VOLUME II

SECTION V: WORK REQUIREMENT AND PARTICULAR TECHNICAL SPECIFICATIONS

FOR

PRIMARY DISTRIBUTION SUBSTATIONS AND ASSOCIATED LINES

NCB NO: KP1/6A.1/OT/3/25/C03

LOT 1- ***BONDO 33/11KV SUBSTATION AND LINES***

LOT 2: ***MBITINI 33/11KV SUBSTATION AND LINES***

LOT 3: ***MARABA 33/11KV SUBSTATION AND LINES***

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TABLE OF CONTENT

1 General Specifications 3

1.1 General Requirement 3

1.2 Document Priority 3

1.3 Completeness Of Contract 3

1.4 Space Requirement 4

1.5 Documentation And Drawings 4

1.5.1 General 4

1.5.2 Bid Drawings 5

1.5.3 Progress Plans 5

1.5.4 Exchange of Interface Information 5

1.5.5 Final Documentation 6

1.6 Contractor's Quality Assurance Procedures 6

1.7 Guarantees And Particulars 6

1.8 Manufacturing And Shipment 6

1.8.1 Places of Manufacture and Sub-Contractors 6

1.8.2 Inspection and Testing 7

1.8.3 Packing, Transportation and Storage 8

1.9 erection, Installation and Commissioning 8

1.9.1 Storage at Site 8

1.9.2 Work on Live Substations 9

1.9.3 Erection, Testing at Site, Commissioning 9

1.9.4 Accommodation of Contractor's Personnel 10

1.9.5 Health, environment and safety 10

1.10 Time of delivery and Completion 10

1.11 On the Job Training 10

1.12 Tools 10

1.13 Spare Parts 10

1. GENERAL SPECIFICATIONS

1.1 General

The scope of work, data sheets, special and general specifications constitute the complete technical specifications and must be read as a whole. If more than one contractor contributes to the completion of the plant, each contractor is obliged to cooperate, adapt solutions and exchange information so that the plant forms a functional and optimized entirety.

1.2 Document Priority

If in conflict, the ranking of documents in the technical specifications, in decreasing priority, is as follows:

1. Scope of Works
2. Technical Specifications for materials and equipment
3. Project Specific Design Data
4. General technical specifications
5. General specifications
6. Internationally accepted Standards

In the event of any difference between the Drawings and the Specifications, the latter shall prevail. In the event of any difference between scaled dimensions and figures on the drawings, the figures shall prevail.

If the Bidder is of the opinion that there is conflict or disagreement between the particulars of the documents, standards etc., this must be clearly stated in the Bid, failing which, the materials and equipment offered shall be deemed to comply in every respect with the current Specification both in manufacture and in performance, and compliance thereof shall be insisted upon without additional cost to the Employer.

1.3 COMPLETENESS OF WORKS

1.3.1 All apparatus, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary in the respective equipment for the completeness of the finished work in an operable status, shall be deemed to be included in the Contract and shall be provided by the Contractor without any extra charge. All equipment shall be complete in all details, whether or not such details are mentioned in the Specifications. This includes fixation details and connection clamps and/or terminals.

1.3.2 All materials and skilled labour, whether of temporary or permanent nature, required by the Contractor for the design, manufacture, erection and testing at site of the equipment shall be supplied and paid for by the Contractor. All computer equipment shall be delivered with all software and licenses necessary to achieve the specified functionality as well as the software necessary for programming, testing, service and maintenance through the lifetime of the equipment.

1.3.3 Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any equipment shall imply equipment that is complete with all accessories, apparatus and fittings as outlined in sub clause 1.1.1 and 1.1.2 above.

The Contractor shall be responsible for ensuring that the equipment supplied is fit for the purpose intended. Available information on the characteristics of the system, to which the works will be connected and associated, will be supplied on request to the contractor who shall be responsible for obtaining and determining all applicable knowledge relevant to the works.

1.4 SPACE REQUIREMENT

The contractor shall utilize space economically and the arrangement of equipment in rooms and outdoor plots shall take into considerations future extensions and accessibility of equipment. The rooms and plots must accommodate the equipment as well as having workspace for operators and maintenance personnel.

1.5 DOCUMENTATION AND DRAWINGS

1.5.1 General

Contractor's obligations with regard to preparation and submission of drawings, calculations, samples, patterns, models, etc. are stated in the Conditions of Contract.

The Contractor shall prepare and submit to the Project Manager for approval dimensioned general and detailed design drawings and other pertinent information of all the Plant and equipment specified in the Bid Documents. Unless otherwise agreed the information shall be exchanged on paper.

Approval of drawings shall not relieve the Contractor of his obligations to supply the Plant in accordance with the Specifications. The Contractor is responsible for any errors that may appear in the approved documents. He shall as soon as an error has been detected, deliver the corrected documents to the Project Manager for re-approval.

If the plant is to be connected to existing equipment the connection shall be documented in a coherent and overlapping way at least containing terminal identification in old equipment. Schematic diagrams shall contain complete loops within new and old equipment.

All text on documents provided by the Contractor shall be in the English language in addition, if necessary, to that of the country of origin. All drawings shall be dimensioned in millimeters.

The Contractor shall, during the total project time, maintain a List of Documentation to be updated by him whenever needed. The List of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

Symbols used for electrical equipment shall be in accordance with IEC 60617. The Contractor shall establish a coherent system for physical and functional reference designation in accordance with IEC61346. A similar systematic scheme shall be defined for cable numeration. These schemes shall be used throughout on the drawings and documentation and the designation shall be labelled on the components and cables.

In addition to what is stated in Conditions of Contract, the following shall apply:

The sizes of all documents and drawings shall conform to the ISO standard, i.e.:

A1	594mm x 841mm	A2	420mm x 594mm
A3	297mm x 420mm	A4	210mm x 297mm

- Sizes larger than A1 shall be avoided. The schematic diagrams and, apparatus and cable lists shall be of size of A4 except for one original and possible transparency copies of schematic diagrams that shall be in A3. Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

- All drawings made special for this project including civil works drawings, mechanical drawings, layout drawings and circuit diagrams shall be compiled on a computer aided drawing system and as part of the as built documentation be handed over on a Flash drive in the latest version of AutoCAD or another format to be agreed upon in addition to the paper copies.

- All drawings shall be bound in hard covers.

1.5.2 Drawings

The Employer's drawings attached to the Bid Documents are of informative character. These drawings are intended to illustrate 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 can be accommodated to best advantage within the available area.

The contractor is at liberty to offer arrangements based on significantly different principles where it is considered that these offer economic or technical advantages. It is emphasized, however, that the layout shall be subject to employer's acceptance.

1.5.3 Progress Plans

The Progress Plans shall at least contain the following milestones:

- Essential information delivered from Employer
- Documentation for approval from Contractor to Employer
- Release of factory documentation
- Factory Tests
- Shipment
- Site ready for erection
- Start erection
- Ready for pre-commissioning
- Ready for commissioning
- Test run
- Taking over
- Submittal of final documentation

1.5.4 Exchange of Interface Information

The Contractors shall in due time supply interface information to other sub-contractors where needed. The Contractor is in particular required to check that all foundations and fixations of his equipment is sufficiently dimensioned to meet the forces acting upon it. If the Contractor feels that he lacks such information from other contractors he is obliged to request such from the Project Manager. The Contractor cannot claim liability exemption for his own contractual responsibilities because of actions performed or omitted by other sub-contractors.

1.5.5 Final Documentation

The Contractor shall supply three copies of final "as built" documentation taking into account all changes done under erection and commissioning.

The documents shall be both hard copies and soft copy in external hard disk and Flash drive.

The Contractor shall also deliver manuals for operation and maintenance. These shall at least contain the following information:

- Detailed description of the equipment, the individual components, relevant clearances, tolerances, allowable temperatures, settings etc.
- Descriptions of main principles including flow diagrams, single line diagrams, circuit diagram, connection diagram, cable schedules, software documentation etc.

- Operational instruction. These shall illustrate the operational sequences in a clear and concise way.
- Test and adjustment procedures containing instruction for test and adjustment of the equipment under operation, after inspection and maintenance
- Test reports
- Spare part lists
- Maintenance instructions split into:
- Manuals for preventive maintenance indicating periodic inspections, cleaning, lubrication and other routine maintenance.
- Repair manuals describing fault location, dismantling, re-assembly etc.

The documentation shall leave the operators and maintenance personnel in position to operate the plant in a safe and optimal way and to perform repairs usual to be done by such personnel. The Project Manager shall approve the manuals and drawings before final submission.

1.6 Contractor's Quality Assurance Procedures

The Contractor shall have established a quality assurance system based on ISO 9001 also covering sub-contractors. The Contractor shall provide a documentation of the system with a list of current procedures, an organization chart of the quality organization and the name of the quality manager. He shall also submit a list of quality revisions performed in the last twelve months with a list of closed and unclosed findings as well as planned revisions during the coming twelve months as well as a list of findings. The documentation shall give special emphasizes on how subcontracts are included in the quality assurance system. The Employer shall be entitled to perform quality revision at the Contractor or any subcontractor with two weeks' notice.

1.7 Guarantees and Particulars

The Works shall comply with the technical guarantee data stated in the Bid. The Contractor shall be responsible for any discrepancies, errors and omissions in the particulars and guarantees.

1.8 MANUFACTURING AND SHIPMENT

1.8.1 Places of Manufacture and Sub-Contractors

All equipment offered should be the product of recognized and experienced manufacturers and shall be of basic design and size similar to such that has been in successful continuous operation for at least three years preferably under similar climatic conditions. Proven plant reliability and high availability are of prime importance and the attention of the Bidder is drawn to these particular requirements.

The manufacturer's identity and places of manufacture, testing and inspection before shipment for the various portions of the Contract Works shall be specified in the Technical Schedules and shall not be departed from without the agreement of the Project Manager.

As soon as practicable after entering into the Contract, the Contractor shall, having obtained the Project Manager's consent in accordance with the Conditions of Contract, enter into the Sub-contracts he considers necessary for the satisfactory completion of the Contract Works.

All Sub-contractors and Sub-suppliers of components and materials shall be subject to the approval of the Project Manager. Information shall be given on each Sub-order sufficient to identify the material or equipment to which the sub-order relates, stating that the material is subject to inspection by the Project Manager before dispatch.

If the Employer at any stage in the design and production period finds out that the sub-contractor does not fulfil the requirements in the specifications and it is obvious that the required quality cannot be achieved by corrective measure he can request the subcontract to be suspended and the works to be produced elsewhere without extra cost for the Employer.

1.8.2 Inspection and Testing

The Contractor shall submit for approval a programme of quality control and inspection procedures to assure that the product during manufacture and on completion comply with the specified requirements. The programme shall relate the quality control and inspection activities to the production cycle. The Contractor shall provide details of quality control and inspection procedures used. The Contractor shall retain responsibility for quality control and inspection activities made by his sub-contractors and shall indicate on the programme, which items are to be sub-contracted and how they are to be inspected and tested both at subcontractor's works and by Contractor's acceptance control.

All materials used in the Contract Works are subject to inspection by the Project Manager and it is the Contractor's responsibility to advise the Project Manager when equipment and materials are available for inspection, at least one month in advance. Factory tests on equipment shall be made according to the applicable IEC Standards, or as specifically specified or according to standards approved by the Project Manager. Routine tests shall be made on each unit of all equipment.

Type tests shall be made on one unit of each type of different equipment. Instead of carrying out the type tests the Contractor may submit suitable certificates of tests made on equipment of the same type; however, the Purchaser reserves the right of accepting these certificates or to reject them partially or totally.
On complex systems the Bidder shall propose factory acceptance tests (FAT) to be performed.

The Project Manager shall be at liberty to demand any additional testing at the manufacturer's works, at site or elsewhere in order to verify that the equipment complies with the conditions of the Specifications.

A test programme shall be submitted to the Project Manager for approval at least one month ahead of the commencement of testing. The program shall include tests to be performed at sub contractor's works. 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.

1.8.3 Packing, Transportation and Storage

The Supplier shall provide such packing of the Goods as is required to prevent their damage or deterioration during transit and temporary storage up to their final destination as indicated in the Contract. The packing shall be sufficient to withstand, without limitation, rough handling and exposure to extreme temperatures, salt and precipitation. Packing case size and weights shall take into consideration, where appropriate, the remoteness of the Goods' final destination and the absence of heavy handling facilities at all points in transit. Indoor electrical equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside.

The following information must be clearly stenciled or printed on each packing case, crate, cask, drum, bundle or loose piece; care being taken that the number and other particulars on each package agree with those entered in the packing list accompanying the Invoice:

- Employer's Identity
- Supplier's Identity
- Destination
- Contract No.
- Package No.
- Item Code
- Weight, dimensions
- Sub-Project (Plant Identity).

The marking shall be durable. The marking shall be upon the body of the package. Marking upon a batten fastened on the case, etc. shall not be used.

In the case of bags, bundles and loose pieces, the shapes of which do not permit the marks to be put on the actual package, each bag, bundle or loose piece shall have two metal labels each with two holes. Securely fastened by independent wires. Each label shall be die-stamped with the above particulars.

Goods belonging to different plants shall not be mixed, but kept in separate packing cases, bundles or similar.
The Contractor shall be responsible for all transportation; from works to port of shipment and onwards to port of unloading, as well as all handling and transport to sites and handling on site.

1.9 ERECTION, INSTALLATION AND COMMISSIONING

1.9.1 Storage at Site

The Contractor shall be responsible for proper storage of equipment when delivered at the different sites until taking over. Care shall be taken to assure adequate storage to avoid damage to equipment due to rain or strong sunshine. The responsibility also covers security measures against theft and vandalism.

1.9.2 Work On Live Substations and Shutdowns for work

If work is to be done on substations in operation the following factors are of paramount importance:

(i) Minimization of outage time and

(ii) adaptation to operational constraints.

All work must be planned with this in mind. The Contractor must obey to all instructions and safety rules given by the Government and the Employer and must strictly follow all instructions from the Employer's supervisory personnel. The Contractor shall appoint his Resident Project Manager/Technician who will be authorized to receive work permits at the work sites as required by safety rules.

All outages shall be discussed with the Employer and the Resident Project Manager at least **two weeks** before the outage is required. The Contractor will normally be allowed to have only one high voltage circuit out of operation at a time.

No work must start before Employer's site manager has authorized the work, established the required earthing and marked the safe area. All switching on live parts shall be done by the Employer. In the rare cases where more than one circuit have to be taken out of operation the Contractor must be prepared to do the work during nights or at off-peak time. The Contractor and his personnel must respect the physical constraints as well as constraints for scheduling set by these circumstances. However, the Employer will co-operate in making the work conditions and the scheduling as efficient as possible for the Contractor and keep a responsible person with switching authority at site during all working hours (including night time).

If physical constraints make it necessary to replace cabinets needed for operation, the Contractor must as far as possible erect and connect the new cabinets temporarily adjacent to the one in operation. A quick disconnection and removal of the old cabinets can then be performed and the new cabinets pulled in with most of its cables already fitted. Location of new cabinets shall be approved by the Project Manager and a proposal for such shall be given by the Contractor one month prior to erection.

1.9.3 Erection, Testing at Site, Commissioning

The Contractor shall carry out erection, testing at site and commissioning of the Plants specified in the Specifications. All work, methods of work and workmanship, whether fully specified herein or not, shall be of the highest order in all respects, the generally accepted requirements and commonly recognized good practice for first-class work of the nature are to be adhered to.

The Contractor shall provide all staff, such as engineers, supervisory staff, skilled and unskilled labour necessary to carry out and complete the Contract Works on schedule as specified. Information regarding site staff shall be shown in the relevant Schedule.

The Contractor shall provide all vehicles, erection, tools and equipment necessary to carry out the Contract Works, including personnel transport. At the completion of the Contract, the Employer reserves the right, at his discretion, to take over vehicles, any tools, special tools, test equipment and other construction equipment used by the Contractor in connection with the Contract, at depreciated prices to be mutually agreed upon at that time.

Testing at site shall be carried out by experienced test engineers. Functional tests shall be inherent in all test procedures. The Contractor shall record the test results in an approved form in such a manner that the test reports can be used as the basis for future maintenance tests. Test methods and equipment shall be noted on the test sheets.

A complete test report in 4 sets shall be handed over to the Project Manager not later than one month after the Plant being commissioned. The test engineers shall at site keep a complete record of correction made during testing and one set of corrected drawings shall be kept at site after commissioning and one set handed over to the Project Manager.

Commissioning shall be carried out by the Contractor in the presence of the Employer's engineers and the Project Manager. The Contractor shall prior to commissioning draw up a detailed commissioning schedule for approval showing the sequence to follow step by step in all connections, including control of phase sequence and other pertinent factors. Switching of energized components will be performed by the Employer.

1.9.4 Accommodation of Contractor's Personnel

The Contractor shall make his own full provision for temporary accommodation of own and sub-contractor’s employees to suit their requirements.

1.9.5 Health, environment and safety

The Contractor shall follow all local rules and regulations related to workers’ safety and health as well as regarding protection of the environment.
The Contractor is responsible for employing a health worker to inform the workforce and affected villages about the increased health risks, especially COVID-19 and HIV/AID.

The Contractor is also responsible for equipping all his workers with necessary safety equipment as helmets, eye protection glasses and safety belts and enforce the use of such
No toxic material (such as Halon, PCB, and Asbestos) shall be utilized neither during construction nor under operation and maintenance.

The Contractor shall at all times during the course of work prevent accumulation of debris caused by the work. He shall also remove all debris and temporary structures when finishing the work. The Contractor shall also be responsible for removal of old equipment and cables. All surplus material should be disposed in an environmental satisfying way. Particular attention should be given to safe disposal of environmentally hazardous substances such as battery acid, transformer oil and capacitors. Workable equipment shall be handed over to the Employer.

1.10 TIME OF DELIVERY AND COMPLETION

The Implementation Schedule shown in the Bid Documents shows the completion of the project of which the equipment forms an integral part. The equipment must thus be delivered and erected in accordance with this schedule.

The guaranteed completion and delivery times shall be stated in the Bid and the guarantee therein signed by the Bidder. In addition, the Bidder shall submit an erection program and estimate the necessary man-weeks for erection, alternatively erection supervision, testing and commissioning.

1.11 ON THE JOB TRAINING

The Employer shall be allowed to take part in erection, pre-commissioning and commissioning thus taking part in a transfer of knowledge scheme. Before the erection starts, the Contractor shall arrange a one-day course in understanding of the Contractors documentation and reference system.

The contractor shall also demonstrate to the operators all the operations of the substation before the tests run of the station.

1.12 TOOLS

The Supplier shall supply in lockable boxes, for the Employer’s use, any special tools that may be required for assembly, dismantling adjustments and maintenance of the equipment. The tools shall be unused and in new condition at the time of handover. Suitable special spanners shall be provided for bolts and nuts, which are not properly accessible by means of an ordinary spanner.

1.13 SPARE PARTS

Mandatory Spare supplied under the contract shall be packed and preserved for long time storage before handover to Kenya power as per the specifications.
Transportation cost of the spare parts to any store of KPLC as directed by the Project Manager shall be borne by contractor at no additional cost to Kenya Power

TABLE OF CONTENT

2.0 GENERAL TECHNICAL SPECIFICATION 12

2.1 Standards… 12

2.2 Units 12

2.3 Auxiliary Power Interruptions 12

2.4 Selectivity 12

2.5 Design and Materials 12

2.5.1 General… 13

2.5.2 Electrical Equipment Materials… 14

2.5.3 Bolts, Studs, Nuts, Screws, Washers, etc. 14

2.5.4 Panels and Support Structure for Electrical Equipment…….14

2.5.5 Insulating Oil 14

2.5.6 Sulphur hexafluoride gas (SF_6) 15

2.5.7 Locking Devices and Padlocks 15

2.5.8 Nameplates and signs 15

2.5.9 Tool Rack in the switchgear Room 15

2.6 Equipment 15

2.6.1 Standardization… 16

2.6.2 Electrical Sockets 16

2.6.3 Degree of Protection 16

2.6.4 Indicators and Instruments… 16

2.6.5 Electronic equipment 17

2.7 Measurement of electrical parameters 17

2.7.1 Fuses and Miniature Circuit Breakers… 17

2.7.2 Relays and Contactors… 18

2.7.3 Motors 18

2.7.3.1 General… 18

2.7.3.2 Special Motors… 19

2.7.4 Motor control gear 19

2.7.5 Computer Based Controllers 19

2.8 Construction and Erection 20

2.8.1 Switchboards, Panels and Cabinets .... …20

2.8.2 Wiring and Terminal Blocks within Enclosures 20

2.8.3 Cable Laying and Routing 22

2.8.4 Earthing (Grounding) 22

2.0 GENERAL TECHNICAL SPECIFICATION

2.1 Standards

Ratings, characteristics, tests and test procedures, etc. for the electrical equipment encompassed by this Specification shall comply with the provisions and requirements of the standards of the International Electro-technical Commission (IEC), unless otherwise expressly stated in Particular Technical Specifications. Where the IEC standards do not fully cover all provisions and requirements for the design, construction, testing, etc. and for equipment and components that are not covered by IEC Recommendations, internationally recognized standards shall be applied. The rules of CEE (International Commission for the approval of electrical equipment) and the standards of CENELEC (Comité Europeen de Normalization Elecrotechnique) may also be applied in such cases.

