall provide three (3) current references from KETRACOs with systems of similar scope and complexity that became operational in the past three (3) years. At least two (2) of the references shall be utilizing the same system components, in a similar configuration as the proposed system.
E. The specified unit shall be manufactured in accordance with ISO9001.

8.19 **Warranty**
All security system components and labour furnished by the contractor including wiring, software, hardware and custom parts shall be fully warranted for parts, materials, labour and travel expenses for a minimum of three (3) years from date of the final acceptance of the Video Surveillance System.
The manufacturer shall provide warranty and optional extended warranty for the camera for a total period of maximum four years. If enacted as part of the contract, the contractor will repair or replace parts and/or labour per the warranty for the length of this warranty at no cost to the KETRACO.

10.6.5 Bay Level Equipment

10.6.5.10 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.

10.6.5.11 Operator Interface

10.6.5.11.1 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
- View and configure power system measurement reports and trends.
- Dynamic colouring capabilities.

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 or NSCC.

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10.6.5.11.2 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/ Network Topology
- Alarm List
- Event List
- Trend displays (real-time and historical)
- Trend and Report Extraction Capability
- Report displays.
- Input Suppression Status
- Protection Relay configuration
- Power disturbance analysis
- Dynamic colouring of bus bars
- 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.

10.6.5.11.3 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.
- Earth Switches
- Lockout Reset Buttons
- 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.

10.6.5.11.4 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
  - Amps
  - Volts
  - Active and Reactive Power, including direction of flow
  - Frequency

10.6.5.11.5 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 (11kV Feeders)
- Plant Measurements
  - Amps
  - Volts
  - Active and Reactive Power, including direction of flow
  - Frequency
- Transformer Measurements
  - Actual Voltage
  - 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.

10.6.5.11.6 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.

10.6.5.11.7 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.

10.6.5.11.8 Common Facilities

The Common Facilities screen shall provide substation control of all common site systems such as local/remote control, alarm klaxon and floodlights.

10.6.5.11.9 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)
- 11kV 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.

10.6.5.11.10 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.

10.6.5.11.11 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

10.6.5.11.12 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

10.6.5.11.13 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.

10.6.5.11.14 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.

10.6.5.11.15 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
- SACS system shall return a feedback message for successful/unsuccessful operation. Unsuccessful operation feedback messages shall be clear on the cause(s).
- 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.
- The control authority selector (HMI/NCC/NSCC) shall have a default state of NCC. The operator shall select HMI when performing an operation and the system shall automatically restore to NCC/NSCC(default) after 15 minutes of operation inactivity on the HMI.

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10.7 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.

10.8 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.

10.9 Performance Requirements

10.9.4 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

10.9.5 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%

10.9.6 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

10.10 Inspection and Testing

10.10.4 General

10.10.4.10 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.

10.10.4.11 Responsibilities

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.

10.10.4.12 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.

10.10.4.13 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	To prove the design of a Subsystem prior to the Subsystem being used in the System FAT. 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.	Subsystem tests shall be completed to the satisfaction of KETRACO before the System FAT can commence. Subsystem tests shall be completed to the satisfaction of KETRACO before despatch to site.
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.

10.10.4.14 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 10.10.4.13 (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.

10.10.4.15 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.

10.10.4.16 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.

10.10.4.17 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.

10.10.4.18 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.

10.10.4.19 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**.

10.10.4.20 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.

10.10.4.21 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.

10.10.4.22 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.

10.10.4.23 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.

10.10.4.24 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.).

10.10.4.25 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.

10.10.4.26 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.

10.10.4.27 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.

10.11 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.

10.12 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.

11 LV Service Equipment

11.6 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.

11.7 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 each Bay 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 each Bay 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.

11.8 Equipment Requirements

11.8.4 LVAC Service Equipment

11.8.4.10 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.

11.8.4.11 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.

11.8.4.12 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.

11.8.4.13 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.

11.8.5 110V DC Service Equipment

11.8.5.10 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 1000% rated duty Nickel-Cadmium (Ni-Cd) type battery units and 2 x 100% rated duty float/boost charger units. 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.

11.8.5.11 110 V Battery Units

The battery units shall be Nickel-Cadmium (Ni-Cd) type. 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 0^0C. 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.

11.8.5.12 Battery Charging Equipment

The battery chargers shall be thyristor controlled devices and shall operate fully automatically.

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.

11.8.5.13 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.

11.8.5.14 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.

11.8.6 415 V AC Uninterruptible Power Supply

11.8.6.10 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 ±10% of nominal and frequency of ±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.

11.8.6.11 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 ±10%
Inverter voltage output	415V, 50 Hz, 4 wire (solidly earthed at the neutral end)
Voltage adjustment	±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.

11.8.6.12 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.

11.8.6.13 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.

11.8.6.14 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).

11.8.6.15 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.

11.9 Diesel Generator

11.9.4 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.

11.9.5 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.

11.9.6 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 to 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.

11.9.7 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 provide 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.

11.9.8 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

11.9.9 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 louvre which shall be supplied and fixed to the wall of the building. The Contractor shall provide anti draught flap louvres at each discharge connection to prevent the ingress of wind. The diesel generator room air intake louvre 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.

11.9.10 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.

11.9.11 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.

11.9.12 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.

11.9.13 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.

11.9.14 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.

11.9.15 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.