The latest revision or edition in effect at the time of Bid Invitation shall apply. Where references are given to numbers in the old numbering scheme from IEC it shall be taken as to be the equivalent number in the new five-digit number scheme. The Bidder shall specifically state the Precise Standard, complete with identification number, to which the various equipment and materials are manufactured. The Bid Documents do not contain a full list of standards to be used, as they only are referred to where useful for clarification of the text.

2.2 Units

The SI-system (meter, Newton, second etc.) shall be used throughout the works covered by this Specification.

2.3 Auxiliary Power Interruptions

The Contractor shall ensure that the plants as a whole will function without interruptions if auxiliary AC power disappears. The plant shall be shut safely down by long interruptions in AC supply or by faults in the DC supply.

2.4 Selectivity

The contractor is responsible for selectivity in the auxiliary AC and DC power system and shall present calculations proving the selectivity between main and sub distributions under maximum and minimum short-circuit levels.

2.5 Design and Materials

2.5.1 General

Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice. Necessary safety factors shall be included. The supplier shall assure himself that the apparatus is suitable for intended use and the environment and stresses to which it will be exposed. He must also assure that the equipment is compatible with equipment it shall be connected to, or work together with.

The design shall be reliable and simple. The design shall incorporate every reasonable precaution and provision for the safety of the general public as well as for all those engaged in the operation and maintenance of the equipment itself or equipment connected to or installed in close proximity to it.

All apparatus shall be designed to ensure reliable and safe 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 of the system. The plant shall withstand without permanent weakening or deformation from short circuit current within the rating of the apparatus (including those due to faulty synchronizing) as well as normal atmospheric over voltages taking into account the use of lightning arresters.

Special considerations shall be given to pressure rises by short circuits and fire risk. All material and equipment shall be designed and arranged so that over pressure will be relieved in a safe direction and so that fire risk is minimized and consequences of a fire reduced. The indoor 11kV switchboard shall be designed with a duct on top of the board for pressure release.

All plastic material used in boxes, panels and boards shall be halogen free and self-extinguishable.

The contract supplies shall be designed to facilitate inspection, cleaning and repairs and for operation, in which continuity of service is the first consideration.

All conductors and current carrying parts must be dimensioned with ample cross sections so that temperatures are kept within limits in operation and under short circuits. Temperature rises on all equipment shall be kept within limits set in IEC standards provided no other values are specified. For all current carrying parts the permissible short circuit duration shall be as stated in the specifications. All electrical connections shall be secured by bolts or set screws of ample size, fitted with locknuts or lock washers of approved types.

The equipment shall as far as possible be factory mounted with internal cables and internal equipment installed before shipment. Plug-in components can be shipped separately.

Equipment for use outdoors or in wet or damp rooms shall be constructed so that water runs off. It shall also have devices draining any inside condensation that may form. Axial bearings on such equipment must be equipped with durable sealing preventing water to ingress.

2.5.2 Electrical Equipment Materials

All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified. They shall withstand the variations of temperature and atmospheric conditions arising under working conditions (including start and stop) without distortion deterioration or undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. The Plant shall be designed for a lifetime of 40 years. Equipment with a shorter life cycle shall be identified and so arranged that they are easy to replace.

No welding, filling or plugging of defective parts will be permitted without the sanction in writing of the Project Manager/Engineer.

Materials that are susceptible to mould growth under tropical conditions shall be treated to exclude moisture and prevent growth of mould after all machining has been carried out.

Copper and aluminium used as electrical conductors shall be of the electrolytic type and comply with the respective ASTM or DIN Standards. Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment that is in tension or subject to impact stresses. Exception is made where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

2.5.3 Bolts, Studs, Nuts, Screws, Washers, etc.

All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. They shall be of Strength Class 8.8 and marked accordingly.

All bolts, studs, nuts, washers, screws, etc., used outdoor or in wet or moist environment shall be in stainless steel or hot-dip galvanised. If hot-dip galvanised bolts and nuts are used, special considerations shall be taken related to pre-stressing. Bolts, nuts, studs and screws that require frequent tightening and unbolting during inspection or maintenance procedures, shall be of stainless steel.

All bolts and nuts shall be hexagonal, either normally or of the round head socket type and secured in an approved manner against becoming loose during operation.

The Contractor shall supply the net quantities plus 5% of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc. which are surplus after the installation of the equipment has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

Taper pins shall have threaded stems with nuts where dismantling of the pins is likely to be required.

Bolts shall not protrude more than 10 mm beyond the nut but not less than two full threads.

2.5.4 Electrical equipment Panels and Support Structure Surface Treatment and Painting

2.5.4.1 Electrical equipment Panels

Panel boards, cubicles, cabinets, etc. in dry rooms shall have interior surfaces painted with at least one priming and one finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion resistant, with one priming coat, and two finishing coats.

Outdoor installations and indoor installations in wet and damp rooms shall at least have one priming coat and two layers of paint on zinc powder basis applied after perfect cleaning.

Structural supports outdoor and in wet or moist rooms and parts that cannot be readily painted, shall be hot-dip galvanised. All galvanizing shall be in accordance with BS 729 or other internationally approved standards. Steel below ground shall in addition to galvanizing be protected with Bitumen or a substance of similar quality.

The particulars of priming and finishing paintings shall be stated in the Bid, with specifications of paint, together with a listing of colours available, for each of the plant and equipment.

The Employer is not bound to accept the finishing colour proposed by the Bidder. Determination of colour shall be at the option of the Employer and shall be finalised at the time of approval of drawings.

2.5.4.2 Substation steel structures equipment support

Unless otherwise specified, metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BSI standards. All steel structures for substation equipment support and gantry shall be hot dip galvanized, with a 110 microns minimum zinc coating thickness. Other steel structures not made for equipment support (outdoor MKs and LV boards supports) shall have 100 microns minimum zing coating.

2.5.5 Insulating Oil

All electrical equipment requiring insulating oil or other insulating liquids shall be furnished with the first filling including flushing, if required. An excess of 10% of the net amount of oil or liquid required for each component shall also be furnished by the Contractor as spare.

The Contractor shall endeavor to employ, as far as practicable, one type and make of insulating oil only for all the electrical equipment.

2.5.6 Sulphur hexafluoride gas (SF_6)

The SF_6 gas shall comply with the requirements of IEC 60376. In addition to the quantity of gas required to fill the equipment supplied, 20% shall be supplied as spare.

The high-pressure cylinders for shipment and storage of the SF_6 gas shall comply with the applicable national regulations. All the necessary pipes, couplings, flexible tubes and valves for coupling to the switchgear for filling or evacuating all the gases to be used, with all necessary instructions for the storage of this equipment, shall be provided.

2.5.7 Locking Devices and Padlocks

Facilities for applying safety or security padlocks to circuit breaker operating mechanisms, disconnector and switch operating handles, control switches, control cubicles, outdoor cabinets etc. shall be provided for all equipment accessible by unauthorized personnel. The facilities shall be suitable for padlocks having a hasp diameter of 10 mm. Padlocks are not required.

2.5.8 Nameplates and signs

Marking shall be in corrosion resistant material with permanent lettering. All equipment shall be marked in accordance with standards and local practice. The Contractor must mark all components in a clear and unambiguous way so that it can be related to the documentation. All operating mechanisms as pushbuttons, switches and handles must be marked in a precise way and necessary warning signs must be supplied.

All outdoor nameplates and signs shall be made of non-corrosive weatherproof material such as trafolyte, aluminium or stainless steel.

Letters shall be white and engraved on black background. For aluminium and steel signs black letters on metallic background shall be used. For warning signs red background shall be used.

2.5.9 Tool Rack in the switchgear Room

A tool rack shall be installed in the switchgear room for all the, handles and tools required for operation of the switchgear including panel/marshalling boxes keys. The rack shall be easily accessible to operators and not cause obstruction to operations.

2.6 Equipment

2.6.1 Standardization

The Contractor shall be responsible for the standardization of all small mechanical and electrical equipment, materials and devices for the Works. He shall arrange and perform the necessary co-ordination work with his subcontractors for the purpose of such standardization. Such equipment, devices, fittings, etc. shall comprise, but not necessarily be restricted to, the following:

- Programmable controllers, control devices and control switches
- Electrical instruments and meters
- Terminals and terminal blocks
- Primary, secondary and auxiliary relaying devices
- Contactors, fuses, miniature breakers and the like.
- Lamps, bulbs, sockets, plugs, etc.
- Lubricants and Oil

2.6.2 Electrical Sockets

Single phase electrical sockets installed for lamps, hand tools, measuring equipment etc., shall be square pin type with earth connection. The sockets shall be rated for at least 16A (lower rating shall not be used). Other sockets shall be according IEC 60309 (CEE type). The Contractor shall endeavor to use components available in the local market.

2.6.3 Degree of Protection

Enclosures for electrical equipment shall have the following degree of protection (ref IEC 60034, IEC 60059, IEC 60529 and IEC 60947):

- Motors/Motor Terminal boxes — IP 54/IP 65
- Dry Transformers — IP 2X
- Limit switches — IP 65
- Indoor switches — IP 5X
- Outdoor switches — IP 54
- Medium voltage enclosed switchgear — IP 42 (IP 20 with front door open)

Low voltage switchgear and control cabinets:

- Indoor — IP 3X
- Outdoor — IP 54
- With open door — IP 20
- Junction boxes — IP 65
- Light fittings — IP 5X
- Outdoor and wet areas — IP 4X
- Indoor — IP 2X

2.6.4 Indicators and Instruments

All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools.

In un-manned operation a switch shall be arranged for turning off the indication lights for the substation. A switch for lamp test shall be arranged.
<u>All indication contacts shall be galvanic isolated and potential free.</u>

Temperature indicators shall be of the PT 100 type protected to suit the environment where it is to be used.

Pressure indicators shall be of corrosion proof material, IP 54, vibration class 1. The scale shall indicate bar or equivalent m water column. The diameter shall be 160 mm and the measuring pipe shall be equipped with stop chock. If the indicator is exposed to vibration it shall be filled with damping liquid (glycerine).

Limit switches for pressure, temperature and flow (even if combined with the indicators) shall be of class 1 without noticeable hysteresis. Where more than one limit is required each limit shall be independently settable. Set points shall be easily readable.

Flow meters shall be graded in litres/s from zero to well above required value. Flow meters for water shall be electronic without moving mechanical parts.

Panel instrument shall be accuracy class 1.5 or better, dimensions 96x96 mm with non-reflective glass. Measuring converters shall be of accuracy class 0.5 with 4-20 mA output, DC auxiliary voltage and galvanic isolated potential free output.

2.6.5 Electronic equipment

Where possible, plug-in type printed circuit boards shall be used. External connections to the boards shall be by plug and socket connection.

All electronic components, including integrated circuits, transistors, resistors, capacitors and inductors shall be selected in order to ensure long life and stable operation. Indication lamps used in conjunction with electronic circuits shall be light emitting diodes.
All relay equipment shall use modern plug-in type circuit boards, containing standard type miniature relays, which can be plugged- in and easily replaced on sockets on the circuit boards. Only a few types of standard relays shall be used. All relays shall be of the encapsulated type. External connections to the boards shall be by plug and socket connection.

2.6.6 Fuses and Miniature Circuit Breakers

Miniature circuit breakers (MCBs) shall replace fuses in control and power circuits 100 Amps and below. They shall be approved as circuit breakers and have a breaking capacity sufficient to break the short circuit at the place of use (i.e. no upstream backup fuses for reduction of fault level shall be necessary). All circuit breakers used in DC circuits must be approved for the relevant DC voltage and current.

Where nothing else is specified, LV power fuses above 100Amps shall be of high rupturing capacity cartridge, type NH gl, according to DIN VDE 0636 and IEC 60269. All fuse bases shall have a load switching capacity and a thermal rating equal to the rating of the largest fuse it can accommodate. Fuse replacement shall be possible without use of special tools and with IP 20 protection against live parts.

2.6.7 Relays and Contactors

All resetting of relays and contactors must be possible without dismantling or removal of top or any covers and without risk for electrical shock. All contactors and relays used in DC circuits must be approved for the relevant DC voltage and current.

Limit switches not mounted in enclosures shall be of the proximity type without need for separate power supply and equipped with light emitting diodes to indicate position.

2.7 Motors

2.7.1 General

As far as possible and if nothing else is specified, motors shall be three phase squirrel cage motors complying with IEC 60034 and with dimensions according to IEC 60072. Such motors shall have the following data:

Continuous rating	130 % of mechanical load
Frequency band for continuous rated operation without exceeding temperature class	47 – 57 Hz
Voltage band for continuous rated operation without exceeding temperature class	-15 % - +10 %
Maximum start current with direct start	
Motors above 75 Kw	5 x I_n
Motors between 35 and 75 kW	6x I_n
Insulation class	F
Temperature rise	B
Direct starting range	75 – 110 % of U_n

Motors shall have sealed ball or roller bearings. If the bearing is not sealed for life it shall withstand two years of operation before refill of lubricants.

Outdoor motors and motors erected in moist environment shall be equipped with still-stand heaters controlled from the starter. The heater shall be so dimensioned that maximum temperature is not reached even if the heater remains connected under operation.

Motors shall withstand three consequent starts without overheating. Motors over 20 kW shall be equipped with thermistor based temperature protection.

The three line connections of A.C. motors shall be brought out to a terminal box sealed from the motor. The terminal arrangement shall be suitable for the reception of aluminium and copper cable. A permanently attached diagram or instruction sheet shall be provided giving the connections for the required direction of rotation. If only one direction of rotation is permitted, this shall be clearly marked.

Motors to be connected to variable speed drives shall be special adapted to this.

2.7.2 Special Motors

Other types of motors shall only be used where squirrel cage motors are inconvenient to use (and then only after approval by the project manager) or if DC motors are specified. Such motors shall as far as possible follow the requirements set above.

Brushes shall be designed with a constant brush pressure and shall withstand at least 5 000 hours of operation before they have to be replaced. It shall always be at least two brushes in parallel and the brush-holders shall not touch the commutators when the brushes wear out. The press fingers shall not carry the current and each brush shall be separately adjustable.

Where single phase motors are used the motors shall be grouped so as to form, approximately, a balanced three phase load.

2.7.3 Motor control gear

Control gear shall comply with the requirements of IEC 60947, the control gear being rated according to the duty imposed by the particular application. No replacement of equipment shall be necessary after short circuit (ref. IEC 60947)

Motor contactors shall comply with IEC 60947 class of intermittent duty 0-3 and utilization category AC4. The contactors, and their associated apparatus shall be capable of switching the stalled current, and shall have a continuous current rating of at least 50% greater than the full load current of the motors they control.

The operating currents of overload trips fitted to motor contactors shall be substantially independent of ambient temperature conditions, including the effect of direct sunlight on the enclosure in which the contactors are installed.

Where small motors are connected in groups, the group protection shall be arranged so that it will operate satisfactorily in the event of a fault occurring on a single motor.
Each motor or group of motors shall be provided with control gear for starting and stopping by hand and automatically. Overload and single-phasing protection shall be provided. Facilities for padlocking the supply in off position shall be provided.

2.7.4 Computer Based Controllers

Computer Based Controllers inclusive Programmable Logical Controllers (PLC) can be used for individual control functions. Such equipment shall be designed for industrial environment and application in high voltage plants. The control equipment must be fed from the general station DC supply.
The control equipment must be equipped with internal "watchdog" function giving external potential free alarm by internal fault. The operational status shall be frozen by fault or un-normal function so it can be re-established after restart. The process must be shut down to a safe stage if fatale faults occur in the controller.

Analogue and digital in and out puts must be galvanic isolated and potential free and must, together with the enclosure, screen against disturbance from electromagnetic field occurring by short-circuit, switching over voltages or lightning discharges. The control equipment shall be tested according IEC 60255 and fulfil relevant EMC requirements for Industrial Environment.

Digital in- and outputs shall be tested and approved for switching of DC voltages supplied by the main plant battery (AC values are irrelevant).

Programme shall be stored in "flash ram" or similar storage medium and shall not be destroyed or changed by power failure (i.e. Separate backup battery shall not be used). The memory shall contain the last program version.

All programming of control sequences shall be documented in a self-explanatory way not requiring special program knowledge for understanding (function block programming or similar)

Communication between various controllers (and the main control system) can be over Fibre optical cable provided agreement between the contractors. Such communication must use open protocols to be approved by the Project Manager. The Bidder shall in any case present a verification of transmission quality.

The Controllers shall be delivered with software and software licenses needed for testing, setting ad reconfiguration. If hardware other than laptop is required for this such shall be included in the supply.

2.8 Construction and Erection

2.8.1 Switchboards, Panels and Cabinets

Switchboards, control, panel boards and cabinets where required shall be of robust construction, formed of a steel frame and covered with smooth steel plate. All outdoor cabinets/Cubicles shall be of powder coated CRCA mild steel grade. The steel plates shall be properly stiffened to prevent distortion. Panels for protection shall be modular in design with two doors; an Inner rack hinged frame Swing door and a front glazed transparent acrylic Perspex/glass door. The frames of the boards shall be designed to permit firm anchoring on the floor. The frames shall permit easy erection, and allowance shall be made for extension of the board by similar additional panels. Panels for power circuits shall be in accordance IEC 61439 (minimum partly type tested apparatus (PTTA)). All enclosures shall be ventilated so that the temperature inside the enclosure do not raise more than 5 °C above ambient even with possible heaters connected.

Outdoor-cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit collection of moisture. The heater must be arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.

All major or important compartments containing electrical equipment shall be provided with a single phase 16A square pin socket and internal lighting facilities switched off by a door switch.
Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting.

Flush mounted relays shall be provided with transparent cover. The cover shall be hinged to allow resetting and adjustment. All terminals and all equipment shall be accessible without dismantling other components. Equipment shall not be mounted in swing-out doors. However, proper swing out frames may be used provided they can be opened will full load without twisting or distorting the panel. Windows shall be provided in front of rack mounted equipment.

2.8.2 Wiring and Terminal Blocks within Enclosures

All wiring shall be stranded flexible copper conductor, PVC with steel armour. Insulated, suitable for operation at voltages below 1000 V and in compliance with the provisions of the applicable IEC Recommendations. Conductors shall not be smaller than 2.5 mm² for current transformer circuits and 1.5mm² for all other control circuits. The selection of conductor sizes for current transformer circuits shall be supported by calculations.

For wiring within boards, the "bunch" pattern shall be adopted. For a small number of connections, wiring may be grouped using flexible plastic bands or equivalent. For a large number of connections, a system using support strips or U-shaped troughs (with covers) shall be used. Ample space shall be provided for running of cable within the enclosures.

The screens or screened pairs of multicore cables shall be earthed in accordance with a coherent Earthing philosophy to be worked out by the main Contractor and approved by the Project Manager. The screen and earth wires shall be terminated in terminals dedicated for this use. All free conductors in connecting cables shall be terminated in terminals that shall be temporarily connected to earth and special marked. Though, in field boxes the free conductors can be laid orderly and short-circuited or insulated. The length shall allow future connection.

Multi-stranded conductor ends shall be fitted with a suitable crimped thimble (bootlace ferrule type). The thimble shall be of correct type and length according to the core size and crimple tools shall be specially adapted to the thimble and cross section used. Each wire shall be separately terminated unless otherwise approved.
It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead. The wiring identification shall be by numbered ferrules, sleeves or other approved means.