11.9.16 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 Clash 155(F) levels respectively. A solid coupling shall connect the generator rotor to the flywheel.

11.9.17 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.

11.9.18 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.

11.10 Inspection and Tests

11.10.4 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.

11.10.5 Workshop Test

11.10.5.10 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.

11.10.5.11 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.

11.10.6 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:

11.10.6.10 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.

11.10.6.11 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.

11.10.6.12 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.

11.11 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.

12 Tariff Metering

12.6 Substation Works

The following specification applies to all new substations.

12.7 General 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.

12.8 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.

12.9 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.

12.10 Marshalling and Cabling

12.10.4 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.

12.10.5 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 2.5mm^2 and 4mm^2 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.

12.10.6 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.

12.11 Metering cubicle

12.11.4 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 belonging Bay 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.

12.11.5 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.

12.11.6 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.

12.11.7 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 hydroscopic 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.

12.12 Energy Meter

12.12.4 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 $6mm^2$.

The meter shall have self-monitoring capability and raise a remote alarm via the substation control system (SCS) when faulty.

12.12.5 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/√3) and nominal measuring current of 1A at a frequency of 50Hz. Maximum current shall be ≥ 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.

12.12.6 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.

12.12.7 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.

12.12.8 Security

For purposes of security the meter shall have multi-level password protection for reading and programming.

12.12.9 Markings

Each meter shall be provided with a nameplate conforming to IEC 62052-11.

12.13 Software

The proprietary metering software shall be supplied in order to locally and remotely configure and retrieve data from the metering system.

12.14 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.

12.15 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.

12.16 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.

13 Fault Monitoring System and Alarm System

13.6 General

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 Bay Control Room belonging to the diameters. The connection between acquisition units and the central system shall be done by fibre optic cables.

13.7 Network Integration

Where compatible systems are provided at NCC/RCC fault record data shall be automatically transferred to the evaluation station for analysis.

13.8 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.

13.9 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.

13.10 Hardware Requirements

13.10.4 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.

13.10.5 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.

13.10.6 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.

13.10.7 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.

13.10.8 Event Channels

External binary triggering facilities shall be provided to enable FMS to capture the system fault information.

13.10.9 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.

13.10.10 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.

13.10.11 Printer

Colour print facilities shall be provided. Printing either locally at the FMS and/or via the LAN connected SCS printers.

13.10.12 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.

13.10.13 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.

13.10.14 Communication with NCC

The communication between the substation and the NCC Evaluation Station (where available) shall be provided via KETRACOs telecommunication networks. Standard communication protocol shall be used. The Contractor shall state in their offer which protocol is to be used.

13.10.15 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.

13.11 Evaluation Facilities

13.11.4 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.

13.11.5 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.

13.11.6 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.

13.11.7 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.

13.12 Fault Evaluation Package

13.12.4 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.

13.12.5 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.

13.12.6 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.

13.12.7 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.

14 Power Transformers

14.6 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 + stabilising tertiary). In the case of the 400/220 kV interbus transformers it may be more economical to provide an autotransformer (YNa0(d)) rather than a 2-winding type (YNyn0(d)). Consequently, bidders are invited to offer either option. Where an OLTC is specified, the autotransformer option shall locate the tap-changer at the LV line-end neutral point, unless this conflicts with other transformers nearby.

Note 2: In certain locations it may be necessary to specify single-phase units, especially with large 400kV units (e.g. 400/220kV Autotransformers). When this is specified in the Technical Schedules the rating per single-phase unit shall be 1/3 of the overall MVA rating. The Contractor shall make the necessary provisions for the tertiary winding output to achieve the required vector group.

14.7 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]

14.8 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 14.8.14, '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.

14.8.4 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 with 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 mm^2. Connections inserted between laminations shall have a cross sectional area of not less than 20 mm^2.

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.

14.8.5 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.

14.8.6 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.

14.8.7 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 14.8.16, 'Neutral and Tertiary Connections' part of this specification.

14.8.8 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.

14.8.9 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.

14.8.10 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 15ºC, 35ºC and 90ºC shall be marked on the gauge.

The front cover of all gauges shall be made of glass.

14.8.11 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.

14.8.12 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.

14.8.13 Cooler 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 of 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.

14.8.14 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.

14.8.15 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

14.8.16 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.

14.8.17 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 0ºC) 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 0ºC) 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 font 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.

14.8.18 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.

14.8.19 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.

14.8.20 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.

14.9 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.

14.9.4 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)

14.9.5 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)

14.9.6 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.

14.10 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.

14.11 Online 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.

14.12 Transformer Inspection and Testing

14.12.4 General

All tests shall be performed in accordance with IEC 60076, IEC 60060, IEC 60270 and other relevant IEC Standards.

14.12.5 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.

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.

14.12.6 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.

14.12.7 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 ($U_m \leq 72.5$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 $U_m \geq 245$kV. There is currently no requirement to apply this test as a Type Test at U_m < 245 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.

14.12.8 Special Tests

The following 'special' category tests shall be performed as specified by the Client during Design Stage.

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 Um.)

b. U_m =145 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. Um =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. Um > 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.

14.12.9 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.

14.12.10 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.

14.12.11 Transformer Tanks

14.12.11.10 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/m^2. 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/m^2 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/m^2.

The operating pressure shall be recorded on the test certificate.

14.12.11.11 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 150ºC and subjected to a pressure equal to the normal pressure plus 35 kN/m^2. 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.

14.12.12 Fans, Motors, Pipework, Oil Sampling Devices and Valves

14.12.12.10 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.

14.12.12.11 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/m^2 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.

14.12.13 Oil

14.12.13.10 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.

14.12.14 Gas and Oil Actuated Relays

14.12.14.10 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^{o}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 150ºC, 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.

14.12.14.11 Sample Test

At the discretion of KETRACO, the following tests shall be made:

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.

14.12.15 Voltage Control Equipment

Type and routine tests shall be carried out in accordance with IEC 60214.

14.12.15.10 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

14.12.15.11 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.

14.12.15.12 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.

14.12.16 Handling Devices and Lifting Tackle

14.12.16.10 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.

14.12.17 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.

14.13 Installation/Dismantling Requirements

The transformer shall be designed for outdoor installation;

Arrangements are to be provided for the hauling of transformers.

14.14 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 advice 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.

14.15 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.

15 Earthing / Auxiliary Transformers

15.6 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.

15.7 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 ±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.

15.8 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.

15.8.4 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

15.8.5 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 250ºC.

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.

15.8.6 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).

15.9 Documentation

15.9.4 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.

15.9.5 Documentation after Award of Contract

All documents required for KETRACO's approval shall be submitted by the Contractor.

16 Optical Fibre Cable for Pilot

14.1 Scope

This specification details the requirements for the design, manufacture and testing of optical fibre cable (OPGW and ADSS for pilot and data applications) and accessories for application as Pilot & Telephone/data cable with EHV power cable circuits.

The OPGW shall have the following design standard:

i. The cross section shall be comprised of:
   a. External aluminium alloy armour layer
   b. Alluminium-clad steel armour layer
   c. Extruded Alluminium Core tube
   d. Heat barrier tape
   e. Gel-Filled Buffer Tube covered
   f. 48 optical fibers separated in groups of 12 with colour coded Group/Binder/Buffer separator following the TIA-598-C colour coding standard

ii. The optical fibers shall be made of high pure silica and germanium doped silica. UV curable acrylate material is applied over fiber cladding as optical fiber primary protective coating.

iii. Fibers shall be contained in one or more loose buffer tubes allowing the fibers to be free from strain even at high operating loads.

iv. Specific colour code shall be as described below in the fiber colour code section.

The ADSS (All Dielectric Self Supporting) Fiber optic cable shall have the following design standard:

i. The cable shall be designed to provide self-support performance of up to 800meters and shall be designed to operate under full weather load, ensuring safe and reliable lifetime performance

ii. For installation in and for high-voltage lines up to 275 kV, an optional track-resistant jacket prevents dry-band arcing damage

iii. The optical fibers shall be made of high pure silica and germanium doped silica. UV curable acrylate material is applied over fiber cladding as optical fiber primary protective coating.

iv. The cable shall be an all-dielectric, single and dual jacket and track resistant construction

v. The cross section shall be comprised of:
   a. HDPE (High-Density Polyethylene) outer jacket
   b. Aramid strength yarns between the outer and inner jackets with rip cord

c. Inner Polyethylene Jacket
d. Water blocking tube
e. 4*Gell-filled buffer tube material containing 12 fibers each in a tube/buffer which shall follow the TIA-598-C colour coding standard
f. Central strength member

vi. Specific colour code shall be as described below in the fiber colour code section.

14.1.1 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.

14.1.2 Fibre Optic 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 the details of the colour coding scheme described below.

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.

14.1.3 Fiber Colour Coding

The colour code for the fiber optic strands shall follow the TIA-598-C standard for the 12 fiber cores. For the 48 fibers (or more) the colour coding scheme shall be as described below:

TUBE/ GROUP	FIBER COLOURS											BINDER COLOUR
1	1	2	3	4	5	6	7	8	9	10	11	12	BLUE
	Blue	Orange	Green	Brown	Slate	White	Red	Black	Yellow	Violet	Rose	Aqua	
2	13	14	15	16	17	18	19	20	21	22	23	24	ORANGE
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
3	25	26	27	28	29	30	31	32	33	34	35	36	GREEN
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
4	37	38	39	40	41	42	43	44	45	46	47	48	BROWN
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	

For 96 core cables, the colour coding scheme shall follow the colour coding scheme as described below for the cores from 49-96:

TUBE/ GROUP	FIBER COLOURS	BINDER COLOUR

5	49	50	51	52	53	54	55	56	57	58	59	60	SLATE
	Blue	Orange	Green	Brown	Slate	White	Red	Black	Yellow	Violet	Rose	Aqua	
6	61	62	63	63	65	66	67	68	69	70	71	72	WHITE
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
7	73	74	75	76	77	78	79	80	81	82	83	84	RED
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
8	85	86	87	88	89	90	91	92	93	94	95	96	BLACK
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	

14.1.4 Fiber Optic Cable Fittings

The fibre optic OPGW and ADSS shall be with approved conductor fittings. The application of these fittings shall not damage the cable or fibres, either mechanically or optically. At each support, a bypass device shall be provided to guide the cable around the cable fittings associated with the support.