All wiring shall terminate at terminal blocks, the latter shall be of the moulded type not less than IP20 and provided with barriers to separate power from control cables. It shall be possible to replace a single terminal block without dismantling a whole row. They shall be clearly marked, the designations being those entered in the respective wiring diagrams. Terminal blocks using screws acting directly on the wire (conductor) as well as spring type terminal blocks are not acceptable. To avoid squeezing of the wire the screw pressure shall be applied by a pressure plate having smooth edges. 'OBA' terminal blocks are not acceptable. Only terminal blocks that are operated using screw drivers are acceptable.

Terminal blocks for current and voltage transformers shall be separated and specially marked. They shall be equipped with a sliding splice for separation and "banana" sockets on both sides for testing. The splices shall be so arranger that they fall into closed position when loose. Where appropriate, other terminal blocks shall be equipped with facilities for testing, such as short-circuiting, separating splices, plugs, etc. All such device shall be accessible even when paralleling strips are used.

Only one conductor shall be connected to each side of a terminal block and the branch-offs shall be made by interconnecting the necessary number of neighboring blocks by means of copper strips.

Terminal blocks shall be located at least 300mm from the bottom of the panel and shall be easily accessible. Terminal blocks for different voltages shall not be mixed between one another. All conductors in a multi-core cable shall be terminated on the same terminal block. The blocks shall be grouped for each voltage and they shall be clearly marked for easy identification of the system voltage. There shall be at least 20 % spare terminals on each block.

2.8.3 Cable Laying and routing

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

Cables shall be laid on corrosion resistant (aluminium or hot dipped zinc galvanised) perforated cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15 % spare capacity. The distance between each tray shall at least be 300 mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

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

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

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

  consideration shall be taken in accordance with EMC standards.

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

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

Cables below 25 mm^2 cross section shall be copper. Larger cross sections may be aluminum. Minimum nominal cross sections for cables shall be as follows:

• All Measuring cables for current	2.5 mm^2 steel wire armoured and flexible
• Control and other measuring cables	2.5 mm^2 steel wire armoured and flexible
• DC supply circuits	2.5 mm^2 steel wire armoured and flexible
• Telecommunication	1.5mm^2 Steel/tape armoured and flexible
• Power cables	according 120 % max load current

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

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

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

The cable supplier's instructions regarding handling and bending radius shall be followed.

Fibre optic cables shall not contain metallic material and be so laid that they have proper mechanical protection. I.e. cables not constructed for embedding shall be laid in protective tubes.

2.8.4 Earthing (Grounding)

An embedded Earthing system shall be designed and supplied by the contractor. The embedded Earthing system shall be arranged, connected to expose and accessible Earthing bars. From here an exposed Earthing system shall be arranged. The Contractor is responsible for installation and connecting of his equipment to this network so that all precautions are taken regarding safety (ref. National regulations) and shielding against disturbances. Cables shall be earthed and shielded in accordance with earthing philosophy of IEC standards for details of the earthing system refer to clause 5.24 of Particular technical specifications.

TABLE OF CONTENTS

3.0.1 Project Specific Data 24
3.1 Definitions 24
3.1.1 Design Data, High and Medium Voltage 24
3.1.2 Design Data, Low Voltage Equipment 26
3.1.3 Phase Relationship 25
3.1.4 Colour Coding 25
3.1.5 Environment 26
3.1.6 Noise 26
3.1.7 Auxiliary Power 27
3.1.8 AC Auxiliary power supply 28
3.1.9 DC Auxiliary supply 28
3.1.10 Un-Interrupted power supply 28
3.1.11 Operation and control… 28
3.1.12 Interface between Contractors and towards Employer 28

3. PROJECT SPECIFIC DATA

3.1 Definitions

Whenever the following terms or words are found in the specifications and/or other documents, they shall have the following meaning:

"High Voltage Equipment" (HV):
Mostly used for equipment provided for a maximum operating voltage higher than 52.5 kV (generically also used for voltages down to 1000 V).

"Medium Voltage Equipment" (MV):
Equipment provided for a maximum operating voltage higher than 1000 V and up to 52.5 kV.

"Low Voltage Equipment" (LV):
Equipment provided for operation at 1000 V or below. (For transformers the term Low Voltage Winding is used for the side with lowest rated voltage regardless value)

AC means Alternating Current, DC means Direct Current, where protection degree IP xx is mentioned it shall generally be according to IEC 60529 "Degree of Protection Provided by Enclosure".

3.1.1 Design Data, High and Medium Voltage

The rating and design criteria for the HV and MV plant and equipment shall be as follows:

Item	Parameters	SYSTEM VOLTAGE			
		132kV	66 kV	33kV	11 kV
1	System	50 Hz, 3 phases			
2	Neutral point earthing	Solid earthed			
3	Nominal voltage of networks	132 kV	66 kV	33 kV	11 kV
4	Highest system voltage as defined by IEC-60038	145 kV	72.5 kV	36kV	12 kV
5	Short circuit and earth fault current, symmetrical r.m.s. value (min breaking current) not less than	40 kA	31.5 kA	25kA	25 kA
6	Thermal short-circuit current, not less than 3 second	40 kA	31.5 kA	25kA	25kA
7	Dynamic peak current (min making current) not less than	80 kA	80 kA	63kA	63 kA
8	Rated current of busbars and bus coupler if not given in Scope of Works, for each individual substation	2,000 A	1250 A	1250A	1250 A
9	Minimum rated current of isolating switches and circuit breakers, if not given in Scope of Works	2,000 A	800 A	800A	630 A
10	Insulation level according IEC 60071:				
a	Switching surge withstand voltage				
b	Phase-to-earth	N/A	N/A	N/A	N/A
c	Longitudinal impulse component of combined test	N/A	N/A	N/A	N/A
d	Lightning impulse withstand Voltage (1.2/50 m/s V_{peak})	650 kV	325 kV	170kV	95 kV
e	Test voltage at power frequency 1 min dry and wet. To earth and between phases	275 kV	140 kV	70kV	28 kV
11	For the design and erection of the conductors in the switchyard below minimum distances shall be observed				
a	Phase to earth [mm]	1270	700	500	500
b	Phase to phase [mm]	1475	790	450	450
c	Busbars phase to phase [mm]	3500	3000	2800	2500
d	Height to live parts above ground [mm]	5000	3500	2900	2900
e	Height to live parts above ground at transformer transport routes [mm]	5000			
f	Lowest part of insulators above ground [mm]	5000	2500		
12	Maximum temperature rise of conductors above ambient temperature (40 ºC)	40 ºC			

Item	Parameters	SYSTEM VOLTAGE			
		132kV	66 kV	33kV	11 kV
13	Maximum wind pressure on conductors and cylindrical objects	400 N/m^2			
14	Maximum wind pressure on flat surfaces	820 N/m^2			
15	Minimum nominal creepage distance as defined in IEC 60815, Table II	25 mm/kV (inland area) 31 mm/kV (in coast and industrial area)			

All High and Medium Voltage equipment shall be designed for installation at 2200m above sea level. IEC 60071 shall apply with the specified correction factor for the altitude above sea level.

3.1.2 Design Data, Low Voltage Equipment

Low voltage installation shall be in accordance with EMC directives. The rating and design criteria for low voltage equipment shall be as follows:

AC Voltage	Parameter
Nominal system voltage	415/230 V -15%, +10% (+ or – 6%), TN - CS
System frequency	50 Hz (±2%)
DC System	110V and 48V (for telecommunication & SAS)
Power frequency test Voltage 1min	2.5 kV
Thermal rating of conductors	120 % of load
Maximum short-circuit Current	25 kA

AC LV equipment can, after the Project Manager's approval, be rated for lower short-circuit current if calculation demonstrates that lower values are applicable at the place of installation. DC equipment shall be adapted to the actual values at sites as shown in calculations.

3.1.3 Phase relationship

The phase relations and designations shall be in accordance with the existing system of the Employer. The phase sequences will be made known to the Contractor at a later date, but not later than 1 month from date of commencement. The standard phase colours are Red, Yellow, Blue (RYB).

3.1.4 Color Coding

All wires must have ferrules at all terminations to distinguish each signal. In addition, the wires shall have the following colours:

Circuit	**Colour of Wire**
Voltage transformers	Red, Yellow, Blue, Black
Current transformers	Red, Yellow, Blue, Black
A.C. Circuit	Red, Black
D.C. Circuit	Grey
Grounding circuit	Green with yellow stripe

Following coloured ferrules shall be provided on each wire in order to identify phase and polarity.

Phase and Polarity	**Colour of ferrules**
A.C.	
First phase	Red
Second Phase	Yellow
Third phase	Blue
Neutral	Black
Grounded	Green with yellow stripe

DC Supply

Positive	Red
Negative	Black

Ferruling system should be submitted to the Employer for approval before commencement of works.

3.1.5 Environment Condition

Unless otherwise specifically stated in Particular Technical Specifications or Scope of Works, any equipment, component and assembly shall be designed for the following service conditions:

Parameter	Max	Min
Ambient air temperature		
Outdoor	+40°C	-1°C
Indoor	+40°C	-1°C
24 hour average maximum	+30°C	-1°C
Ambient temperature for cables in the ground	+40 °C	-1°C
Relative humidity	90%	
Height above sea level	2200m	2200m
Cooling water temperature	N/A	N/A
EMC Class (IEC 61000)	Industrial environments	
Seismic coefficient	0.15	
Wind pressure on project area of conductors and cylindrical objects	430 N/m²	383N/m²
Maximum wind pressure on steel members on 1.5 times projected area	820 N/m²	
Maximum Wind velocity	120km/hr (33.3 m/s)	
Rainfall conditions		
Average	800-1700 mm/year	
Maximum	160mm in 24 hrs.	
Annual mean isokeraunic level	Max 180 thunderstorm days	
Pollution (IEC 60815)	Heavy: class II	

Wherever any of these maximum or 24hour average temperatures exceed the normal service condition temperatures of the IEC Recommendations for the relevant equipment, or of such other standard which is approved to be applied, the permissible temperature rises of the IEC Recommendations or the standard shall be reduced by the same amount as the difference between the above figures and the normal service condition temperatures. The Contractor shall guarantee these reduced temperature rises.

All air cooled equipment shall be cooled with convection (i.e. without fans) provided other cooling methods are not explicitly allowed for in the specifications.

3.1.6 Noise

The equipment shall as far as possible not generate undue vibrations or bothersome noise. Provided nothing else is specified the following requirements shall not be exceeded:

- Machine hall, workshop etc. (one meter from the machine) max 85 dB(A)
- Office, control room, day room etc. max 55 dB(A)
- Emergency diesel generator (7 meters from engine room) max 85 dB(A)

3.1.7 Auxiliary Power

3.1.7.1 Electric Service during Construction

The contractor shall ensure the availability of metered electric supply at 415/230V, 3-phase, 50 Hz TN-S at the substation sites. All tools and equipment supplied by the Contractor shall be suitable for this supply system.

3.1.7.2 Power Supply

On HV substations the power for the auxiliary service is in general supplied from the station transformers connected to the tertiary windings of the transformers whereas on MV substations the, power is supplied from station transformers connected to the MV busbars. The system is shown in detail on the single-line diagrams enclosed in the drawing section and further specified in Scope of Work. Less important MV substations may take the auxiliary voltage from the general surrounding grid. Equipment needing uninterruptable supply shall be fed from permanently charged station batteries. If other voltage sources or voltage levels are required, they shall be included in the Bid. Such voltages shall not be brought out of the cabinet where they are used.

All the substations that have more than one source shall have an automatic change-over scheme for the two 415Vac power supply sources at the substations

3.1.8 AC Auxiliary Supply

Components in the AC low voltage main distribution system shall have a voltage rating of 415/230 volts, 50 Hz. The system shall be 3-phase-4wire, with the transformer neutral grounded (TN-CS)

For lighting, small power socket outlets, domestic appliances and other small power, 230V shall be used. 16A sockets shall be of the British Standard type with square pins.

3.1.9 DC Auxiliary Supply

The DC auxiliary supply shall be (unless otherwise stated in Scope of Works):

- For control, protection and alarm circuits shall be 110V-IT

All bulbs and any voltage sensitive relays shall be rated 125/52Vdc.

3.1.10 Un-interrupted supply (UPS)

DC/AC UPS shall supply dedicated computer and measuring equipment. The supply shall be 230 V-IT.

3.1.11 Operation and Control

The operations, control procedures, monitoring and protective devices for the plants are described in Particular Technical Specifications.

The Contractor shall take all measures and furnish all requirements necessary for effecting the intended method of operation and control.

The station functional control shall be possible in a hierarchic structure as follows:

- <u>Supervisory Control</u> from a Supervisory Control and Data Acquisition (SCADA) System. All voltage levels will be connected to Regional Control Centres (RCCs) in Nairobi. All equipment and stations to be refurbished under this project shall be prepared for normal day-to-day operation from these centres. The RCCs are subordinated to the National Control Centre (NCC). The station HV and LV switchgear shall be controlled from RCC. Indications shall be available both in NCC and RCC.

- Local Control from the local relay and protection panels and from the instrument sections on MV switchboards. If these contains full mimic and display functions the remote control can be omitted in MV panels.

- Direct Control/Emergency Control from the apparatus itself.

The stations shall function without interruptions even if connection to higher levels fails. A local/remote switch shall be accommodated on each control position blocking remote operation but not indication. **The position of this switch shall be indicated in the higher levels of operation**.

The control shall include operation of all circuit breakers and motorized disconnectors. Status indication shall be available in the supervisory system for all HV and MV breakers in the system as well as Bus bar voltages, line and transformer load in Ampere (plus MW and MVAr). For on-load tap changers position indication and raising/lowering of the tap changer position shall be possible supervisory and remotely. MV transformers may be equipped with automatic voltage control functions and manual override shall then only be possible if the automatic function is blocked locally. Relay trips and other relevant alarms shall also be transferred.

Direct control of all station switchgear at the respective switchyards/panels shall be possible.

Interlocking devices and automatic change-over systems shall be incorporated in the control circuits in the quantity needed to guarantee non-interruption and correct sequence of operation of the equipment. Protective devices shall be supplied in accordance with the Particular Technical Specifications, and the particular needs of such equipment furnished with the aim of ensuring a safe and reliable operation of the plants in the event of electrical and mechanical disturbances or in case of mal-operation by the plant personnel shall be taken into consideration.

The signals and command to be transmitted are given in Particular Technical Specifications

All equipment, instruments and devices in the substation necessary for supervisory, remote and local control as well as for protection, signaling and indication shall be included in the Bid and hence the Contract, it being understood so that the enumeration found in Scope of Works, in this respect is indicative but not limiting.

3.1.12 Interface between Contractors and towards Employer

For substations to be upgraded, all connections shall be made and all equipment and drawings be provided by the Contractor to ensure proper operation of the complete plants, although this should not be specifically mentioned in the Scope of Works Section. The Employer will for such stations, supply to the Contractor within one month from the date of commencement all documentation available for adaptation to the existing plant.

All equipment specified under the various lots within a plant. Specified in the Particular Technical Specifications and Scope of Works shall constitute a complete and functioning system together with equipment covered by any other lot even if this lot is contracted by separate contractor. The Contractor shall pay special attention to the Power Transformers. All necessary equipment and connections required to form a complete working plant and not mentioned under the Power transformer shall be included in the switchgear contract whether or not specifically mentioned in these Particular Technical Specifications.

The Contractor shall supply and execute all cable connections between the control room and the transformer marshalling boxes and cabinets as well as supply all AC power for motors and DC voltage for control, indication and alarm purpose. The Contractor shall also provide all necessary connections to the control system from other sources like voltage and current transformer terminals, etc.

The Contractor shall connect the transformer to the grid and supply clamps for the transformer bushing. He shall also design and construct the transformer foundations based on Transformer Contractor's specifications and drawings and supply and erect LV cables from auxiliary transformer terminals to the auxiliary voltage board.

For the substations to be refurbished or extended the Contractor shall provide and make drawings of the cable connections from actuators, sensors, transducers and relays to the Distributed Control Units as well as all materials required. He shall also document the adaptation to the existing plant with complete circuit diagrams, cable lists etc. including proper cross references.

The Contractor shall connect the switchgear to the line landing span erected by the Line Contractor.

SECTION V- SCOPE OF WORK

PRIMARY DISTRIBUTION SUBSTATIONS

AND

ASSOCIATED LINES

TABLE OF CONTENTS

4.0 General Scope for Substations Works 33
4.1 General....33
4.1.1 Standard Substation....33
4.2 132 KV Bay....34
4.2.1 Transformer Bay....34
4.2.2 Line incomer Bay....34
4.2.3 Bus coupler protection....35
4.3 66 kV Bay… 36
4.3.1 Transformer Bay....38
4.3.2 Feeder Bay....38
4.3.3 66kV Bus bar protection....38
4.4 33 kV Bay....39
4.4.1 Transformer Bay....39
4.4.2 Feeder Bay....39
4.4.3 33KV Bus bar Protection....40
4.4.4 Transformer for auxiliary supply....41
4.4.5 33 KV Switching station....41
4.4.6 11KV Bays out AIS Switchgear type....41
4.4.7 11KV Feeder Bay....42
4.4.8 Auxiliary transformer Bay…....42
4.4.9 11KV Indoor Switchgear panel....42
4.4.10 11KV transformer Incomer panel....42
4.4.11 11KV Feeder Indoor panel....43
4.4.12 11KV Indoor Bus section.... 43
4.4.13 11KV Auxiliary transformer panel....44
4.4.14 11KV Power cables for transformer incomer....44
4.4.15 11KV feeder out power cables....44
4.4.16 Substation Automation, Protection and Control… 45
4.4.16.1 Substation Automation system....45
4.4.16.2 SAS for 7.5MVA transformer and above....45
4.4.16.3 Control and measurement cables....47
4.4.17 Telecommunication system....47
4.4.17.1 Scope of telecommunication system....47
4.4.17.2 VHF 2-Way radio Base station… 48
4.4.18 Ancillary AC supply equipment....49
4.4.18.1 Main AC distribution Board....49
4.4.18.2 Sub distribution boards....49
4.4.18.3 Cable Accessories....49
4.4.18.4 DC Supply equipment....49
4.4.18.5 Batteries....49
4.4.18.6 Charger....49
4.4.18.7 DC System distribution board… 50
4.4.18.8 Battery conductors....50
4.4.18.9 Sub distribution board....50
4.4.19 Earthing system....50
4.4.19.1 Auxiliary equipment....51
4.4.20 Power Transformers Vector group....51
4.4.21 Outdoor Current transformer technical data....52
4.4.22 Outdoor Voltage transformer technical data....52

4.4.23 Outdoor substation Bus bar materials……………………………………….…....53
4.4.24 Civil works……………………………………………………………….......53
4.4.24.1 Platform works…………………………… ………………………………..53
4.4.24.2 Switchgear Building……………………..…………………………………53
4.4.25 Training…………………………………..………………….…………...54
4.4.26 Factory acceptance tests……………………………………………...………. 54
4.4.27 Communication equipment and tools……………………………………........54
4.4.28 Final documentation…………………………………………...…………54
4.5 Facilities for KPLC Project implementation team…………………………………55
4.6 General Scope of work for 33KV and 11KV Lines…………………………...…..55
4.6.1 Factory accept test for Line materials and equipment…………………………..…56
4.6.2 Overhead lines and Cable circuits…………………………………..………....56
4.6.3 Factory Acceptance Test………………………………………………………...…..56
4.7 Definite scope of Proposed 33/11KV Substation and Lines……………………....58
4.7.1 Bondo 7.5MVA 33/11KV Substation and lines……………………………………58
4.7.2 Mbitini 2.5MVA 33/11KV Substation and Lines……………………………….....60
4.7.3 Maraba 7.5MVA 33/11KV Substation and lines…………………………..…63

4.0 GENERAL SCOPE OF SUBSTATIONS WORK

4.1 General

The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents.

Special attention shall be paid to General Specifications and Particular Technical Specifications, in which the general technical requirements are specified. The drawings enclosed in are for bidding purposes only.

If the Specifications and/or Drawings do not contain particulars of materials or goods, which are necessary for the proper and safe completion, operation, and maintenance of the equipment in question, all such materials shall be deemed to be included in the supply.

In the event of any conflict between the Drawings and the Specifications, the latter shall prevail.

In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.

Should the Bidder find discrepancies in or omissions from these Specifications or from the other Documents, or should he be in doubt as to their meaning, he should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting his Bid. Such action shall, however, in no case be considered as a cause for altering the closing date of the Bid.