14.1.5 Fibre Optic Joint Closures

Optical joint boxes shall be provided to protect the splice joint of optical fibres, either when individual lengths of the fibre optic OPGW and/or ADSS, are jointed or between the fibre optic cables and the underground fibre optic cable. The joint boxes shall consist of external steel or die cast aluminium housing providing protection to water, moisture and insect ingress.

The external housing shall be designed so that the rainwater is directed away from the door and there shall be no water ingress when the door is opened. The joint boxes shall be supplied complete with all fittings to secure and seal the cable in the gland plates or blank the unused spigots. The cable cleats to secure the fibre optic OPGW or underground cable shall be fitted inside the box. The cleats shall not have a detrimental effect on the performance of the optical fibres when tightened to the recommended torque.

The top and bottom of the joint box shall be vented and the vents provided with the vermin shields. The box shall be supplied complete with internal splice cassettes to accommodate the required number of splices. The glands shall be fitted to accommodate either the fibre optic OPGW or underground fibre optic cable.

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 (and 96 fibers for a 96 fiber OPGW) as per Employers Requirements**
Installation alternatives	**direct buried, in manholes, on portal supports**
Attenuation	**max 0.03 dB/splice**

14.1.6 Optical Distribution Frames

Optical distribution frames for fibre communication and approach cables shall be 42U free standing fiber cabinets designed for termination of single mode optical fiber's with FC connectors inside equipment enclosure racks located within the Telecom Room. The patch panels shall include the following specifications and accessories for fiber optic cables:

- Minimum 19" width:800mm by depth:800mm cabine
- Glass door
- IP55
- 600kg minimum carrying capacity
- Light grey in colour
- Mounting bolts
- FC Type receptacle,
- Interconnect sleeve or bulkhead adapter
- Jumper cables
- 48 core fiber drawers
- Storage for fiber
- Cable clamps with strain relief
- Flipcard for easier record keeping

Bottom case integrated with wide cable entry point provides maximum versality. The rubber edged slid ing mechanism on the cable entry point at bottom with w=350mmxd=250mm allows large cabling infr astructure applications. On rubber edged sliding mechanism max cable entry opening is w=350xd= 150mm. After inserting the cables, the rubber edged mechanism holds and fixes the cables in parallel preventing the cabinet from dust entry.
Front door is integrated with decorative 2,5mm thickness aluminium extruded frames, full length s moked , shatterproof, antistatic, 4,0mm thickness glass with single point locking handled lock.
Front door Aluminium extruded frame allows , decorative PVC Stripes charming the attraction, Anthrac ite Grey for Light Grey Cabinets. Front door opening direction is set right to left, but reversible to left to right at site with removing the hinge system. Hinge System shall
be spring loaded easy operating version, which allows you to remove the whole front door from cabinet.
Side Panels shall be lockable and removable with barrel style lock, multifolded bending technology with 8 fold bending to provide rigidity. Additional Vertical Cable Tray w:100mm can be housed at back side where the main cable bundless run through. Extensibility feature of
cable trays by using 2 pcs for 200mm wide, 3 pcs for 300mm wide cable tray system could be managed.
The panel shall contain railed shelves where the 48Core fiber drawers can be drawn for easy splicing and maintenance works. The shelves shall also be well spaced to avail comfortable fiber working environment.

Capacity	min. 4 shelves for fibre optic cables, each with 48 fibres
Installations	–Free standing Cabinet mounted type
Attenuation	0.5 – 1 dB/per connector 0.03 dB/per splice
Optical connectors	F.C. - P.C. type

14.1.7 **Installation**

14.1.7.1 **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 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.

14.1.7.2 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 not more than 0.03 dB. Optical fibre splices shall be of the fusion type and the optical attenuation of each splice shall be not more than 0.03 dB. The jointing shall be performed carefully to ensure similar cores are joined together throughout the line and to ensure 1:1 fiber continuity and core matching. Proper coordination between the fiber jointing teams shall be emphasized to ensure 1:1 fiber core matching and continuity.

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.

14.1.7.3 Terminations

The interface between the fibre optical transmission system and the fibres of the optical cable shall be at the optical distribution frames 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.

14.1.7.4 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.

14.1.7.5 Optical Distribution Frames

Optical Distribution Frames (ODFs) shall be provided by the Contractor to facilitate the termination of incoming fibres into the substation.

The ODFs shall be panel mounted in the substation telecommunication room. Optical fibres shall be terminated by detachable connectors, complying with the requirements of IEC 60874, at the optical distribution frame and shall be properly labelled with fibre identity, destination or source, go or return.

All fibre terminal panels 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 Contractor's scope of works.

14.1.8 Testing

14.1.8.1 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 Employer’s representative for consideration after conclusion of tests.
The following type tests shall be performed:

For the Optical Fibre Pilot Cable (before assembly)

- Mode Field Diameter Test (variable aperture ITU-T G655)
- Cladding Diameter and Non-circularity Test (near field ITU-T G655)
- Mode Field Concentricity Error Test (near field ITU-T G655)
- Tensile Strength Test (Weibull IEC 60793-1 UTS measurement)
- Microbending Sensitivity Test
- Torsion Test
- Flexing Test
- Abrasion Test
- Spectral - Attenuation Cutback test (cutback ITU - T G 655)
- Chromatic Dispersion Test (phase shift variation ITU-T G655)
- Cut-off Wave-length Test (multi-mode reference ITU-T G655)
- Point Defects Test (backscattering ITU-T G655)
- Temperature Cycling Test (transmitted power IEC 60793-1)
- Min. /Max. Temperature Test (to be done under the temperature cycling test)
- Temperature - Shock Test (to be done under the temperature cycling test)
- Temperature dependence of attenuation test (to be done under the temperature cycling test)
- Accelerated Oxygen Ageing Test

For the completed Fibre Optic Pilot Cable:

- Overall Diameter measurement
- Optical Cable Length measurement
- Bend, low and high temperature test (IEC 60794 1 E11)
- Cyclic Flexing test (IEC 60794 1 E6)
- Impact Test (IEC 60794 1 E4)
- Compressive Loading and bending Test
- Tensile, loading and bending test (IEC 60794 1 E1)
- Spectral-Attenuation Cutback Test and Backscatter Light Test (IEC 60793 - 4)
- Temperature Humidity Cycling Test (IEC 60794 1 F1)
- Cut-off Wavelength Test (ITU - T G650)
- Accelerated Oxygen Ageing Test

Type test for:

- Optical Joint Box, and
- Optical Distribution Frame

shall be carried according to IEC Publications, where applicable.

14.1.8.2 **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:

- Overall Diameter Measurement
- Length of Fibre Measurement
- Cable Length Measurement
- Fibre Point Defects Test
- Fibre Attenuation Test

Routine test for:

- Optical Joint Box, and
- Optical Distribution Frame

shall be carried out according to IEC Publications, where applicable.

14.1.8.3 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 Employer's representative.

14.1.9 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:

- Fibre Optic Pilot Cable Length Measurement,
- Verification of Fibre Optic Pilot Cable Continuity, and
- Optical Attenuation Measurement.
- Fiber Continuity and 1:1 Core Matching

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 and a report provided to the Employer proving the completeness of the works and the conformity to the specifications herein:

- Optical Attenuation Test
- Fiber Continuity and 1:1 Core Matching

General list of tests:

Description	**Routine**	**FAT**	**Type Test**	**Test Procedure**
Test on Fibers				
Mode Field Diameter		●		IEC 60793-1-45
Geometric Parameter		●		IEC 60793-1-20
Attenuation (OTDR)	●	●		IEC 60793-1-40
Chromatic Dispersion		●		IEC 60793-1-42
Cut-off wavelength		●		IEC 60793-1-44
Test on wires before stranding				
Diameter	●	●		IEC 61232/IEC 60104
Tensile strength	●	●		IEC 61232/IEC 60104
Stress at % extension (Only ACS wire)	●	●		IEC 60104
Elongation at break	●	●		IEC 61232/IEC 60104
Wrapping test (only AA wire)	●	●		IEC 60104
Conductivity	●	●		IEC 61232/
Thickness of Al-cladding (Only ACS wire)	●	●		IEC 61232/IEC 60104
Torsion test (Only ACS wire)	●	●		IEC 61232
Test on OPGW				
Quality of surface	●	●		IEC 60794-4-10
Direction of lay outer	●	●		IEC 60794-4-10
Lay length	●	●		IEC 60794-4-10
Diameter of cable	●	●		IEC 60794-4-10

Weight of cable	●	●		IEC 60794-4-10
DC-resistance		●		IEC 60794-4-10
Stress strain test		●	●	IEC 60794-4-10
Tensile performance test		●	●	IEC 60794-4-10
Sheave test			●	IEC 60794-4-10
Aeolian vibration simulation			●	IEC 60794-4-10
Galloping test			●	IEC 60794-4-10
Creep test			●	IEC 60794-4-10
Temperature cycle test			●	IEC 60794-4-10
Water penetration			●	IEC 60794-4-10
Short Circuit current test			●	IEC 60794-4-10
Lightning test			●	IEC 60794-4-10

15 Civil Works

15.1 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.

15.2 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
- Complete water supply system shall be provided. The contractor shall be required to connect to the existing water distribution system around the substation area. Incase 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 5000 liters (as minimum) capacity, adequate to serve requirements of control building and guard house . with automatic level controls shall be provided. Also 1500 liters elevated water tanks shall be considered near the control building, guard house and staff housings with required pumps to be fed from the main water reservoir.
- 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.

15.3 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 rom, 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 dowser.

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 rom, main equipment room, battery room, office and toilets according to bid drawings.

15.4Bay Control Rooms (BCRs)

For the housing of the diameter’s protection, control, metering and fault recorder cubicles, Bay Control Rooms shall be foreseen in-between the diameters. Each house shall accommodate the cubicles for each diameter.

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.

15.4.1 Other Requirements

The Bay Control Rooms shall be equipped with raised floor to house the power, control and signal cabling.

The Bay 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

Preferably the Bay Control Rooms shall be constructed as pre-fabricated container solution, providing that there are no manufacturing or transport limitations preventing such solution. The contractor shall check for any limitations before the design is finally decided. In case the container solution is not feasible, the Bay Control Rooms shall be an on-site construction by concrete/brickwall.

The container shall be designed as complete modules to accommodate the electrical equipment and accessories equipment. The specification for the container is as below:

Structural Components

- Support seating underside points at the four corners of concrete or steel piers installations.
- Double acoustic door sets for equipment access ~1800/2400mm (width/height) with inside panic bolts.
- Access stairways 1m above ground level
- Steel structures of stainless Steel
- Roofs consisting of two weather roofs, to reduce heat loading and door roofings against rainfall
- Walls shall be made of aluminium featuring as double wall (clearance between wall ~60mm, filled with insulations material and min. thickness 1mm/3mm inner/outer).