The scope of work for equipment shall cover engineering design, manufacture, testing before shipment and packing sea worthy or otherwise as required, delivery duty paid (DDP) site, of all equipment as specified in the preceding chapters.

For substations contracted on turn-key basis the substation contractor shall be responsible for design, supply material, transport, erection, installation, test and commissioning as well as having the full responsibility for civil works including design and construction of transformer foundations and control building.

The Contractor shall design and construct the transformer foundations with oil collection pit, oil trap (Oil interceptor) and fire damper consisting of crushed stones laying on a galvanized steel grating. Fire wall shall be constructed where necessary.

Loose equipment for the Employer’s rehabilitation shall be complete with documentation and ancillaries like programs, licenses and programming tools.

Equipment that is to be dismantled and removed from existing substations is to be recovered by the Contractor and deposited to sites within or in the immediate vicinity of each substation. Such sites are to be designated by the Employer. The recovered equipment/materials are to be handed over by employer.

4.1.1 Standard Substation

This section defines the standard substation components. The actual scope and bill of quantities to be used in price schedules for each substation are summarized in the subsequent sections.

4.2 132 kV Bays

4.2.1 Transformer Bay

One complete bay shall be equipped with:

a. 1 (One) HV and 1 (One) MV Circuit breaker
b. 1 (One) HV and 1 (One) MV motorised isolator
c. 2 (two) sets of busbars materials and post insulators (HV and MV)
d. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and to and between the apparatus.
e. 2 (two) set of current transformers (HV and MV)
f. 1 (one) MV neutral current transformer with neutral isolating link
a. 2 (two) set of surge diverters (HV and MV) installed close to the power transformer
g. 1 (one) set of steel structures for support
h. Numerical automatic voltage regulating relay (AVR) compliant to IEC61850 standards
i. 2 (two) Control panels (HV and MV) equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):

    i. 2 (two) bay control unit with control and measurement
    ii. 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW
    iii. Set of Mimic, Semaphores, indications, discrepancy switches and instruments
    iv. Annunciation relay for Alarms and trips
    v. Set of trip circuit supervision relay
    vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

j. 2 (two) Protection panels equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection)
    i. 1 (one) restricted fault IED
    ii. 1 (one) differential protection IED
    iii. HV and MV overcurrent and earth fault protection IED.
    iv. 1 (one) MV neutral point earth fault relay function
    v. 2 (two) lock-out trip relay with electrical and hand reset facilities (HV and MV)
    vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation.

4.2.2 Line Bay

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) earthing switch
d. 1 (one) set of busbars materials and post insulators
e. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
f. 1 (one) set of current transformers
g. 1 (one) set of voltage transformers
h. 1 (one) set of surge diverters
i. 1 (one) set of steel structures for support
k. 1 (one) Control panel equipped with a minimum of the following IEDs and components as per paragraph 5.16 (HV and LV system protection)
    i. 1 (one) bay control unit with control and measurement
    ii. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii. 1 (one) tariff energy meter
    iv. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    v. Annunciation relay for alarms and trips
    vi. Set of trip circuit supervision relays
    vii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation
l. 1 (one) Protection panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
    i. 1 (one) sensitive earth fault function
    ii. 1 (one) multifunctional line protection IED unit with both line distance and line differential functions.
    iii. HV overcurrent and earth fault protection IED.
    iv. 1 (one) lock-out trip relay with electrical and hand reset facilities
    v. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.3 Bus Section / Bus Coupler

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) set of busbars materials and post insulators
d. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
e. 1 (one) set of current transformers
f. 2 (two) set of voltage transformers
g. 1 (one) set of steel structures for support

h. 1 (one) Control panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. 1 (one) bay control unit with control and measurement
   ii. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iv. Annunciation relay for alarms and trips
   v. Set of trip circuit supervision relays
   vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation

i. 1 (one) Protection panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. HV overcurrent and earth fault protection IED.
   ii. 1 (one) lock-out trip relay with electrical and hand reset facilities
   iii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.4 Bus Bar Protection

1 (one) bus bar protection and control panel with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation
   ii. Annunciation relay for alarms and trips
   iii. 1 (one) lock-out trip relay with electrical and hand reset facilities

1 (one) multifunctional IED unit with busbar protection function

4.3 66 kV Bays

4.3.1 Transformer Bay

1 (one) complete bay (HV and MV) shall be equipped with:
a. 1 (One) HV and 1 (One) MV Circuit breaker
b. 1 (One) HV and 1 (One) MV motorised isolator
c. 2 (two) sets of busbars materials and post insulators (HV and MV)
d. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and to and between the apparatus.
e. 2 (two) set of current transformers (HV and MV)
f. 1 (one) MV neutral current transformer with neutral isolating link
b. 2 (two) set of surge diverters (HV and MV) installed close to the power transformer
g. 1 (one) set of steel structures for support
h. Numerical automatic voltage regulating relay (AVR) compliant to IEC61850 standards
i. 2 (two) Control panels (HV and MV) equipped with a minimum of the following as per paragraph 5.16 (HV and LV system protection):
   i. 2 (two) bay control unit with control and measurement

ii. 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW
iii. Set of Mimic, Semaphores, indications, discrepancy switches and instruments
iv. Annunciation relay for Alarms and trips
v. Set of trip circuit supervision relay
vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

j. 2 (two) Protection panels equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
i. 1 (one) restricted fault IED
ii. 1 (one) differential protection IED
iii. HV and MV overcurrent and earth fault protection IED.
iv. 1 (one) MV neutral point earth fault relay function
v. 2 (two) lock-out trip relay with electrical and hand reset facilities (HV and MV)
vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation

4.3.2 Feeder Bay

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) earthing switch
d. 1 (one) set of busbars materials and post insulators
e. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
f. 1 (one) set of current transformers
g. 1 (one) set of voltage transformers
h. 1 (one) set of surge diverters
i. 1 (one) set of steel structures for support
j. 1 (one) Control panel equipped with a minimum of following IEDs and components 1 (one) bay control unit with control and measurement
i. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
ii. 1 (one) tariff energy meter
iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
iv. Annunciation relay for alarms and trips
v. Set of trip circuit supervision relays
vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation

k. 1 (one) Protection panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. 1 (one) sensitive earth fault function
   ii. 1 (one) multifunctional line protection IED unit with both line distance and line differential functions.
   iii. HV overcurrent and earth fault protection IED.
   iv. 1 (one) lock-out trip relay with electrical and hand reset facilities
   v. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.3.3 66kV Busbar Bay (Bus Coupler/ Section)

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) set of busbars materials and post insulators
d. 1 (one) complete set of three-phase line including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
e. 1 (one) set of current transformers
f. 2 (two) set of voltage transformers
g. 1 (one) set of steel structures for support
h. 1 (one) Control panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. 1 (one) bay control unit with control and measurement
   ii. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iv. Annunciation relay for alarms and trips
   v. Set of trip circuit supervision relays
   vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation
i. 1 (one) Protection panel equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
   i. HV overcurrent and earth fault protection IED.
   ii. 1 (one) lock-out trip relay with electrical and hand reset facilities
   iii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.3.4 Bus Bar Protection

1(one) bus bar protection and control panel with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):

i. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation
ii. Annunciation relay for alarms and trips
iii. 1 (one) lock-out trip relay with electrical and hand reset facilities
iv. 1 (one) multifunctional IED unit with busbar protection function

4.4 33 kV Bay

4.4.1 Transformer Bay

1 (one) complete bay (MV and LV) shall be equipped with:

c. 1 (One) MV and 1 (One) LV Circuit breaker
d. 1 (One) MV and 1 (One) LV motorised isolator
e. 2 (two) sets of busbars materials and post insulators (MV and LV)
f. 1 (one) complete set of three-phase line conductor including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and to and between the apparatus.
g. 2 (two) set of current transformers (MV and LV)
h. 1 (one) LV neutral current transformer with neutral isolating link
i. 2 (two) set of surge diverters (MV and LV) installed close to the power transformer
j. 1 (one) set of steel structures for support
k. Numerical automatic voltage regulating relay (AVR) compliant to IEC61850
l. 1 (one) Control panel (MV and LV) equipped with a minimum of following IEDs and components as per paragraph 5.16 (HV and LV system protection):
    i. 1 (one) bay control unit with control and measurement
    ii. 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW
    iii. Set of Mimic, Semaphores, indications, discrepancy switches and instruments
    iv. Annunciation relay for Alarms and trips
    v. Set of trip circuit supervision relay
    vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

m. 1 (one) Protection panel equipped with a minimum of following IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):
    i. 1 (one) restricted fault IED
    ii. 1 (one) differential protection IED
    iii. MV and LV overcurrent and earth fault protection IED.
    iv. 1 (one) LV neutral point earth fault relay function
    v. 2 (two) lock-out trip relay with electrical and hand reset facilities (MV and LV)
    vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation

4.4.2 Feeder Bay

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) earthing switch
d. 1 (one) set of busbars materials and post insulators
e. 1 (one) complete set of three-phase line conductor including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
f. 1 (one) set of current transformers
g. 1 (one) set of voltage transformers
h. 1 (one) set of surge diverters

i. 1 (one) set of steel structures for support

j. 1 (one) Control panel equipped with a minimum of IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):
   i. 1 (one) bay control unit with control and measurement
   ii. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii. 1 (one) tariff energy meter
   iv. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   v. Annunciation relay for alarms and trips
   vi. Set of trip circuit supervision relays
   vii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation

k. 1 (one) Protection panel equipped with a minimum of IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):
   i. 1 (one) sensitive earth fault function
   ii. 1 (one) multifunctional line protection IED unit with line distance protection function.
   iii. MV overcurrent and earth fault protection IED.
   iv. 1 (one) lock-out trip relay with electrical and hand reset facilities
   v. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.4.3 33kV Busbar Bay (Bus Coupler/ Section)

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) set of busbars materials and post insulators
d. 1 (one) complete set of three-phase line conductor including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
e. 1 (one) set of current transformers
f. 2 (two) set of voltage transformers
g. 1 (one) set of steel structures for support
h 1 (one) Control panel equipped with a minimum of IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):
   i. 1 (one) bay control unit with control and measurement
   ii. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iv. Annunciation relay for alarms and trips
   v. Set of trip circuit supervision relays
   vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation

i 1 (one) Protection panel equipped with a minimum of IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):

i. MV overcurrent and earth fault protection IED.
ii. 1 (one) lock-out trip relay with electrical and hand reset facilities
iii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.4.4 Auxiliary transformer bay

1 (one) complete bay equipped with:

i. 1 (one) 100kVA 33/0.415 kV Dyn11 auxiliary transformer
ii. 1 (one) set of 33kV drop out expulsion fuses
iii. 1 (one) set of busbars jumpers and steel support structures
iv. 1 (one) Set of 33kV Surge diverters

4.4.5 33kV Switching Station

1 (one) complete bay shall be equipped with:

a. 4 (four) auto recloser with bypass switch, isolating links and surge arrestors
b. 4 (four) 33kv Isolators
c. Auxiliary supply transformer 50kVA 33/0.415kV
d. 1 (one) set of busbars materials and insulators
e. 1 (one) complete set of three-phase line conductors including clamps for the busbars
f. 1 (one) set of surge diverters
g. 1 (one) set of support structures
h. 1 (one) prefabricated building

4.4.6 11 kV Bays Outdoor Switchgear Type

4.4.7 11 kV Feeder Bay

1 (one) complete bay shall be equipped with:

a. 1 (one) circuit breaker
b. 2 (two) isolators with motor operation
c. 1 (one) earthing switch
d. 1 (one) set of busbars materials and post insulators
e. 1 (one) complete set of three-phase line conductor including clamps for the flying busbars and for connection between the gantries, to the busbars and to and between the apparatus.
f. 1 (one) set of current transformers
g. 1 (one) set of surge diverters
h. 1 (one) set of steel structures for support
i. 1 (one) Control & Protection panel equipped with a minimum of IEDs and components as per Particular technical specifications paragraph 5.16 (HV and LV system protection):

i. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW, W
ii. 1 (one) tariff energy meter
iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
iv. Annunciation relay for alarms and trips
v. Set of trip circuit supervision relays

vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay protection & control which shall be prepared for SCADA operation
vii. 1 (one) multifunctional bay control & protection unit with control and measurement
viii. 1 (one) sensitive earth fault function
ix. 1 (one) LV Overcurrent & Earth Fault protection function.
x. 1 (one) lock-out trip relay with electrical and hand reset facilities

4.4.8 Auxiliary Transformer Bay

1 (one) complete bay equipped with:

i. 1(one) 100kVA 11/0.415 kV Dyn11 auxiliary transformer
ii. 1 (one) set of 11kV drop out expulsion fuses
iii. 1 (one) set of busbars jumpers and steel support structures
iv. 1 (one) Set of 11kV Surge diverters

4.4.9 11 kV Indoor Switchgear Panels

4.4.10 11 kV Transformer incomer panel

1 (one) complete bay shall be equipped with:

a) 1 (one) Withdrawable circuit breaker
b) 1 (one) earthing switch
c) 1 (one) set of busbars
d) 1 (one) set of current transformers
e) 1 (one) Control & Protection panel equipped with a minimum of following IEDs and components as per Particular technical specifications paragraph 8.12 (MV Indoor switchgear panel):
   i. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   ii. 1 (one) tariff energy meter
   iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iv. Annunciation relay for alarms and trips
   v. Set of trip circuit supervision relays
   vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay protection & control which shall be prepared for SCADA operation
   vii. 1 (one) multifunctional bay control & protection unit with control and measurement
   vi. 1 (one) sensitive earth fault function
   vii. 1 (one) LV Overcurrent & Earth Fault protection function.
   viii. 1 (one) lock-out trip relay with electrical and hand reset facilities.
f) 1 (one) set of voltage transformers (with a facility for primary isolation)

4.4.11 11 kV Feeder indoor panel

1 (one) complete bay shall be equipped with:

a) 1 (one) Withdrawable circuit breaker
b) 1 (one) earthing switch
c) 1 (one) set of busbars
d) 1 (one) set of current transformers

e) 1 (one) Control & Protection panel equipped with a minimum of following IEDs and components as per Particular technical specifications paragraph 8.12 (MV Indoor switchgear panel):
   - i. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   - ii. 1 (one) tariff energy meter
   - iii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   - iv. Annunciation relay for alarms and trips
   - v. Set of trip circuit supervision relays
   - vi. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay protection & control which shall be prepared for SCADA operation
   - vii. 1 (one) multifunctional bay control & protection unit with control and measurement
   - ix. 1 (one) sensitive earth fault function
   - x. 1 (one) LV Overcurrent & Earth Fault protection function.
   - xi 1 (one) lock-out trip relay with electrical and hand reset facilities.

4.4.12 Indoor Bus - Section panel

1 (one) complete bay shall be equipped with:

(a) 1 (one) withdrawable circuit breaker
(b) 1 (one) set of current transformers.
(c) 2 (two) earthing switches (one on each busbar section if not located elsewhere)
(d) 1 (one) set of busbars including droppers and risers
(e) 2 (two) set of voltage transformers (one on each busbar section if not located elsewhere, with a facility for primary isolation)
(f) 1 (one) Control & Protection panel equipped with a minimum of following IEDs and components as per Particular technical specifications paragraph 8.12 (MV Indoor switchgear panel):
   - i. 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   - ii. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   - iii. Annunciation relay for alarms and trips
   - iv. Set of trip circuit supervision relays
   - v. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay protection & control which shall be prepared for SCADA operation
   - vi. 1 (one) multifunctional bay control & protection unit with control and measurement
   - vii. 1 (one) LV Overcurrent & Earth Fault protection function.
   - viii. 1 (one) lock-out trip relay with electrical and hand reset facilities

4.4.13 Auxiliary Transformer Panel

1 (one) complete bay equipped with:

a) 1 (one) 11kV withdrawable motorized fuse switch
b) 1 (one) earthing switch
c) 1 (one) set of busbars
d) 1 (one) Control & Protection panel equipped with a minimum of following IEDs and components as per Particular technical specifications paragraph 8.12 (MV Indoor switchgear panel):
   - i. Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.

ii. Annunciation relay for alarms and trips
iii. 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control.

4.4.14 Power Cables from Power transformer to 11kV Indoor Switchgear

(a) 1 (one) lot of 11 kV cable from main transformers to 11 kV switchgear, rated for 120 % of nominal transformer rating
(b) 1 (one) lot of 11 kV cable terminations for transformer and switchgear connection
(c) 1 (one) lot of support structures for power cable support at the power transformer
(d) 1 (one) lot of 11 kV cable from switchgear to auxiliary transformer
(e) 1 (one) lot of 11 kV cable terminations for auxiliary transformer and switchgear connection
(f) 1 (one) lot of steel support structures for the power cables of the auxiliary transformer.

4.4.15 Power Cables from Indoor Switchgear to 11kV Take Off Structure

a) 1 (one) lot of 11 kV cable from indoor 11 kV switchgear to take off structure
b) 1 (one) lot of 11 kV cable terminations for switchgear connection (indoor termination kit) and line connection (outdoor termination kit)
c) 1 (one) lot of support structures for cable terminations and surge arrestors on take-off structure

4.4.16 Substation Automation, Protection and Metering

4.4.16.1 Substation Automation System

General

1 (one) lot complete substation automation system (equipment and software) for substation control.
To the extent the internal control and interlocking system for the equipment supplied is not included for that particular equipment, it shall be included herein. All interconnections needed to form a complete installation shall also be included herein.

The control system specified hereunder shall include all necessary equipment for control, protection, metering and signaling. The system shall include all instruments, meters, switches, position indicators, inscriptions and mimic diagrams, protective and auxiliary relays, terminal blocks, internal wiring and any other equipment required to form a complete installation.

Drawings showing the control system, protection units and the boards as they are proposed shall be supplied with the Bid.

The space needed for the boards should not exceed the available space.

Information defining the internal local control communication protocol shall be submitted with the Bid.
Complete sets of schematic diagrams for control, protection, indication, metering, signaling, alarms, etc. shall be supplied as part of the project and shall be subject to the Project Manager's approval.

The requirements as to submission of diagrams, drawings and other documents with the Bid and after award of Contract are stated in the standard form of contract.

4.4.16.2 Scope of Substation Automation System (SAS)

a) Substation Automation System (SAS) for 132/66/33/11kV substation with 7.5 MVA transformer and above.

The system scope shall include detailed system design, manufacture, supply, installation, testing, and commissioning of complete functional SAS system.

The proposed SAS system shall at least have the following functionality: -

a) Full operational Control, Monitoring, Reporting, Alarm, Signaling and Indications facilities for NCC/RCC station control (Supervisory level).
b) Full operational control, Monitoring, reporting, alarm and indications facilities for the substation from the Human Machine interface (HMI) workstations in the substation control room (Substation Level).
c) Operational control of each new circuit/bay from the protection relay panel using the bay control unit LCD display (Bay level).
d) Control of each item of plant from the Local Control Cubicle (LCC) (Local Level)
e) The control facilities from each control point are to be interlocked (hardwired) to prevent operation of any device simultaneously from more than one control point.
f) At least one fully operational control point shall remain available in the event of a single equipment or communications failure.
g) 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
h) The SA system shall use open communication protocols and be readily interfaced with third part devices operating on open protocols (IEC61850, IEC60870-101/104). The Tenderer shall describe such interfaces and provide an experience list of devices with which the offered control system has previously been interfaced.
i) The integration works of the SAS to existing SCADA System shall not be included in the scope. However, contractor shall provide and clearly label all the required signals and commands for Telecom and SCADA integration at the control panels' Terminal Block.

Station Level

At station level proposed SAS shall typically include but not limited to following features:

a) 2 Independent Gateways (Main and Hot-standby) for communications to the SCADA system
b) Configuration and parameterization software with onetime licenses fully paid.
c) 1 Operator Workstation/HMI-OWS, and the complete workplace (desk, chair & File cabinet).
d) 1 Engineering Work Station-EWS (Industrial) to be installed in Panel.
e) Color printer. To print screen shots
f) Satellite clock, complete with GPS Receiver, Antenna and necessary time synchronization ports.
g) Interface for laptop computer for maintenance, information transfer and emergency HMI
h) Laptop Computer for maintenance, information transfer and emergency HMI
i) UPS system for SCMS/ SAS (including OWS, EWS and Printers).
j) Communication network equipment [station (system) LAN, Field Communication Network, Various optical couplers, etc.].
k) Interface for control and monitoring of the circuit/bay.