- Floors steel construction shall be designed to withstand all anticipated loads on the structure including that of transportation of completed already installed equipment.
- Fixed points for panels/boards/etc. on walls/floors.
- Cable double floor by means of individual double floor plates and water proof cable entries
- Earthing connection points (Container- S/S earthing min. two)

The complete container with all inside installed equipment shall be factory tested before shipped to side. The factors of safety used in the design of the container must at least take the lifting (lifting lungs), permanent position operation requirements transport to side and permanent position operation requirements for a long-term operation (>25 years) aspects into account.

The following fire ratings shall be applicable for the outdoor containers (not cubicles):

- External walls 120 minutes
- Fire rated steel doors 90 minutes.

Should the design of the Bay Control Rooms be an on-site construction by concrete/brickwall, the specification is as below:

Structural Components:

- Concrete foundations as required according to the soil investigation. The foundations to be protected by a bituminous coating.
- Walls and roof of concrete/brickwall construction or steel structure with insulated cladding and adequate corrosion protection.
- Double acoustic door sets for equipment access ~2000/2400 mm (width/height) with panic bolts inside.
- Access stairways ca. 1 m above ground level.
- Raised floor steel construction to be designed to withstand all anticipated loads on the structure including that of transportation of completed already installed equipment.

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.

15.5 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
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

Number	Title
	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.
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

Number	Title
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

15.6 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.

15.7 Site Surveys

15.7.1 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.

15.7.2 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.

15.7.3 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.

15.7.4 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)

15.8 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.

15.9 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.

15.10 Dimensions and Levels

All dimensions and levels shown on the drawings shall be verified on site by the Contractor.

15.11 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.

15.12 Inclement Weather

No payment will be made to the Contractor in respect of loss of output of plant or labour due to inclement weather.

15.13 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.

15.14 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.

15.15 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.

15.16 Design Process

15.16.1Management 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.

15.16.2Detailed 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.

15.16.3Loading

15.16.3.1 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.

15.16.3.2 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.

15.16.3.3 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.

15.16.3.4 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.

15.17 Materials and Workmanship

15.17.1 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.

15.17.2 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.

15.17.3 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.

15.17.4 Names of Suppliers and Copies of Orders

15.17.4.1 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.

15.17.4.2 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.

15.17.5 Site Clearance and Demolition

15.17.5.1 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.

15.17.5.2 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.

15.17.5.3 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.

15.17.5.4 Explosives

Explosives shall not be used in the Works.

15.17.6 Earthworks and Excavation

15.17.6.1 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.

15.17.6.2 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.

15.17.6.3 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.

15.17.6.4 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.

15.17.6.5 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.

15.17.6.6 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.

15.17.6.7 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.

15.17.6.8 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.

15.17.6.9 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.

15.17.6.10 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.

15.17.6.11 Weed-killer

Weed killer shall be spread over areas to be covered with site surfacing before such surfacing is laid. The weedkiller shall be of approved make which does not cause corrosion of metals and should be environmentally friendly. It shall be used strictly in accordance with the manufacturer's instructions.

15.17.6.12 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 at least 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.

15.17.7 Concrete, Reinforced Concrete and Mortar

15.17.7.1 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/mm^2 at 28 days.

Blinding concrete shall have a minimum 28 day cube strength of 15.0N/mm^2.

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. cementitous, 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.

15.17.7.2 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.

15.17.7.3 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.

15.17.7.4 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.

15.17.7.5 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.

15.17.7.6 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.

15.17.7.7 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.

15.17.7.8 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.

15.17.7.9 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.

15.17.7.10 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.

15.17.7.11 Tying Wire

The tying wire for reinforcement shall be one and one half (1.5) millimetres in diameter annealed soft iron tying wire.

15.17.7.12 Threaded Inserts

The threaded inserts for casting into concrete shall be electro-galvanized and of malleable iron or mild steel.

15.17.7.13 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.

15.17.7.14 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.

15.17.7.15 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.

15.17.7.16 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.

15.17.7.17 Testing on Site

Samples of concrete shall be taken from the works at a rate of one sample per 20m^3 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.

15.17.7.18 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.

15.17.7.19 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.

15.17.7.20 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.

15.17.7.21 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.

15.17.7.22 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 competed. 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.

15.17.7.23 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.

15.17.7.24 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.

15.17.7.25 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.

15.17.7.26 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.

15.17.7.27 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.

15.17.7.28 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.

15.17.7.29 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.

15.17.7.30 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.

15.17.7.31 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.

15.17.7.32 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.

15.17.7.33 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.

15.17.7.34 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.

15.17.7.35 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

15.17.7.36 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.

15.17.7.37 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.

15.17.7.38 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.

15.17.7.39 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.

15.17.7.40 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.

15.17.7.41 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.

15.17.7.42 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.

15.17.7.43 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/cm^2 after 7 days and not less than 600 kg/cm^2 after 28 days.

15.17.8Concrete Blockwork

15.17.8.1 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.

15.17.8.2 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.

15.17.8.3 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.

15.17.8.4 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.

15.17.8.5 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.

15.17.8.6 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.

15.17.8.7 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.

15.17.8.8 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.

15.17.8.9 Completion

Upon completion of blockwork, it shall be thoroughly washed down and left clean.

15.17.8.10 Protection of work

Partially completed work shall be adequately protected from damage by rain, heat or any other cause.

15.17.9Drainage

15.17.9.1 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 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

15.17.9.2 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.

15.17.9.3 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.

15.17.9.4 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 put 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.

15.17.9.5 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.

15.17.9.6 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.

15.17.9.7 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.

15.17.9.8 Catchpit Covers

Where concrete slabs covers are required they shall be pre-cast and have a strength of 35N/mm^3 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.

15.17.9.9 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.

15.17.9.10 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.

15.17.9.11 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.

15.17.9.12 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.

15.17.9.13 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.

15.17.9.14 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.

15.17.9.15 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^{o} bevel. Joints shall be undisturbed and kept covered with wet sacking for 7 days.

15.17.9.16 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.

15.17.9.17 Concrete Surroundings

Where required the pipes shall be bedded on or surrounded by Grade 12/15 concrete with an aggregate size of 20mm.

15.17.9.18 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 that (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.

15.17.9.19 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.

15.17.9.20 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.

15.17.10 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.

15.17.11 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/ m^2. The fire barrier wall height shall be a minimum of 500mm above the highest part of the transformers.

15.17.12 Permanent Access Roads

15.17.12.1 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.

15.17.12.2 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

15.17.12.3 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.

15.17.12.4 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.

15.17.12.5 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.

15.17.13 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.

15.17.13.1 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.

15.17.13.2 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.

15.17.13.3 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.

15.17.13.4 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.

15.17.13.5 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.

15.17.13.6 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/m^2 of surface area on 2.5mm dia (12 gauge) wire and 0.198kg/m^2 of surface area on 2.0mm dia (14 gauge) wire.

Barbed wire shall conform to BS EN 10223-1.

15.17.13.7 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.

15.17.13.8 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.

15.17.13.9 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.

15.17.14 Miscellaneous

15.17.14.1 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.

15.17.14.2 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.

15.17.14.3 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 which-ever 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.

15.17.14.4 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.

15.18 Building Services

15.18.1Electrical Building Services

15.18.1.1 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.

15.18.1.2 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	Control areas/room	250-500
Emergency Diesel generator building	Data printers	300
Control and administration building	Project Managers/offices	300
Workshop and stores	Monitoring room	300
Firefighting pump house	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 valves.

- 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.

15.18.1.3 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.

15.18.1.4 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.

15.18.1.5 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.

15.18.2 Mechanical Building Services

15.18.2.1 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.

15.18.2.2 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.

15.18.2.3 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.

15.18.2.4 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.

15.18.2.5 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: 25ºC db ± 1.5ºC 50% r.h ± 5% Winter: 22ºC db ± 1.5ºC 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:- 25ºC db ± 1.5ºC 50% r.h ± 5% Winter: 22ºC db ± 1.5ºC No humidity control.	Central air conditioning systems 2 x 50% air handling units. No standby mechanical cooling.
Corridors. Stairs.	28ºC db max. 20ºC db min.	Pressurization systems for smoke control may be required in these areas.

Area (s)	**Internal Condition**	**Comment**
Toilets	28ºC db max. 18ºC db min.	Extract ventilation (10 AC/h min.) Rooms under negative pressure.
Mess rooms.	25ºC db max. 18ºC db min.	Extract ventilation (6 AC/h min.) Rooms under negative pressure.
Excitation Switchgear Rectifier/inverter	42ºC db max. 25ºC db min 40ºC 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	27ºC db max. 22ºC 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	5ºC 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

15.18.2.6 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.

15.18.2.7 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.

15.18.2.8 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.

15.18.2.9 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.

15.18.2.9.1 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 completed 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 impellors shall be galvanized, and fixed to the extended shaft of the drive motor.

15.18.2.9.2 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.

15.18.2.9.3 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.

15.18.2.9.4 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.

15.18.2.10 Solar Water Heating System

15.18.2.10.1 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.

15.18.2.10.2 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

15.18.2.10.3 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%

15.18.2.10.4 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.

15.18.2.10.5 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 ºC

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.

15.18.2.10.6 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.

15.18.2.10.7 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.

15.18.2.10.8 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.

15.18.2.10.9 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.

15.18.2.10.10 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 sir 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.

15.18.2.10.11 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.

15.18.2.10.12 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.

15.18.2.10.13 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.

15.18.2.10.14 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 monitoringthis 30 day period is considered acceptable, and approved by the client.

15.18.2.10.15 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.

15.18.2.11 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.

15.18.2.12 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.

15.19 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 ¾ 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.

15.19.1Fire 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
Service shafts for HVAC ducts etc.	Fire barriers at each floor level	Smoke detectors at each floor level

Fire Zones	Protection system	Detection system
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.

15.19.2 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.

15.19.3 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)

15.19.4 Portable and Trolley-Mounted Fire Extinguishers

15.19.4.1 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.

15.19.4.2 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.

15.19.5 Fire Alarm

- Automatic fire detectors shall be designed, installed, testes & 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.

15.19.6 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.

15.19.6.1 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

15.19.6.2 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.

15.20 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.

15.20.1 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.

15.21 Steel work detailing and manufacture

15.21.1Detailing 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.