SCADA Interface

(a) 1 (one) lot complete system (equipment and software), with communication gateway, data concentrator etc. for interface to a regional (RCC) SCADA system and to the national (NCC) SCADA system. using IEC60870-101/104 protocols.

- The integration works of the SAS to existing SCADA System shall not be included in the scope. However, contractor shall implement stage three (3) of Scada and telecommunication system i.e. testing to ensure all substation level signals and commands are received at NCC or RCC for the purpose of KPLC integration.
- Contractor shall provide and clearly label all the required signals and commands for Telecom and SCADA integration at the Control panels' terminal block.

b) Substation Automation System (SAS) for 33/11kV substation with 2.5 MVA transformer up to 7.5 MVA.

The system scope shall include detailed system design, manufacture, supply, installation, testing, and commissioning of SAS system comprising of:

- 1 (One) RTU (Remote terminal unit) fully wired functional panel with all necessary accessories
- 2 (two) Multiplexer Switch IP620 with Ethernet LAN switches. One for main station and another for integration with RCC.
- Set of SFP modules necessary for integration with existing SAS system Multiplexer
- Set of patch cords and ethernet cables necessary for Bay interconnections.
- 110 to 48Vdc supply Converter for RTU auxiliary supply.
- At station level the SAS system shall not have HMI Work stations for control and operation

SCADA Interface

- The integration works of the SAS to existing SCADA System shall not be included in the scope. However, contractor shall implement stage three (3) of Scada and telecommunication system i.e. testing to ensure all substation level signals and commands are received at NCC or RCC for the purpose of KPLC integration.

4.4.16.3 Control and Measuring Cables

(a) All external cables, conventional or fibre optical, for control, protection, measuring, indication, etc., for the complete plant. Wiring between the switchyard apparatus, transformers, the board(s) and the control system in the control building and the interconnections between the various apparatus in the switchyard shall be included.

4.4.17 Telecommunication System

i. The system shall have telecommunication based primarily on Fiber (OPGW and ADSS) multiplexers and on some cases Base radio stations shall be established linking various equipment in substations to Regional Control Centers (RCCs). It shall include all necessary equipment in substations and Control Centers as described in varies sections of work scope under telecommunication.

ii. In order for the SCADA data to be transferred to the Regional Control Centers, the bidder shall design and commission an appropriate communication system based on Fiber, PLC, Radio or other approved communication media for data and speech requirement.

iii. Equipment supplied shall be digital and latest technology and shall comply to the latest ITU-T, IEC, ITU-R, IEEE and ETSI standards.

iv. It is required that one remote subscriber be implemented in each substation.

v. Interface for data transmission shall be according to ITU-T recommendation V.24 or V.35 Bit error rates of $1x10^{-6}$ shall not be exceeded.

vi. It is the responsibility of the contractor to interconnect with existing SCADA and Telecommunications system. However, use and extension of existing infrastructure where possible shall be encouraged.

vii. The Tenderer shall acquaint himself with all the sites and determine the requirements for towers or masts to suit his design. When a new tower or mast is necessary, the contractor shall supply drawings for the proposed installation. All towers shall be 36 m and self-supporting. The contractor shall provide details of loading and guy stresses for masts or towers to be erected on buildings. All antennae mounting components including wave-guides, cables, cable clamps and external cable connectors shall be specified.

viii. All communications equipment installed in the country must be type approved by the Communications Authority of Kenya (CAK). The Contractor will obtain the type approval.

ix. The CAK has to be consulted and give approval for each new project and an application has to be submitted stating the location of the sites and request for the frequencies to be used. Unless otherwise stated this application for frequencies is normally done by KPLC.

x. The radio frequency plan shall be prepared by the Contractor and closely coordinated with KPLC during the project design stage. All path surveys shall be carried out by contractor.

xi. The Contractor shall provide a list of recommended spares, the quantities and prices to last for a period of five (5) years after expiry of guarantee period.

xii. The contractor shall offer training for five (5) technical appointees of the employer for 2 weeks at manufacturer's premises.

xiii. The contractor shall provide necessary configuration software pre-installed on a maintenance laptop with a one-time software license.

4.4.17.1 Scope of Telecommunication system

The scope for 132/66/33/11 substation with a 10 MVA transformer and above shall include detailed system design, manufacture, supply, installation, testing, commissioning, remedying of defects, maintaining the works during the defects liability period and any incidental work necessary for the proper completion of the work in accordance with this contract. Scope shall include integration of STM-1/4 and IP phone system to the existing KPLC Network Management System. In some cases, there shall be need to upgrade existing.

Telecommunication equipment in order to achieve data and speech routing to regional and national control centers. Survey and necessary preparation work on existing systems, Equipment and substations to achieve specified functionality shall be in the scope of supply. All stations shall be equipped with two (2N0.) IP telephones extensions communicating with RCC and NCC via fibre optic.
All communication equipment supplied under this project shall be type approved by the regulator, Communication Authority of Kenya (CAK) and the Kenya Bureau of Standards (KBS) where applicable. It is the responsibility of the contractor to obtain these necessary approvals.

The telecommunication system scope for 33/11kV substation with a 2.5MVA transformer and below shall be achieved by installation of 2-way Base radio station and integrating it to region control centers or as shall be specified in the defined scope of work or in the bill of quantities for equipment.
Minimum technical requirement for a 2-way base radio station are summarized below:

4.4.17.2 Specifications for VHF 2-Way Base Radio station

No	Description
1	Motorola base station AAPX 2500 digital Vhf Radio Freq;138-150MHZ or its internationally equivalent type. *Flash port code:* Complete with:12 to 20Vdc PWR cable, desk microphone, desk tray etc.
2.	Fiberglass: Collinear base station Omni-directional 3db antenna 138-150MHZ range
3.	30 Meters Rg 213 Coaxial cable
4.	Mini-UHF Crimp type connector to N-MALE RG213, 2Mtr RG58 N-Male/Mini-UHF pigtail Jumper
5.	Power Supply Unit/Battery Charger
6.	RS-232 Programming cable or equivalent type
7.	Most current Programming software
8.	75 or 70 Ah 12V DC Free maintenance battery
9.	6 Meter 1-1/2 Galvanized pipe complete with support arms brackets for mounting antenna

4.4.18 Auxiliary AC Supply equipment

4.4.18.1 Main AC Distribution board

1 (one) main distribution board rated 250A minimum for a 7.5MVA substation and above, shall be supplied with all necessary panels and accessories as indicated below:

(a) Auto change Over switch for two 415VAC supply sources shall be to be incorporated in the board. The Auto Change Over scheme switch shall be for a 23MVA substations capacity and above.

(b) 2 (two) circuit breaker and busbars rated 250A minimum, manual and auto operated for each incomer from the station supply transformers.

(c) 2 (two) current transformers 250/1/1 A with two cores, one core for measuring and one for protection.

(d) 1 (one) constant time overcurrent IED for each incomer.

(e) 1 (one) earth fault protection function for each incomer.

(f) 1 (one) A-meter function with selector switch for each incomer.

(g) 1 (one) V-meter function with selector switch for each incomer.

(h) 1 (one) lot of correct rated loads circuit breakers with electro-magnetic and thermal releases. Breaker ratings shall be chosen to suit the different consumers/loads to be connected. 20% of the breakers of each size shall be spare and readily mounted.

4.4.18.2 Sub-distribution Boards and Panels

1 (one) lot of all necessary sub-distribution boards and panels (including the distribution panel for lighting and small power of the control building). The boards shall be completely equipped with busbars, circuit breakers, miniature circuit breakers etc. contactors, motor starters, instruments, operating switches, push buttons, indicating lamps, etc., shall be included whenever required. 20% of the breakers of each size shall be spare and readily mounted.

4.4.18.3 Cables

1 (one) lot of all necessary armored copper power and control cables for supply to the main distribution board and to sub-distribution boards, panels and equipment except for the cables for lighting and small power points which are included in switchgear building materials.

4.4.18.4 DC Supply Equipment

4.4.18.5 Vented Nickel – Cadmium Batteries

i. 1 (one) 110 V battery bank with a capacity of at least 165Ah/10h for 66/33/11kV substations.
ii. 2 (two) 110 V battery banks with a capacity of at least 265 Ah/10h each for 132kV and 220 kV substation.
iii. 1(one) 48V battery bank with a capacity of at least 100 Ah/10h for telecommunication equipment and SCADA for 66/33/11kV substations
iv. 2(two) 48V battery banks each with a capacity of at least 200Ah/10h for telecommunication equipment and RTU for 132kV and 220kV substations
The battery capacities shall be based upon the calculated consumption considering a full developed substation, with the above minimum ratings.
Batteries shall be installed in separate room with proof ventilation fan and independent door opening from outside.

4.4.18.6 Charger

(a) 1 (one) DC charger for each 110 V battery bank.
(b) 1 (one) DC charger for each 48 V Battery bank.

The chargers shall be complete with instruments, breakers on AC and DC side, and protection. The chargers shall have auxiliary contacts for collection of status, alarms and measurands for connection to the SCADA system.
The charger to have a battery monitoring system.

Note 1 - *The battery and chargers shall meet KPLC and IEC specifications and general requirements*
Note 2 – *If the DC System ratings in the attached KPLC Specifications differ with the values given in the scope for the works, the parameters in the scope of works shall apply (prevail).*

4.4.18.7 DC System Distribution board

1 (one) switchboard each for 110 V DC System and 48V DC system.
The DC system board shall have.
(a) 1 (one) appropriately rated circuit breaker with magnetic and thermal release for each feeder from the charger and battery.
(b) 1 (one) appropriately rated tie breaker for each DC bus in the stations with 2 (two) battery banks.
(c) 1 (one) A-meter with shunt for each battery bank.
(d) 1 (one) V-meter with selector switch for the voltage between the poles and between poles and earth for each battery bank.
(e) 1 (one) set of contacts on the front for banana jacks for the battery voltage and earth.
(f) 1 (one) battery monitoring devices with alarm contacts.
(g) 1 (one) lot of all necessary circuit breakers and miniature circuit breakers for the outgoing feeders and circuits.
20% of the breakers of any size shall be spare and readily mounted.

4.4.18.8 Battery Conductors and Fuses/Circuit breakers

(a) 1 (one) set of single core conductor from each battery bank to the associated DC Chargers.
(b) 2 (two) single pole fuse boxes/Circuit breakers for the batteries, placed on the wall inside the battery room.

4.4.18.9 Sub-distribution boards and panels

1 (one) lot of all necessary sub-distribution boards and panels for the DC System.
The boards shall be completely equipped with busbars, miniature circuit breakers, fuses, etc. Contactors, motor starters, instruments, operating switches, push buttons, indicating lamps, under-voltage relays with alarm contact, etc., shall be included in the system.

4.4.18.10 Cables

1 (one) lot of all necessary DC power supply cables, including wiring to the equipment at switchyard.

4.4.19 Earthing System

An earthing system shall be installed comprising the following:

(a) 1 (one) lot of underground earthing system covering the platforms and control building with risers.

(b) 1 (one) complete set of "above-floor" earthing system for the control building, as applicable, with connections to the risers from the under-ground system.

4.4.19.1 Ancillary Equipment

The following ancillary equipment shall meet KPLC technical specifications:

4.4.19.2 Station Equipment

a) 2 (two) self-contained, rechargeable, portable hand-held lights.
b) 1 (one) audible alarm system with the necessary control wiring.
c) Emergency lighting system to be provided in the Substation Control Building.

4.4.19.3 Earthing Devices

a) 2 (two) set each of three phase portable earthing devices for outdoor 11 kV to 132 kV with operating link sticks suitable for earthing of substation bay conductors and busbars.
b) 2 (two) set of voltage indicator for 11 kV to 132 kV with audible and visual indication for the voltages.

4.4.19.4 Cable Accessories

a) 1 (one) lot of all connecting material, cable boxes and material for fixing the cables.
b) Terminals and terminal labels to the extent that this is not included in other sections.

4.4.19.5 Racks, Conduits and Ducts

a) 1 (one) lot of all cable racks and trays to the extent necessary for the proper distribution of cables.
b) Provide conduits, protection tubes and ducts, wherever cables may deteriorate or where cable laying may otherwise present difficulties during installation.

4.4.20 Power transformers

To be supplied as specified for each substation, and in accordance with below data

4.4.20.1 Type of transformers

Main data for the transformers that shall be supplied:

Pos.	Rating MVA (ONAN/ONAF)	Voltage	Tapping range	OLTC
1	35/45	132/66	±8 x 1.67%	yes
2	35/45	66/11	±8 x 1.67%	yes
3	18/23	132/66	±8 x 1.67%	yes
4	18/23	132/33	±8 x 1.67%	yes
5	18/23	66/11	±8 x 1.67%	yes
6	18/23	33/11	±8 x 1.67%	yes
7	7.5/N.A	33/11	±8 x 1.67%	yes
8	2.5/N. A	33/11	± 2 x 2.5 %	no

Transformers in Coastal region- shall be of vector group: Ynynd1 (with stabilizing winding).
Transformers in Mt Kenya region & Nairobi region – shall be of vector group: Dyn1
Transformers in West Kenya region – shall be of vector group: Dyn11

4.4.21 Outdoor Current transformer technical data

33kV and 66kV outdoor current transformers shall have cores whose Ratio, Class and Burden shall be as specified in table 4.3.2. LV and HV windings for the current transformers for this project shall be made of high-grade copper. Aluminium windings shall not the accepted in this contract. Where in the attached KPLC specifications require use of Aluminium or Copper windings, it shall be ignored.

Table 4.4.21.1: Outdoor Current transformer technical parameters (2.5MVA - 7.5MVA, 33/11kV Substation)

33kV			**11kV**		**11kV**	
Line Bay/ Transformer Bay HV)			**Transformer Bay (LV)**		**Feeder Bay**	
Core	Ratio	Class/Burden	Ratio	Class/Burden	Ratio	Class/Burden
1	400/200/100/1-1-1A	0.2/15VA	400/200/100/1-1-1A	0.2/15VA	400/200/100/1-1-1A	0.2/15VA
2	400/200/100/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA
3	400/200/100/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA
4	400/200/100/1-1-1A	X/Vk>350V Ik<30mA	400/200/100/1-1-1A	X/Vk>350V Ik<30mA	400/200/100/1-1-1A	X/Vk>350V Ik<30mA

Table 4.4.21.2: Outdoor Current transformer technical parameters (10MVA - 23MVA 33/11kV Substation)

33kV			11kV		11kV	
Line Bay/ Transformer Bay HV)			Transformer Bay (LV)		Feeder Bay	
Core	Ratio	Class/Burden	Ratio	Class/Burden	Ratio	Class/Burden
1	400/200/100/1-1-1A	0.2/15VA	1200/600/300/1-1-1A	0.2/15VA	400/200/100/1-1-1A	0.2/15VA
2	400/200/100/1-1-1A	5P20/15VA	1200/600/300/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA
3	400/200/100/1-1-1A	5P20/15VA	1200/600/300/1-1-1A	5P20/15VA	400/200/100/1-1-1A	5P20/15VA
4	400/200/100/1-1-1A	X/Vk>350V Ik<30mA	1200/600/300/1-1-1A	X/Vk>350V Ik<30mA	400/200/100/1-1-1A	X/Vk>350V Ik<30mA

Table 4.4.21.3: Outdoor Current transformer technical parameters (23MVA and above, 132/66kV Substation)

132kV			66kV		66kV	
Line Bay/ Transformer Bay (HV)			Transformer Bay (LV)		Feeder Bay	
Core	Ratio	Class/Burden	Ratio	Class/Burden	Ratio	Class/Burden
1	400/200/100/1-1-1A	0.2/15VA	400/200/1A	0.2/15VA	400/200/1A	0.2/15VA
2	400/200/100/1-1-1A	5P20/15VA	400/200/1A	5P20/15VA	400/200/1A	5P20/15VA
3	400/200/100/1-1-1A	5P20/15VA	400/200/1A	5P20/15VA	400/200/1A	5P20/15VA
4	400/200/100/1-1-1A	X/Vk>350V Ik<30mA	400/200/1A	X/Vk>350V Ik<30mA	400/200/1A	X/Vk>350V Ik<30mA

Table 4.4.21.4: Outdoor Current transformer technical parameters (23MVA and above, 132/33kV Substation)

132kV			33kV		33kV	
Line Bay/ Transformer Bay (HV)			Transformer Bay (LV)		Feeder Bay	
Core	Ratio	Class/Burden	Ratio	Class/Burden	Ratio	Class/Burden
1	400/200/100/1-1-1A	0.2/15VA	800/400/1-1A	0.2/15VA	400/200/1A	0.2/15VA
2	400/200/100/1-1-1A	5P20/15VA	800/400/1-1A	5P20/15VA	400/200/1A	5P20/15VA
3	400/200/100/1-1-1A	5P20/15VA	800/400/1-1A	5P20/15VA	400/200/1A	5P20/15VA
4	400/200/100/1-1-1A	X/Vk>350V Ik<30mA	800/400/1-1A	X/Vk>350V Ik<30mA	400/200/1A	X/Vk>350V Ik<30mA

4.4.22 Outdoor Voltage transformer technical data

The technical parameters for the Voltage transformers for this project shall meet the KPLC specifications for outdoor Voltage transformer.

The Voltage transformer LV and HV windings shall be made of high-grade copper, Aluminium windings shall not be accepted in this project.

4.4.23 Outdoor substation bus bar material

Substation bus bar material shall be high-grade tubular aluminium/copper alloy or ACSR/AAAC conductors of correct rating. Material for Aluminium alloy shall be Aluminium-magnesium-silicon in accordance with IEC 60114. They shall be designed to withstand thermal and dynamic stresses under normal duty and maximum short-circuit current as per KPLC specifications. Fastening shall be such that thermal expansion is accommodated without any undue stresses

4.4.24 Civil Works

4.4.24.1 Platform works

Platform with perimeter wall, earthwork, roads and drainage shall be constructed as specified in particular specifications for civil works.

4.4.24.2 Switchgear buildings

Switchgear buildings shall be constructed as specified in particular specifications.

Control Panels, Medium voltage indoor switchgears, AC and DC systems of different Voltage levels shall be installed in separate rooms.

In addition, a guardhouse with toilet facilities located at the main gate shall be constructed.

4.4.24.3 Transformer and Equipment foundations

Transformer and equipment foundations shall be constructed as specified particular specifications for civil works.

4.4.24.4 Cable Trenches

Cable trenches shall be constructed as specified in particular specifications for civil works.

4.4.25 Training

The training shall be for 5 (five) KPLC engineers for each of the courses indicated below. The training shall be held at the manufacturer’s premises. All training, air fare and transport costs at manufacturers premises shall be met by the Contractor. KPLC will meet the accommodation costs. The training shall cover design, application, testing, commissioning and maintenance of the relevant digital control and protection systems. The training course shall have a minimum of 2 (two) weeks duration. The training shall be for principles of substation design & construction, SAS and Control & Protection and Contract Management.

4.4.26 Factory Acceptance Test

The Contractor shall arrange for 2 (two) KPLC engineers and the Project Manager to witness tests of major equipment listed below in the manufacturer’s plant. All routine tests shall be carried out in the presence of the Employer’s representatives. The Contractor shall arrange and meet the full cost of the air tickets, local transportation and training at manufactures factory. KPLC staff per diem costs shall be based on SRC rates or individual KPLC designation rates whichever is higher.

- Circuit breakers
- Protection and control system
- Transformers
- Power Cables and Conductors
- Instrument transformers

- Disconnectors
- SAS and Telecommunication System
- Insulators and Surge arrestors
- Concrete Poles and Towers
- OPGW/ADSS
- DC System
- Substation Steel Structures

FAT shall be carried out as prescribed in the particular technical specifications of the equipment.

4.4.27 Commissioning Equipment or Tools

Laptop computers: Two pieces per Lot, installed with comprehensive software. The PC shall be supplied with all the necessary accessories and ports and loaded with latest operating system. The laptop must be able to run all the relay and equipment software's supplied under the contract. The lap top specifications shall be approved by the project manager.

4.4.28 Final documentation

a) Witnessed and signed commissioning site acceptance tests. 3 (three) hard copies and 1 (one) soft copy.
b) As built drawings in 4 (four) paper copies delivered in box files as approved by project manager; and three (3) Soft copy in flash drive (all drawings in AutoCAD and PDF)
c) Operation and maintenance manuals in 3 paper copies delivered in box files as approved by project manager and 3 (three) soft copy in flash drive
d) Installation software and configuring files for all SAS, telecommunication system and protection equipment and a copy in hard drive. 2 (two) soft copies
e) Back up for the system and files, including all the above soft copy files in hard drive (HDD)

4.5 Facilities for the KPLC Project management team

4.5.1 Site Offices

At the location where the contractor will establish his main site, an administration office for the site KPLC project management team with basic office furniture, drinking water, internet, telephone and a copier shall be provided by the contractor for the entire project implementation period.

4.5.2 Communication Facilities

The contractor shall supply 2nos. pre-paid smart phones and Airtime equivalent to KES 20,000/= per month for KPLC Project implementation team for the entire contract period. The communication facilities are subject to approval by the project manager.

4.5.3 Drawing approval and Commissioning facilities

The contractor shall supply two (2) Laptops per lot for design approval and substation protection & control and SAS commissioning. 2No. commissioning laptop shall be pre-installed with IEDs testing and configuration software/backup files for SAS, Control &Protection IEDs. Application software shall be running on most recent MS window 64-bit OS, Intel core i7 with unlimited licenses period. The Design approval laptop(s) shall be pre-installed with MS application packages, AutoCAD, MS Project management and running on most recent MS window 64-bit OS, Intel core i7. Application software licenses shall have unlimited period. The laptops shall be subject to project manager approval.

4.5.4 Transport Services for project implementation team

The Contractor shall provide transport services on a 24-hour basis for use by KPLC Project Manager and his team throughout entire contract period. The Vehicle to be provided shall be double Cab, 4X4 wheel drive of at least 2400 cc engine capacity. In addition, the vehicle shall be used to provide transport services for work related to project management. It shall also be stationed/parked at KPLC premises or any other place authorized by project manager. The contractor shall bear cost of fueling, maintenance, driving etc. The vehicle shall be subject to the approval of Project manager.

4.6 GENERAL SCOPE FOR 33 AND 11KV LINES

4.6.1 General

The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents. Special attention shall be paid to Technical Specifications, in which the general technical requirements are specified. The drawings enclosed in are for bidding purposes only. If the Specifications and/or Drawings do not contain particulars of materials or goods that are necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials shall be deemed to be included in the supply.
In the event of any conflict between the Drawings and the Specifications, the latter shall prevail. In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.
Should the Bidder find discrepancies in or omissions from these Specifications or from the other documents, or should he be in doubt as to their meaning, he should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting his Bid. Such action shall, however, in no case be considered as a cause for altering the closing date of the Bid.

The scope of work covers supply of equipment, design engineering, manufacture, testing before shipment and packing sea worthy or otherwise as required, delivery of all equipment to site (DDP), construction, installation and commissioning.

Where the new line shares the route with existing lines, the scope of work shall include all the necessary works/modifications that will be required to accommodate the lines along the same route. The conductors of the existing lines may be re-used subject to Project manager approval, while new hardware/fittings of correct type and size shall be used.

The term "transfer" in this scope of works shall mean supply of new hardware/fittings, new concrete poles, stays, conductor, insulators as well as construction work in existing line routes. It also includes moving all equipment, such as distribution transformers, Autoreclosers, switches and links, capacitor banks etc., mounted on the present poles over to the new poles. In addition, all existing poles, conductors and hardware/fittings shall be recovered and handed over to the KPLC stores at locations nearest to the installation sites.

<u>Cross arms:</u>
Steel cross-arms shall be used in all cases including re-conductoring. Steel cross arms shall be grounded, and shall meet international accepted standards in addition to KPLC specifications for steel structures and line fittings

<u>Line conductor</u>
The 11and 33kV Overhead line conductors shall be 150mm^2 ACSR.

The 66kv overhead conductor shall be 300mm^2 AAAC.

The 132kv overhead conductor shall be 175mm^2 Lynx or as specified in the definite scope of work

<u>Conductor Joints and terminations</u>
All joints and terminations shall be of compression type for conductors of 150mm^2 and above.

Line Poles

Concrete poles shall be used in all 66, 33 and 11kV overhead line construction. All poles shall meet design class of 50SC (10, 11 and 12m) poles and 75SC (14 and 15m) poles and KPLC Pre-stressed concrete poles particular specifications.

Optical Ground Earth Wire (OPGW)

OPGW (Optical Ground Earth Wire) shall be used in all 33kV lines and above. Standard size for KPLC is 48 cores single mode Optic fiber. Where 33kV line is done in underground cable an Underground Fibre Optic cable will be laid together in the trace of the MV cable.

OPGW earthing shall be done after every fourth pole.

4.6.2 Overhead Lines and Cables Circuits

Scope of line works shall involve construction of new 66, 33 and 11kV lines and reconductoring/adoption of existing lines. Conversion of some existing 33/0.420 kV distribution substations to 11/0.420kV distribution transformers. Most of the new lines shall be constructed dual to the existing 33/11/0.420kV lines or in adaptation to the existing lines.

Contractor shall provide materials for line transfer/adoption (fittings and accessories) of existing lines to the new lines' poles.

All the lines shall be constructed on concrete poles.

Detailed scope of the lines is described under definite scope for substation and lines work.

4.6.3 Factory Acceptance Test

The Contractor shall arrange for 2 (two) KPLC engineers and the Project Manager to witness tests of major equipment listed below in the manufacturer's plant. All routine tests shall be carried out in the presence of the Employer's representatives. The Contractor shall arrange and meet the full cost of the air tickets, local transportation and training at manufactures factory. The KPLC staff per diem costs shall be based on SRC rates or individual KPLC designation rates whichever is higher.

a) Phase Conductor
b) Bus bar conductor materials
c) OPGW/ADSS
d) MV Cables
e) Circuit breakers and Auto reclosers
f) Isolators and ABS
g) Insulators and Surge arrestors
h) Concrete poles

FAT shall be carried as prescribed in the KPLC technical specifications.

4.7 DEFINITE SCOPE OF PROPOSED 33/11KV SUBSTATIONS AND LINES

The scope of work shall involve design, supply, equipment installation, line construction and commissioning. Substation and line work shall involve but not limited to following main activities.

1) Establishment of 7.5 MVA 33/11kV substation and associated 33/11kV lines at Bondo town in Siaya County
2) Establishment of 2.5 MVA 33/11kV substation and associated 33/11kV lines at Mbitini market in Kitui County
3) Establishment of 7.5 MVA 33/11kV substation and associated 33/11kV lines at Maraba market in Nandi County

4.7.1 Bondo 7.5 MVA 33/11kV Substation and Lines

Scope includes installation of a new 1x7.5MVA, 33/11kV substation, one line bay for 33 kV incoming line and four (4) bays for 11kV feeder outs within 0.75 acres substation plot. Tubular steel structures shall be used for equipment support and lattice steel channels may be used for bus bar gantries. Establishment of substation switchyard and approximately 120 Sqr. meters control building with VIP toilet among other facilities and rooms. Control building shall have open control room with, office facilities and open kitchen. Rain water harvesting system with ground mounted 10,00 liter tank shall also be installed. All office facilities are subject to approval of project manager. Substation Earth work shall include, internal access, excavation backfilling with external material, compaction and ballasting of approximately 0.75 acres. Substation drainage and cable trenches shall be constructed.

Construction of all-weather external access murram road and fencing of substation plot with chain link and racer wire on concrete posts. Guard house and substation gates shall also be constructed. Additional civil works include equipment foundations and other related infrastructure as specified in the substation civil work particular specifications.

Line works shall include construction of 14 km (Ndori-OPonda link) 33kV overhead 3 phase circuit in 150 mm2 ACSR conductor with OPGW, and a total of 14 km of 11kV overhead 3 phase circuit in 75 mm2 ACSR Conductor. 11kV Overhead lines are for three number feeder outs (Bondo town fdr-4 km, Aram market fdr-5 km, Jaramogi University fdr-5 km) and spare bay
Scope shall also involve conversion of 10 NO. 33/0.42 kV pole mounted substation to 11/0.42 kV pole mounted substations.

Transfer/adaptation of existing lines and substations to the new lines' concrete poles. All lines shall be constructed on concrete poles.

4.7.1.1 Bill of Quantities for Bondo 7.5MVA 33/11kV Substation and Lines

Item	Material and Equipment description	UoM	Qty
BON-101	7.5 MVA, 33/11kV transformer	Pc.	1
BON-102	33KV Circuit breakers	Pc.	2
BON-103	33kV motorized Isolator with Earth switch	Pc.	1
BON-104	33kV motorized Isolator without Earth switch	Pc.	3
BON-105	33kV Current Transformer	Pc.	6
BON-106	33kV Voltage Transformer	Pc.	6
BON-107	33 & 11kV Bay and Bus bar conductor material and clamps	lot	1
BON-108	Steel Structures for bay equipment support and gantries	lot	1
BON-109	33kV Surge Arresters	Pc	6
BON-110	Transformer Protection relay Panel	Pc	1
BON-111	Transformer Bay Control Panel with BCU and Voltage regulating relay (AVR)	pc	1
BON-112	33kV line Protection and Control panel with BCU	pc	1
BON-113	11kV feeder Protection and Control panel (1Panel for 2 feeders) with BCPU)	pc	2
BON-115	11kV Neutral link with neutral CT	Pc.	1
BON-116	11kV Circuit breakers	pc	5
BON-117	11kV motorized Isolator without Earth switch	pc	6
BON-118	11kV motorized Isolator with Earth switch	pc	4
BON-119	11kV Surge Arrestors	Pc.	15
BON-120	11kV Current Transformer	Pc.	15
BON-121	11kV Voltage Transformer	Pc.	3
BON-122	100kVA, 33/0.420kV Auxiliary transformer with HV and LV fuse protection, supply cables and terminations	Lot/pc	1
BON-123	RTU (floor standing) Panel for Bays and IEDs signals complete with Gateway (IP620 switch), Ethernet LAN switches and associated accessories including dc to dc converter	Lot	1
BON-124	Multicore cables for control, protection and measurements	Lot	1
BON-125	3 Phase auxiliary AC Supply system and distribution board	Lot	1
BON-126	110 DC Supply System and distribution Board	Lot	1
BON-127	Substation earthing and Lightning protection system	Lot	1
BON-128	Substation switchyard lighting system	Lot	1
BON-129	Control building with fire detection and suppression system	Lot	1
BON-130	Rain water harvesting system with ground mounted tank	Lot	1
BON-131	Substation Switchyard and equipment foundations	Lot	1
BON-132	Cable trenches and drainage system	lot	1
BON-133	Chain link fence for the plot and Guard house	Lot	1
BON-134	Substation Earth work and Access roads	lot	1
BON-135	33kV O/H Line in 150mm^2 ACSR conductors, insulators, fittings and necessary line hardware	lot/km	14
BON-136	Establish 33kV line bay at Ndori 33kV switching station with Autorecloser on concrete poles	Lot	1
BON-137	OPGW cable complete with fittings, splice boxes, ODF and approach cable	Lot/km	14
BON-138	11kV O/H Line in 75mm^2 ACSR conductors, insulators, fittings and necessary line hardware	lot/km	14
BON-139	Materials for transfer/dualling and adoption of existing 33/0.45kV lines and distribution transformers to new lines	lot/km	4
BON-140	33 kV Air break switches complete with fittings	Lot/pc	2
BON-141	11kV Air break switches complete with fittings	Lot/Pc	4

BON-142	6 Nos 100 kVA 11/0.42 kV and 4Nos. 200 kVA 11/0.42 kV pole mounted distribution transformers	Pc	10
BON-143	Concrete Poles and Stay blocks for Lines	lot/km	28
BON-144	Control room office facilities and Guard house facilities	lot	1
BON-145	Site office and communication facilities for KPLC Project implementation team	lot	1
BON-146	Facilities for KPLC Project implementation team for entire contract period	lot	1
BON-147	Cost of statutory approvals	lot	1
Schedule 3: Design Services			
BON-301	Substation engineering design (electrical, mechanical, civil, RTU/SAS system, Control and Protection)	lot	1
BON-302	Coordination of relay Settings	lot	1
BON-303	Line engineering design (civil and electrical)	lot	1

4.7.2 Mbitini 2.5MVA 33/11kV Substation and lines

Scope shall include installation of new 1 x 2.5MVA, 33/11kV transformer bay and incoming 33kV line bay with circuit breakers. 11kV four (4) line bays for feeder outs with Auto reclosers. Tubular steel structures shall be used for equipment support and lattice steel channels may be used for bus bar gantries. Establishment of substation switchyard within one acre plot. Construction of Control building with a minimum floor area of 120 Sqr. meters. Control building shall have an open control room, among other facilities and rooms. Rainwater-harvesting system with ground mounted 10,000 liters water tank, Electrical, Plumbing, fire suppression system, and other related infrastructure as specified in bill of quantities shall be constructed. Substation civil work shall also include construction of chain link fence with racer wire on concrete poles for one-acre plot, equipment foundations, drainage system, cable trenches, transformer plinth to accommodate 7.5 MVA transformer. Murram all weather external access road shall be constructed. Demarcated guard house with a VIP Pit latrine shall also be constructed within the plot

Scope of line works shall entail construction of 12 km of 33kV O/H 3phase circuit in 75 mm^2 ACSR conductor on concrete poles. (Tee-off from Mutomo Ex Kitui 33KV line at Mosa market) Approximately total of 12 km of 11kV Overhead 3phase circuits in 75 mm^2 ACSR Conductor on concrete poles shall also be constructed. The four feeder outs are: 1) Mbitini market fdr -1.0 km, 2) Kanzau fdr -4.0km, Voo fdr 2.0 Km and Kisasi fdr 5.0 Km.

Where new 33 and 11kV lines are to be constructed in dual with existing lines, existing wooden poles shall be replaced with concrete poles and the MV/LV lines transferred to the new concrete poles. Cost of fittings and associated materials to transfer, adapt and/or dualling of existing lines to new lines shall be included in the bid

4.7.2.1 Bill of Quantities for Mbitini 2.5MVA 33/11kV Substation and Lines

Item	Material and equipment description	UoM	Qty
MBT- 101	2.5 MVA, 33/11 kV transformer with bushing CTs	Pc	1
MBT- 102	33kV Circuit breaker	Pc	2
MBT- 103	33 kV motorized Isolator with earth switch	Pc	1
MBT -104	33kV motorized Isolator without earth switch	Pc	2
MBT -105	33kV Voltage Transformers	Pc	6
MBT -106	33kV Current transformers	Pc	6
MBT -107	Bays and bay bus bar conductor materials	Lot	1
MBT -108	Steel support structures for Bay, bus bar and gantries	Lot	1
MBT -109	33kV Surge arresters	Pc	6
MBT -110	33kV Transformer Control and Relay Panel with BCU	Lot	1
MBT -111	11kV Feeders Control panel (One panel for 2 feeders) with BCU	Pc	2
MBT -113	11kV Motorized Isolators without earth switches	Pcs	6
MBT -114	11kV Neutral isolating link with a neutral CT	Pc	1
MBT -115	11kV Surge Arrestors	Pc	15
MBT -116	11kV Auto-recloser complete with bypass switch, solid links, and surge arrestors	Lot/Pc	5
MBT -117	11kV Current Transformer	Pc	15
MBT- 118	11kV Voltage Transformer	Pc	3
MBT -119	Auxiliary transformer 100 kVA 33/0.420 kV complete with HV expulsion fuses, surge arrestors and LV fuse cut out protection	Lot/Pc	1

MBT -120	11kV Auto-recloser complete with bypass switch, solid links, surge arrestors and 240Vac auxiliary supply system at terminal point	Lot/Pc	2
MBT -121	3-Phase auxiliary supply system and distribution board	Pc	1
MBT- 122	110Vdc/165Ah Battery, Charger and DC board (DC supply system)	lot	1
MBT -123	RTU floor standing Panel, Gateway (IP620 Switch), Ethernet LAN switches, 110/48V DC Converter and associated accessories	lot	1
MBT -124	Multicore cables for signal, control, protection and measurements	lot	1
MBT- 125	Substation Earthing and Lightning protection system	lot	1
MBT -126	Control building with fire detection and suppression system	lot	1
MBT -127	Substation Switchyard lighting system	lot	1
MBT -128	Transformer and equipment foundations	lot	1
MBT- 129	Guard house and VIP pit latrine	lot	1
MBT- 130	Rain water harvesting system with ground mounted tank	lot	1
MBT- 130	Substation earth work, access roads, drainage and cable trenches	lot	1
MBT -131	Chain link fence on concrete post for entire Plot and Guard house	lot	2
MBT- 132	Control room office and guard house facilities	lot	1
MBT- 133	Site office, transport services and communication facilities for KPLC project implementation team	lot	1
33 and 11kV line materials			
MBT -134	33kV 3 Phase O/H line in 75 mm^2 ACSR conductors, insulators, fittings and other line hardware	lot/km	12
MBT- 135	11kV 3phase OH line in 75mm^2 ACSR conductor, insulators, fittings and other line hardware	lot/km	12
MBT- 136	33 kV Air break switches and fittings	Lot/pc	2
MBT -137	11 kV Air break switches and fittings	Lot/Pc	4
MBT -138	Materials for transfer/adaptation of existing Overhead lines and distribution transformers (Concrete poles, fittings and hardware) to the new lines	Lot/km	4
MBT -139	Concrete Poles, fittings, stay wire and stay blocks	Lot/km	24
Design Services			
MBT-301	Substation engineering design (Electrical, Mechanical, Civil, Control, Protection and RTU/SAS)	Lot	1
MBT-302	Relay setting coordination	Lot	1
MBT-303	Line engineering design and route survey	Lot	1

4.7.3 Maraba 7.5MVA 33/11kV Substation and lines

Scope includes installation of a new 1x 7.5MVA, 33/11kV substation, one line bay for 33kV incoming line and four (4) bays for 11kV feeder outs within one acre plot. Tubular steel structures shall be used for equipment support and lattice steel channels may be used for bus bar gantry. Establishment of substation switchyard and approximately 120 Sqr. meters control building with VIP toilet among other facilities and rooms. Control building shall have open control room with office facilities and open kitchen. Rain water harvesting system with 10,000 ground mounted tank shall also be installed. Substation Earth work shall include, Access roads, excavation, backfilling with external material, compaction and ballasting of substation switchyard. Substation drainage and cable trenches shall be constructed. Remaining areas of the plot not occupied by the substation shall be levelled and compacted.

Construction of all-weather external access murram road, Guard house, fencing of one acre plot with chain link and racer wire on concrete posts. Additional civil works include equipment foundations and other related infrastructure as specified in the substation civil work particular specifications.

Line works shall include construction of 16.0 km of 33kV O/H 3phase circuit in 150 mm2 ACSR conductor. This shall be a tee off from existing lines 33kV line at Kopere. A total of approximately 10.0 km of 11kV Overhead 3-Phase circuits in 150 mm^2 ACSR conductor shall also be constructed. The 11kV lines to be constructed shall be short four feeder outs to link to the existing network.

All lines shall be constructed on concrete poles.