15.21.2 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.

15.21.3 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.

15.21.4 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.

15.21.5 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.

15.22 Galvanizing

15.22.1General

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.

15.23 Error! Reference source not found.**Low Voltage Power and Control Cables (LV Cables)**

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.

15.22.2 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.

15.23 Technical Description

15.23.1 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 %.

15.23.2 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.

15.23.3 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 ≥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.

15.23.4 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.

15.23.5 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.

15.23.6 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.

15.23.7 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.

15.23.8 Cable Installation

15.23.8.1 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.

15.23.8.2 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.

15.23.9 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.

15.24 Documentation

As a minimum requirement the following documentation shall be handed over with the Bid.

- Brochures and data sheets of the typical cables Bidder intents to use.
- Brochures and data sheets of the typical cable supporting systems Bidder intents 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

15.25 Tests

15.25.1 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.

15.25.2 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

15.25.3 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.

16 Earthing And Lightning Protection

16.1 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 earhting 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.

16.2 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.

16.3 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.

16.4 Main Technical Data

The 400, 220, 132, 66 and 33 kV Systems' Neutrals are solidly earthed.

16.5 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.

16.6 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.

16.6.1 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.

16.6.2 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.

16.6.3 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.

16.6.4 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.

16.6.5 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 han 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.

16.7Lightning 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.

16.7.1 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.

16.8 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.

16.9 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.

16.10 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.

B. Drawings

C. Schedules of Technical Information

25. C. Supplementary Information

26. Table of Contents

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 SF6 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
LINE DISCONNECTOR (S)HEATING FAILURE

HV LINE SIGNALS
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 BREAKERF 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
LINE EARTH FAULT TRIP

HV LINE SIGNALS
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
LINE PHASE DISTANCE ZONE 1 TRIP

HV LINE SIGNALS
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 MVAr
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 CIRCUIT BREAKER SF6 OPERATING LOCKOUT

TRANSFORMER HV SIDE
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 WINDING TEMPERATURE HV TRIP

TRANSFORMER HV SIDE
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 TRANSFOMER PERCENTAGE DIFFERENTIAL TRIP
TRANSFORMER HV TRANSFOMER INSTANTANEOUS DIFFERENTIAL TRIP
TRANSFORMER HV LOW IMPEDANCE RESTRICTED EARTH FAULT TRIP
TRANSFORMER HV (MV TRANFORMER) 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 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 MVAr
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
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
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 3 and Figure 4.

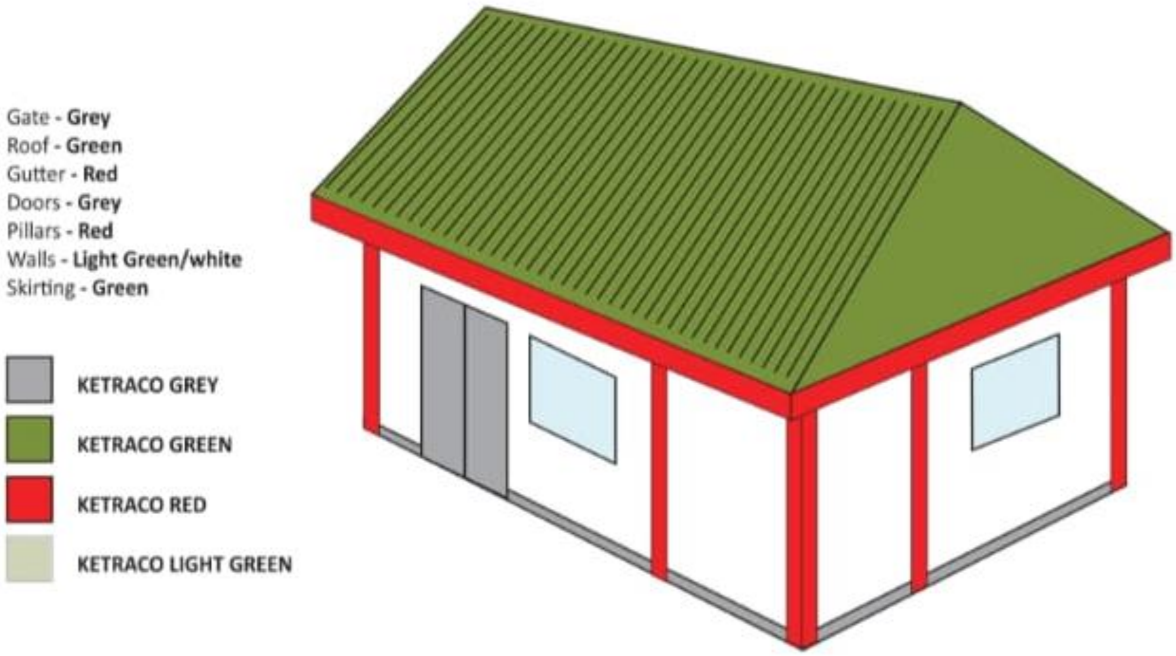

Figure 3: Substation Building Recommended Colors

Figure 4: Substation Main Gate Recommended Colors and Branding.

Substation signs contents and dimensions shall be according to Figure 5 and Figure 6.

Figure 5: Substation Sign Single Sided (20 x 10.6 Ft).

Figure 6: Directional Sign Double Sided (8 x 4).