4.7.3.1 Bill of Quantities for Maraba 7.5MVA 33/11kV Substation and Lines

Item	Materials and equipment description	Unit	Qty
MAR 101	7.5MVA, 33/11 kV Transformer	pc	1
MAR-102	33kV Circuit breakers	pc	2
MAR-103	33 kV motorized Isolator with earth switch	pc	1
MAR-104	33kV motorized Isolator without earth switch	pc	2
MAR-105	33kV Voltage Transformer	pc	3
MAR-106	33kV Current transformer	pc	6
MAR-107	33 &11 kV Bay and Bus bar conductor materials	lot	1
MAR-108	Steel support structures for bay, bus bar and gantries	lot	1
MAR-109	33kV Surge Arresters	pc	6
MAR-110	33kV Transformer protection relay panel	Pc	1
MAR-111	Transformer bay Control panel with BCU and Voltage regulating relay (AVR)	Pc	1
MAR-112	33 kV Line Control and relay panel with BCU	Pc	1
MAR-113	11kV feeder Control and Protection panel (1Panel for 2 feeders) with BCPU	Pc	2
MAR-114	11kV Voltage Transformer	pc	3
MAR-115	11kV Current transformers	pc	15
MAR-116	11kV Isolator with earth switch	pc	4
MAR-117	11kV Circuit breaker	pc	5
MAR-118	11kV Isolator without earth switch	pc	6
MAR-119	11 kV Neutral CT with Isolating link	pc	1

Item	Materials and equipment description	Unit	Qty
MAR-120	11 kV Surge Arresters	pc	15
MAR-121	Auxiliary transformer 100 kVA, 33/0.415 kV, with HV expulsion fuse, surge arrestors and LV fuses for protection	Lot/Pc	1
MAR-122	3 Phase Ac Auxiliary supply distribution board	Pc	1
MAR-123	110Vdc/165Ah Battery, Charger and Distribution board (DC supply system)	Lot	1
MAR-124	Multicore cables for signal, control, protection and measurements	Lot	1
MAR-125	Substation Earthing and Lightning protection system	Lot	1
MAR-126	Control building with fire detection and suppression system	Lot	1
MAR-127	Substation Switchyard lighting system	Lot	1
MAR-128	Transformer and equipment foundations	Lot	1
	Chain link fence on concrete posts for entire plot and Guard house	Lot	1
	Rain water harvesting system with a ground mounted tank	Lot	1
MAR-129	Substations earth work, Access roads, drainage and cable trenches	Lot	1
MAR-131	Control room and guard house office facilities	Lot	1
MAR-132	Site office, transport services and communication facilities for KPLC project implementation team	Lot	1
33 and 11kV line materials			
MAR-133	33 kV 3 Phase O/H line in 150mm^2 ACSR conductors, complete with, insulators, fittings and other line hardware	lot/km	16
MAR-134	11kV 3phase O/H line 150mm^2 ACSR conductor including insulators, fittings and other line hardware	lot/km	10
MAR-135	33 kV Air break switches and fittings	Lot/pc	1
MAR-136	11 kV Air break switches and fittings	Lot/pc	2
	33 kV Auto-recloser complete with bypass switch, solid links, surge arrestors and 240Vac auxiliary supply system at Tee-off point	Lot/pc	1
MAR-137	Materials for transfer/adaptation of existing Overhead lines (Concrete pole fittings and hardware) to the new lines	Lot/km	2
MAR-138	Concrete Poles, Fittings, stay wire and stay blocks	Lot/km	26
Design Services			
MBT-301	Substation engineering design (Electrical, Mechanical, Civil, Control, Protection and RTU/SAS)	Lot	1
	Relay setting coordination	Lot	1
MBT-303	Line engineering design and route survey	Lot	1

4.7.3.2 Substation and associated Lines ESHS Work site activities

The contractor shall implement the following worksite key ESHS activities in addition to any other environmental, social, health and safety (ESHS) activities required in the works specifications.

Cost of ESHS activities shall be deemed to have been included in the pricing of substation and lines works.

No separate price schedule is required for ESHS scope.

Substation and associated Lines ESHS activities	
ESHS 01	**Air pollution management (Noise and dust control)**
	Suppress dust during dry periods by watering areas/Cover stock piles of soil
ESHS 02	**Solid waste generation**
	All solid waste management and disposal, including provision of Pit latrines/Portable toilets and sanitary materials
ESHS 03	**Traffic control and management**
	a. Traffic control and management shall be carried out during line construction to minimise jam in roads within construction sites
	b. Laison with county traffic police for traffic control and road closures when necessary
ESHS 04	**Occupational Health & Safety at worksite**
	a. Training local workers and subcontractors on ESHS issues and creating awareness to the workers on social and health issues.
	b. Creation of Covid-19 and HIV & AIDS awareness, and provision of materials for control and prevention to the workers in collaboration with county government health agencies
	c. Provision of water for drinking, handwashing and soap. Provision of hand sanitizers in worksite offices
	d. Maintain a fully stocked and accessible first aid kit and trained first aider.
	e. Provision of appropriate PPEs (Clothing and equipment for all workers at site)
ESHS 05	**Public health and safety**
	Proper securing of worksite to control access, and hazard communication to the public by use of appropriate warning signages
ESHS 06	Local stakeholder/leaders and community engagement to create conducive environment for project implementation

4.8 PARTICULAR TECHNICAL SPECIFICATIONS FOR TRANSFORMERS

TABLE OF CONTENT

4.8.1 General 68
4.8.1.2 Power Transformers 68
4.8.1.2.1 Design Criteria 68
4.8.1.2.2 Construction 70
4.8.1.2.3 Painting and Galvanising 74
4.8.1.2.4 Fittings 75
4.8.1.2.5 Cooling 77
4.8.1.2.6 Off-load Tap Changer 78
4.8.1.2.7 Drain, Filter and Sampling Valves 78
4.8.1.2.8 Oil 79
4.8.1.2.9 On-Load Tap Changers 79
4.8.1.2.10 Local Control Cubicles and Wiring Cabinets 82
4.8.1.2.11 Wiring and Terminal Blocks 82
4.8.1.2.12 Manufacturing, Inspections and Tests 82
4.8.1.2.13 Erection 84
4.8.1.2.14 Delivery and Transport 84
4.8.1.2.15 Evaluation of Losses 85
4.8.1.2.16 Transformer drawings 86
4.8.1.3 Distribution and Auxiliary Transformers 87
4.8.1.3.1 General 87
4.8.1.3.2 General Design 87
4.8.1.3.3 Tanks and Conservators 89
4.8.1.3.4 Tests 91
4.8.1.3.5 Packing and Transport 92
4.8.1.3.6 Drawings and Diagrams 92
4.8.1.3.7 Evaluation of Losses 92

4.8 PARTICULAR SPECIFICATIONS FOR POWER TRANSFORMERS

4.8.1 General

This Specification provides for the manufacture, supply, testing before shipment, delivery, erection and commissioning of the transformers detailed in Scope of Works. Particular reference is also made to General Specification, General Technical Specification, Project Specific Data and IEC 60076.

The transformer shall be designed for a 40 years lifetime under full load operation and be supplied together with all ancillary equipment for a complete installation.

All connections and contacts shall be of ample section and surface for carrying continuously 120 % of the specified current without undue heating. Fixed connection shall be secured by bolts or set screws of ample size, adequately locked. Lock nuts shall be used on stud connections carrying current.

On outdoor equipment, all bolts nuts and washers in contact with non-ferrous parts that carry current shall be of phosphor bronze.

Wherever possible, bolts shall be fitted in such a manner that in the event of the nut working loose and falling off, the bolts will remain in position.

4.8.1.2 Power Transformers

4.8.1.2.1 Design Criteria

4.8.1.2.1.1 Service Conditions

The transformer shall be capable of operating continuously outdoors at any tapping during the ambient conditions specified in the section: "Project Specific Data"

Note that the average maximum ambient temperature in any one day is 30 ºC. The maximum temperature rise shall therefore not exceed 55 ºC of the top oil and 60 ºC of the winding above the maximum ambient temperature of 40 ºC.

For temperature correction due to attitude reference is made to IEC 60076 which limits the temperature rise further when tested a normal altitude. The altitude used in the calculations shall be 2200m a.s.l.

4.8.1.2.1.2 Rating

The transformers shall comply with the ratings specified in Scope of Works under the stated service conditions without exceeding the temperature rise limits specified above, over the complete tapping range. If the voltage on the secondary (LV) side is reduced or raised by up to 5% from the rated voltage, the temperature rises of any part shall not rise by more than 5ºC (at rated power on any primary tapping).

4.8.1.2.1.3 Tapping

All tappings shall be designed for constant kVA output, the rated voltage of each winding of the transformer on the principal tapping shall be as specified in Scope of Works and unless otherwise specified, shall correspond to the system nominal voltage. The tapping ranges shall be as specified in Scope of Works.

4.8.1.2.1.4 Noise

The transformer, tap-changing equipment and supplementary cooling equipment shall operate without undue noise and every care shall be taken in the design and manufacture to reduce noise to the level of that obtained in good modern practice. The noise level of the transformer shall not exceed 78 dB (A) when tested in accordance with IEC 60076.

4.8.1.2.1.5 Radio Interference

The design of the transformer shall be such that they will not cause any objectionable interference with radio reception in the vicinity of the transformer, either by direct radiation or by transmission through the power-lines and system to which the transformer may be connected, when energizing at full rated voltage and when delivering any load up to the continuous maximum rating.

4.8.1.2.1.6 Interchangeability and Parallel Operation

All transformer of any one type shall be identical and interchangeable with one another. No alteration to control circuits shall be permissible for this purpose except by means of built-in terminal boards fitted with links for effecting the alteration. All parts are to be made accurately to dimensions so that any corresponding parts will be interchangeable and any spare parts will fit into place without need of adjustments. Where similar equipment has previously been supplied, components shall interchange with those on previous contracts, unless otherwise approved.
The transformer shall be suitable for parallel master-follower operation with each other and with previously supplied transformer of similar rating which shall remain in service on the substations covered by this contract, both in respect of transformer characteristics and control circuits on all relevant taps. The new and old transformers shall share the load subject to the tolerances of impedance and voltage laid down in, IEC 60076.

4.8.1.2.1.7 Insulation Levels

When assembled complete with connections as in service, electrical clearances in air shall be adequate to withstand the required impulse withstand voltage given in Project Specific Data. The Bidder shall propose in his Bid details of bushings with drawings showing air clearances and creepage distances. The creepage distance shall not be less than 31mm/kV line voltage in Coast and industrial area, while for inland installations it shall be 25mm/kV. Care shall be taken to ensure that no fittings are located so as to interfere with the external connections to the bushing terminals.

The insulation test levels are given in Project Specific Data. All transformers shall be designed for full insulation on all terminations also the neutral termination.

4.8.1.2.1.8 Short Circuit Performance

The transformer shall be capable of withstanding, without damage, the effects of a symmetrical three-phase short circuit and a phase to earth short circuit under conditions specified in IEC 60076. It can be assumed that during a short circuit, nominal voltage will be maintained on one side of the transformer with a short on the other, the external impedance being zero. It can also be assumed that up to four transformers may be connected in parallel between HV and LV bus bars.

4.8.1.2.1.9 Frequency

The normal frequency will be 50 cycles per second. The transformer shall, however, be suitable for continuous operation with frequency variation of plus or minus 2.5 % from the normal, without exceeding the temperature rise limit specified.

4.8.1.2.1.10 Flux Density

The maximum flux density in any magnetic component under any condition of voltage and frequency specified under all the operating conditions given in these specifications shall not exceed 1.6 Tesla.

4.8.1.2.2 Construction

4.8.1.2.2.1 General

Transformers shall be of the oil immersed “core” type (i.e. not “shell” type) suitable for outdoor use, they shall be dried out at the manufacturer’s works and it should be possible to commission them without further dry out.

Designs shall be such that water does not collect on any of the equipment. Particular attention shall be paid in the design of all equipment to ensure that there is not damage to working parts or insulation through the ingress of dust, insects or vermin which are prevalent for long periods in the year.

4.8.1.2.2.2 Cores

The transformer core shall be built of laminations of the best quality non-ageing (CRGO) cold-rolled grain oriented silicon sheet steel of high permeability and low loss coefficient. All joints between laminations shall be of the interleaved type and the laminations shall be clamped securely. Bolting of the core should be avoided to reduce losses. On no account shall butt joints be offered. The cross-section of the core shall form an approximate circle.

The laminations shall be separated by hot-oil proof insulation, and the clamping of the frame shall be firm to ensure even pressure over the whole of the core laminations so as to prevent undue vibrations or noises.

The core sheets shall be insulated with high-grade oil-proof insulation, for example magnesium-silicate-phosphate. Paper will not be accepted.

The core clamping arrangement and framework shall be efficiently insulated from the cores and withstand a test voltage of 2kV, 50 HZ during 1 minute. The core shall be designed and built up in such a manner as to avoid accidental or slow development of short circuit paths through the iron and framework.
The core, framework, clamping arrangements and general structure of the transformer shall be of robust design, capable of withstanding any shock to which they may be subjected during transport, installation or service.

Suitable axial cooling ducts shall be provided to ensure free circulation of oil and efficient cooling of the core. The ducts shall be proportioned so that the maximum temperature at any point will be within the prescribed limits of temperature rise.

Lifting lugs or other similar means shall be provided for conveniently lifting the complete assembly (with windings).
Provision shall be made for efficient arrangement of guides to prevent movement of the core and windings during transport, installation or service.

The framework of the core shall be so designed as to prevent the presence of oil pockets, which would prevent complete emptying of the oil from the tank through the drain valve.

4.8.1.2.2.3 Windings

The windings shall be circular and consist of high quality enameled copper wire/ rectangular copper strips, wound with age resisting paper of high dielectric strength. The current densities in the windings shall be stated in the Bid.

The amount of insulation between turns shall be determined not merely by normal volts per turn, but also by due consideration of the line voltages and the service conditions, under heavy lightning

storms.
Adequate insulation and clearances between the windings shall be provided and all insulation and clearance between live parts must be adequate for operation at 5 per cent over the highest tap voltages on all the windings.

Phase and neutral shall be insulated for full design Voltage. **Graded winding insulation** shall not be allowed for HV, LV, Neutral or Tertiary windings.

The insulation of the end turns of each winding adjacent to the transformer terminals shall be reinforced between turns to protect the windings satisfactorily against surges and transients. Details of the reinforcements shall be given in the Bid.

None of the materials used shall shrink, disintegrate, carbonize or become brittle under the action of hot oil, to an extent lowering the lifetime below 40 years when the transformer is operated continuously at the maximum specified loading.

The windings shall be so placed that they remain electrostatically balanced with their magnetic centers coincident under all conditions or operation. To prevent excessive static voltage, static end rings shall be provided, wherever necessary, at the live end of the windings.

The windings, connections and trappings of the transformer shall be clamped in position and braced so as to withstand shocks or undue stresses during transport, short circuit conditions, and other transient causes. No mechanical movement of the coils should be possible with dead short circuit on the transformers.

All windings and all fibrous and hygroscopic materials used in the construction ofthe transformer, shall be dried under vacuum and impregnated with hot oil. Full details of the drying out and vacuum treatment shall be furnished by the Bidder.
Leads from windings to terminal board and bushings shall be rigidly supported to prevent damage from vibration and short circuit forces.

Adequate provision shall be made for the circulation of oil round and between the winding so that a low temperature gradient between the conductors and the oil is assured and any danger of excessive local heating is avoided.

The finished width of any duct and clamping arrangement shall be such as not to impede the free circulation of oil through the ducts.

It is essential that the windings shall be subjected to a thorough shrinking and seasoning process, so that no further shrinking of windings shall occur at site. However, clamping arrangement shall be provided for taking up any possible shrinking of coils when in service. All similar coils shall be strictly interchangeable. Full detailed description of the windings shall be submitted with the Bid.

When specified in Scope of Works, stabilising windings shall be provided. The windings shall be capable of withstanding the forces to which they are 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. When stabilising windings are to be used for purposes other than decreasing zero sequence impedance, this will be declared in the scope of work and the windings must be designed accordingly.
Unless otherwise specified, only one terminal of the stabilising winding shall be brought outside the tank and a suitable bushing shall be provided for this purpose through the tank cover. When

used additionally for an auxiliary supply each corner of the winding shall be brought out.

It shall be possible to earth the winding externally to the main tank by means of a flexible bolted link to be provided by the supplier between the terminal and a suitable pad on the tank cover.

The neutral points of star connected windings shall unless otherwise specified in Scope of Works be brought out to bushings located on the tank cover and connected to an earthing bus attached to the main transformer earth terminal.

Where the star point of a winding is not specified to be brought out through a neutral bushing, the connection shall, nevertheless, be available under the main tank cover plate to permit the subsequent fitting of a neutral bushing. The subsequent installation of this bushing shall not necessitate any alteration to, or repositioning of existing fittings.

4.8.1.2.2.4 Internal Earthing

Each part of the core shall be electrically earthed to the transformer tank. The internal earth connection shall be of the detachable link type and shall be located in an accessible position.

The magnetic circuit shall be earthed to the clamping structure at one point only through a removable link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection and be taken from the extreme edge of the top yoke. The main core clamping structure shall be connected to the tank body.

Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section and the arrangement of the connections shall be to approval.

Where oil ducts or insulation parallel to the plane of the laminations divide the magnetic circuit into two or more electrically separate parts, the ducts or barriers shall be bridged and the magnetic circuit shall not be regarded as being of sectional construction.

Where coil clamping rings are of metal, each ring shall be connected to the adjacent core clamping structure on the same side of the transformer as the main earth connection.

All earthing connections, with the exception of those from the individual coil clamping rings, shall have a cross-sectional area of not less than 90 mm^2. Connections inserted between laminations may have the cross-sectional area reduced to 25 mm^2 where in close thermal contact with the core.

4.8.1.2.2.5 Transformer Tank

Each transformer shall be enclosed in a steel tank of welded construction, suitably stiffened by means of channel or angle sections welded to the tank, for withstanding the stresses imposed during transit to site and subsequent operation with no signs of oil leakage. The transformer tank shall have a removable lid on top, i.e. “Bell” type transformer tanks are not permitted.

The tank shall be complete with all accessories and shall be designed to allow the complete transformer (tanked and filled with oil) to be lifted by crane or jacks, transported by road, rail and water without overstraining any joints and without causing subsequent leakage of oil. Corrugated tanks are not acceptable.

The tanks must be so constructed as to be capable of withstanding an internal positive pressure of not less than 70kPa without any permanent deflection of any parts. The tank must also be capable of withstanding a vacuum of 50mm of mercury absolute when emptied of oil.

Guides shall be provided inside the tank to facilitate the lowering into the tank of the core and coils and their raising and correct positioning. The guides shall extend from the bottom of the tank to within 150mm of the top of the tank.

The tank covers shall be of adequate strength and shall not be distorted when lifted in the lifting eyes to be provided. Inspection openings/manholes suitably bolted shall be provided as necessary to give easy access to bushings, tap changer connections and earth connections. Each inspection opening shall be of ample size for the purpose for which it is provided. Covers for such openings shall not weight more than 25kg and shall be provided with lifting eyes.

A rail for connection of safety belt shall be arranged on the tank cover.

All oil-pipe connections shall have flanged joints provided with gaskets, preferable set in grooves or held in position by stops to prevent over compression of the gaskets.

Four jacking lugs shall be fitted 500mm above ground level and four holes with a diameter of not less than 50.8mm shall be provided on the jacking lugs in order to permit the transformer to be slewed in any direction.

The base of the tank shall be reinforced and so designed that it shall be possible to move the complete transformer unit in any direction without injury when using rollers, plates or rails. A design which necessitates rails being placed in a particular position shall not be used.

Wheels, where specified, shall be plain, flanged uni-directional or bi-directional, whichever is specified in Scope of Works. Bi-directional wheels shall be designed so that it is possible to change the direction of the wheels without removing them from the transformer, and provision shall be made for locking the wheels parallel or at right angles to the major axis. Grease nipples or cups shall be provided for lubricating the swivel bearings and the wheel bearings. The Employer will provide the wheel gauge.

Lifting lugs shall be fitted capable of lifting the transformer complete with windings and filled with oil.

The tank cover shall be fitted with pockets for a thermometer and for the bulbs of the winding temperature and oil temperature indicators specified. Protection shall be provided when necessary for each capillary tube. The thermometer pocket shall be fitted with a captive screwed cap to prevent ingress of water. The pockets shall be located in the position of maximum oil temperature and it shall be possible to remove the instrument bulbs without lowering the oil in the tank.

The tank and cooling equipment shall be designed to permit vacuum treatment on site. The maximum safe permissible vacuum (millimeters of mercury) which may be applied above oil level, to the tank, cooling equipment and to the conservator, without causing permanent distortion, shall be stated in the Bid.

Two earthing terminals located at opposite side of the tank, capable of carrying for 30 seconds the full lower voltage current of the transformer, shall be provided. Provision shall be made at positions close to each of the four bottom corners of the tank for bolting the earth terminals to the tank structure to suit local conditions.

4.8.1.2.2.6 Gaskets

Oil-resisting synthetic rubber gaskets will be preferred. If cork or similar material is used oil-resisting synthetic rubber be applied as a bonding medium. The Contractor shall submit details of gasket material for approval.

Spare unused sets of gaskets shall be supplied for use on site for all positions where joints have to be made after transportation of the transformer.

4.8.1.2.2.7 Current Transformer

Current transformer for winding temperature measurements shall be mounted inside the transformer on a bushing turret, and in the connection between winding and neutral point for auto-transformers.

Accuracy class 3 or better shall be used for temperature indication.

4.8.1.2.2.8 Current Transformers

Phase and Neutral Current transformers as indicated in scope of works shall be mounted in the bushing turrets.

4.8.1.2.2.9 Bushings

Bushings shall be fitted to the equipment as specified in Scope of Works. Bushings for 66 kV and above shall be of the condenser type. Other bushings may be of solid porcelain.

All terminals shall be marked to correspond with the markings on the diagram plate.

The transformer bushings shall withstand accidental arcing or flashover without seals or other vital parts becoming damaged. Stresses due to expansion and contraction in any part of the bushing shall not lead to development of bulges, hair-line cracks or other defects. Suitable connecting clamps shall be able to absorb shocks due to vibration of the connecting jumpers. The bushings shall withstand internal vacuum in the transformer tank.

All the bushings of any transformer shall have a rated current of at least 120% of the rated currents of the windings to which they are connected (in order not to limit over- loads).

4.8.1.2.3 Painting and Galvanizing

Oil-filled transformer shall have their interior surfaces sandblasted and finished with two coats of anti-corrosive and oil-resistant priming paint. Exterior surfaces shall be sand-blasted and have two rust inhibiting priming coats and one intermediate coat with paint on zinc chromate or urethane alkyd basis or equivalent; one final coat of weather and oil resistant paint. Minimum total thickness shall be 0.16 mm.

The radiator external surfaces shall be hot-dip galvanized with a zinc deposit on average not less than 400g/m^2.

Outdoor control and marshalling boxes/cabinets shall have at least one prime coat and two layers of paint on zinc powder basis to be applied after perfect cleaning.

The particulars of priming and finishing paintings shall be stated in the Bid, with specifications of paint, together with a listing of colours available, for each of the plant and equipment.

The Employer is not bound to accept the finishing colour proposed by the Bidder. Determination of colour shall be at the option of the Employer and shall be finalised at the time of approval of drawings.

\The exterior finish of outdoor control cabinets shall be in the same colour as that for the transformer.

Should any paint work be damaged during transit or erection, this shall be made good on site.

All interior and exterior surfaces, subject to corrosion, that cannot readily be painted, or where galvanising is explicitly specified, shall be hot-dip galvanised with an average thickness not less than 0.1 mm. Bolts and nuts associated with galvanised parts shall be hot-dip galvanised.

4.8.1.2.4 Fittings

The transformer shall be supplied with the fittings as indicated in particular specifications. These fittings shall comply with the following clauses.

4.8.1.2.4.1 Conservator

The conservator shall be mounted on the main tank but not obstruct connection to overhead connection.

The conservator shall be fitted with a removable end on which shall be mounted the oil gauge. The conservator tank shall be mounted to slope lightly downwards towards the drain valve, which shall be adjacent to the removable end.

The pipe connecting the conservator to the tank shall extend at least 50 mm into the conservator and shall be brought out from the highest point of the main tank cover. A valve shall be provided immediately adjacent to the conservator. All pockets and bushing turrets of the main tank shall be connected into this pipe between the transformer and the Buchholz relay.

The conservator shall be so dimensioned that it will permit all expansion over the working range of temperatures from no load with the transformer cold and at -5 ^{o}C ambient air temperature to full load at 45 ^{o}C ambient air temperature while the sump pipe remains covered with oil and the oil level is visible or indicated. In any case, the volume of the conservator shall be at least 10% of the transformer oil volume.

The oil connections from the transformer tank to the conservator vessel shall be arranged at rising angle to the horizontal. The Buchholz relay (see Clause 4.6) shall be fitted in this pipe in such a position that inspection, testing and dismantling is possible with the transformer in operation. A step valve shall be provided between the conservator and the relay.

The conservator shall be equipped with the following fittings:

a) A sump formed by extending the inlet pipe inside the conservator.
b) A manhole formed by bolting one end-plate of the conservator.
c) A drain valve with flanged plug.
d) A flanged filling plug.
e) An oil level gauge.
f) A filter valve.

4.8.1.2.4.2 Dial-type Oil Gauges

Dial-type oil gauges, where specified, shall be of the magnetically operated type, in which breaking of the gauge glass will not release any oil. The gauge shall be fitted with at least two circuit-closing, potential free, low-oil-level alarm contacts wired to the marshalling box.

4.8.1.2.4.3 Silica-Gel Breathers

Each conservator shall be fitted with a silica-gel type dehydrating breather to approval. The breather shall be provided with an oil cup or other device which prevents contact between the dehydrating agent and the air outside the transformer. If an oil cup is provided, the oil should be visible from the outside and the lowest oil level should be marked.

The weight of the dehydrating agent shall be not less than 0.5 kg per 1500 liters of oil in the transformer and cooler.

Unless the silica-gel container is transparent the breathers shall have a window for inspection of the colour and condition of the silica-gel.

4.8.1.2.4.4 Explosion-Vents

An over-pressure device of the spring release type or similar shall be used for pressure relief in case of explosion or sudden overpressure. The type shall be approved by the Project Manager. Separate oil compartments as OLTC compartment shall have separate explosion vents.

The explosion-vent shall be provided of sufficient size for the rapid release of any pressure which may be generated within the tank and which might result in damage to the equipment. The device if used shall be so placed that any discharge from it will not be deposited on any part of the transformer or its associated equipment.

4.8.1.2.4.5 Buchholz Relays

Buchholz relays shall be of the double-float type with separate floats for alarm and shut-down at low and high speed gas development and shall be of approved manufacture suitable for operation in transformer oil as specified over the temperature range -10 ºC to 115 ºC The two contact sets shall not be exposed to oil and shall be wired to the marshalling box.

The relays must be interposed in the connecting pipe between the oil conservator and the transformer tank in such a manner that all gas from the tank must pass through the relay as it rises to the oil conservator.

Two copper pipes shall be connected to the two pet cocks on the relay and extended to position 1 m above ground level and fitted with stop cocks for sampling and testing purposes. The stop cocks are to be labelled and easily accessible and be clear of surrounding steel-work. The sight window of the relay shall be readily visible from ground level. Separate oil compartment shall have separate Buchholz relays. However, the OLTC chamber shall be equipped with pressure rise relay instead.

4.8.1.2.4.6 Temperature Indicators

The local temperature indicators shall be of the dial-type graded in ^{O}C with a manually resettable pointer to register the highest temperature reached. The local indicators shall be mounted on the transformer tank in a suitable weatherproof steel cabinet with a lockable door. The cabinet shall be so positioned as to allow easy access to and readability of the gauges.

Each transformer shall be provided with winding temperature indicators of the "thermal image" type compensated for changes in ambient temperature (one for each winding type: common, series, HV, LV and tertiary as appropriate). The indicator shall have a load - temperature characteristic approximately the same as the hottest part of the windings. The primary current transformer for operating the indicator shall be built into the main transformer tank on the bushings. Information shall be included in the maintenance instructions in the form of either a graph or table showing the relationship between current injected into the heater coil and the corresponding temperature reading.

The indicators shall be provided with two sets of alarm/trip contacts, adjustable to close at any temperature between 45ºC and 150ºC such adjustment being possible without dismantling the instrument. Where supplementary forced cooling is specified, two additional set of contacts shall be provided on the winding temperature indicators, for automatic start of the cooling fans in two stages. The differential between "switch on" and "switch off" temperatures must also be variable in the range 15°C to 30°C.

The instrument and set points shall have an accuracy of ±1% of full scale deflection and the indicated temperature must reflect the hot spot temperature to within ± 3 ºC under all operating conditions. Test links are to be provided for calibration purpose.

One temperature indicator of the capillary type for measurement of the top oil temperature shall be provided for each transformer.

4.8.1.2.5 Cooling

4.8.1.2.5.1 Definition

The types of cooling shall be designated by the IEC lettering symbols:

a) Natural Air Circulation (ONAN) By radiators directly attached to the tank.
b) Forced Air Circulation (ONAF) By fans cooling the radiators.

4.8.1.2.5.2 Declaration of Ratings

The Bidder shall declare in the Schedule of Technical Guarantees the rated power available under the operating conditions ONAN or ONAF (as required in Scope of Works) and the ratings shall be indicated on the rating plate.

4.8.1.2.5.3 Radiators

The transformers shall be fitted with detachable radiators (tube coolers are not accepted). Suitable valves, with blanking plates shall be provided at the inlet and outlet of each radiator so that it may be removed without draining oil from the tank. Inlet and outlet valve "OPEN" and "CLOSED" positions shall be clearly marked. The valves shall be readily accessible and easy to operate. Lifting facilities, a drain cock and an air release vent shall be provided on each radiator.

Radiators shall be hot dip galvanized and designed so that it is possible for the whole of the cooling surface to be cleaned. They shall also be designed so that they shall withstand dry-out vacuum without distortion or causing leakage of hot oil.

4.8.1.2.5.4 Forced-Air Cooling ONAN/ONAF

The forced-cooling equipment shall be designed to start automatically from winding- temperature relay control at predetermined temperatures recommended by the Contractor. The equipment shall be designed to start in 2 stages at pre-set temperatures.

Indicate setting values are as follows:

Stages	On	Off
Stage	65°C	50°C
Stage	75°C	60°C

The cooler arrangement must allow for the maintenance or failure of any one fan or radiator without losing more than 20 % of the total cooling capacity.

All fans shall operate as a unit. Fan blades and fan ducting shall be of aluminium alloy, stainless steel, galvanized steel, or other corrosion-resistant metal and shall be designed to keep noise and vibration to a minimum. All fans shall be provided with galvanized wire-mesh guards. It shall be possible to remove fan assemblies complete without dismantling other equipment.

4.8.1.2.5.5 Cooler Capacity

The coolers and fans shall be so dimensioned that at least 80 % of the transformer capacity remains (in both ONAN and ONAF) if one cooler or one fan is removed.

4.8.1.2.5.6 Cooler Control Equipment

All the necessary automatic control, motor contactors, protective devices and switches for the forced-cooling equipment shall be assembled in cabinet or marshalling box mounted on the transformer.

The cooler control equipment shall include:

- An isolating switch rated to carry and break full-load current for each group of fan and pump motors.
- An "Auto" – "Manual" Cooler changeover switch.
- Magnetic contactor for each group of fan motors. Contactor coil leads shall be wired to the terminal board. A set of normally-closed contacts shall be provided on each motor contactor for alarm purposes.
- Overload and single-phasing relays.
- Fuses, links, MCBs and terminal boards to approval to make a complete assembly.

All equipment must be in accordance with the requirement given in general technical specifications.

4.8.1.2.6 Off-load Tap Changer

Transformer with an Off-load tap changer, if specified in Scope of Works, shall be provided with a ganged mechanism operated by means of an external handle which can be pad-locked in each tap position. This ganged Off-load tap changer shall have a rotary motion of operation. The tap positions shall be indelibly marked to indicate tapping position corresponding to the diagram plate.

The tapping ranges shall be ±2 x 2.5%, with a maximum of 5 tap positions as specified in the particular specifications and scope of works.

Tap changers with Mercury sealing glands are not acceptable in this project.

4.8.1.2.7 Drain, Filter and Sampling Valves

4.8.1.2.7.1 General

All valves shall be attached by bolted-on flanges and shall not be screwed or welded to the tank. Drain valves or isolating valves larger than 101.6 mm (4"B.S.P.) and of the double-flanged gate-type construction may have bodies of cast iron or cast steel. All valves shall be opened by turning counter-clockwise when facing the hand wheel.

Every valve shall be provided with an indicator to show clearly the position of the valve.
Means shall be provided for padlocking the valves in their open and closed position.

All valves shall be suitable for operation in conjunction with transformer oil as specified in IEC Publication 60296 at temperatures up to 115°C.

4.8.1.2.7.2 Drain Valves

Drain valves shall be of suitable dimensions in relation to the volume of oil in the transformer tank and coolers.

4.8.1.2.7.3 Oil Sampling Valves

Oil sampling valves shall be of the screwed globe type; handle or gate valves located so as to permit sampling of oil from the extreme bottom of the transformer tank and the bottom of the tap changer compartment.

4.8.1.2.7.4 Filtration Connections

Filtration connections, which shall have flanges drilled to BS 4504 Table 6 for 50.8 mm (2") valves, or screwed 50.8 mm (2"B.S.P.) female, shall be as follows:

A valve at the top and bottom of the main tank. The drain valve of the main tank may be used for this purpose if of the size described above.

The oil conservator drain valve located within easy reach of the ground, by means of a pipe extension, if necessary, shall be suitable for a filter connection.

4.8.1.2.7.5 Valve Entries

All valve entries shall be blanked off with gasketed bolted-on plates or plugs.

4.8.1.2.7.6 Rating and Diagram Plates

Rating diagram and valve plates shall be to IEC 60076, stamped or embossed on brass or stainless steel. They shall show the employer's Order Number and shall have a blank space for the Employer's serial number. The diagram plate shall show the internal connections and the voltage vector relationship of the terminals.

Where applicable, rating or diagram plates shall show locations, ratio, rating and accuracy class of current transformers. Rating diagram and valve plates shall be approved by the Project Manager.

4.8.1.2.8 Oil

The oil shall be of the uninhibited mineral type and comply with BS 148, IEC 60296 or equivalent standard. Oil shall preferably be supplied in bulk from within Kenya and dried and cleaned on site. If oil is provided in drums, these shall have a volume of approximately 200 liters and be full. A separate price shall be quoted for transformer oil.

4.8.1.2.9 On-Load Tap Changers

4.8.1.2.9.1 General

The transformer's voltage control equipment shall, if specified in Scope of Work, be of the tap changing type for varying its effective transformation ratio whilst the transformer is on load and without producing phase displacement. The on-load tap changing equipment shall comply with IEC 60214. The tappings shall be arranged in the electrical centre of the higher winding.

The tap changing equipment shall be of 3-phase type, preferably with combined diverter and selector switches and shall be designed so that it will not be possible for the main transformer winding to be open circuited or for a portion thereof to be short circuited, except through a transition impedance. The tap changers for transformer with higher capacity than 2.5MVA shall be of the vacuum type mounted inside the transformer, whilst lower capacity transformers may have conventional oil type.

Operation from any type of control shall cause one tap movement only.

The equipment shall be so arranged as to ensure that when a tap change has commenced, it shall be completed independently of the operations of the control relays or switches. Failure of the auxiliary supply during a tap change operation must not inhibit the independent completion of the tap change operation.

An auxiliary supply of 415/240 volts, 50 Hz, 3-phase 4-wire AC. will be available for operating the tap changing equipment and all its accessories. All equipment shall operate correctly at any voltage between the limits of 85 % and 115 % of nominal value.

The tapping ranges shall be ±8 x1.67%, with a maximum of 17 tap positions.

Tap changing equipment shall be capable of carrying the same currents due to external short-circuit as the transformer windings and shall withstand the impulse and dielectric tests of the associated winding. The tap changer connection and switches shall be capable of handling continuously currents at least 20 % above the highest operating current in order to limit overloading.

Where oil type used, it shall not be possible for the insulating oil in those compartments which contain contacts for making or breaking current to mix with the oil in the main transformer tank or with the oil in compartments containing contacts not used for making or breaking current

Drop-down tanks which necessitate the provision of pits in the foundations are not acceptable.
Where it is necessary to remove parts, or the whole of the on-load tap-changer for transport purposes, it shall be possible to complete erection on site with the transformer windings covered with oil.

4.8.1.2.9.2 Construction

The number of the tappings in use shall be indicated mechanically at the transformer, electrically at the local control room panel and digitally at the Control Centre.

The tap-changing switches and mechanism shall be mounted in an easily accessible cabinet on the transformer tank and shall be supported from the main tank or its base.

The oil compartment for the tap changing switch shall be fitted with its own over- pressure device and Conservator; together with suitable oil level indication and drain valves. The conservator shall be dimensioned such that applicable expansion rates can be met.

All switches forming part of the main tap-changing apparatus shall be readily accessible and it shall be possible to examine or repair such apparatus without lowering the oil level in the main transformer tank.

Each compartment in which the oil level is not maintained from the conservator shall be provided with an oil gauge of approved design.

Limit switches shall be provided to prevent the over-running of the mechanism and shall be connected directly in the circuit of the operating motor. In addition, mechanical stops or other approved devices shall be provided to prevent the overrunning of the mechanism under any condition.

Approved means shall be provided to protect the motor and control circuits.
The whole tap-changing equipment shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.

An externally visible mechanical recorder shall be fitted to the mechanism to indicate the number of tap-change operations completed by the equipment. At least five digits must be provided. No provision for resetting the counter is to be made.

4.8.1.2.9.3 Operation

The tap changer shall be operated in the following modes:

- From an automatic voltage regulator (AVR) in the substation (normal control).
  The AVR control panel is part of the transformer supply contract.
- Directly on the motor control cabinet in the switchyard (direct control).
  From the control room in the substation (local control).
  From the Control Centre (remote control).

A blocking switch shall be provided on the motor control cabinet/marshalling box with two positions: local/remote (supervisory).

When the switch is in local position, control can only take place from the control cabinet on the transformer and vice versa for the other position.

All the necessary equipment like relays, contactors, etc. shall be provided, wired up to terminal blocks to facilitate the functions outlined above. A potentiometer switch of the make before break type shall be provided for local and remote reading of tap position. The numbers shall range from 1 upwards, the lowest number representing a tapping position corresponding to the maximum number of high voltage winding turns i.e. the highest plus-percent positions. The lowest minus-percent position shall be represented by the highest number.
Grey or BCD codes shall be provided as an alternative for remote supervisory reading of tap position.

Unless specifically asked for in this document, all equipment for control and indication required in the control room shall be provided by the supplier of the control room equipment. Operating voltage for direct and local control shall be Single Phase 230V AC/50Hz.

Facilities shall also be provided to prepare the transformer for parallel operation with one or more transformers on the master - follower principle. An out-of-step device shall be provided and arranged to prevent further tap changing after a definite time interval when the transformer in parallel control is one tap out of step.

4.8.1.2.9.4 Tapping Switches

The switch shall be mechanically robust and provided with a device between the handle and the switch to permit operation without strain in the event of imperfect alignment between switch and handle; the switch operating shaft shall be fully insulated as between tank and switch and shall be provided with a suitable oil and vacuum tight gland where it passes through the tank.

The use of wood shall be avoided wherever possible and all the supports and terminal boards shall be completely unaffected by hot oil and non-moisture absorbent. High grade insulating materials shall be used in the construction of tapping switches which shall be designed with special attention to the elimination of points where tracking is likely to occur.

4.8.1.2.9.5 Alarm and Trip Signals

All alarm contacts shall have ample inductive making and breaking at the specified alarm and tripping voltage. Any auxiliary relays associated with the trip circuits shall be DC operated and suitable for the specified alarm and tripping voltage. Alarm and trip relays shall be provided with independent potential free contact.

The following alarms shall be provided and wired up to terminal blocks in the transformer cabinet:

- Tap changer not operating.
- Transformers on parallel control are out of step.
- Partial or complete failure of the voltage transformer supply to the voltage regulating relay. This alarm shall be inoperative when the transformer is on non- automatic control.
- Fan failure alarm.
- Bucholz relay transformer alarm.
- Bucholz relay transformer trip.
- Oil surge relay (OLTC) trip.
- Oil gauge low level transformer alarm.
- Oil gauge low level transformer, trip
- Oil gauge low level OLTC, alarm.

- Oil gauge low level OLTC, trip.
- Pressure relief device transformer trip.
- Pressure relief device OLTC trip.
- Top oil temperature high alarm.
- Top oil temperature high trip.
- Winding temperature high alarm.
- Winding temperature high trip.

4.8.1.2.10 Local Control Cubicles and Wiring Cabinets

Each power transformer shall be provided with a weatherproof (IP54) local mechanism/control cubicle for control of the tap changer and the same for instrumentation and control of cooling fans. The cubicle shall be mounted on the side of the transformer tank. The cabinets and equipment installed there shall strictly follow the requirements found in general technical specifications.

All cubicles and cabinets shall be complete with the requisite front panels. Bidder shall provide in their bid a complete list of all control, alarm, protection and indication facilities .

All indicating analogue instruments shall be flush mounting and the dials shall preferably be not less than 95 mm diameter if circular or, if rectangular have no side less than 95 mm.
An indelible chart showing lubrication points and specifying recommended lubricants and frequency of application shall be provided in all mechanism cubicles.

Provision for outgoing connections from the transformer control cubicles and cabinets shall be made for multicore cables. An undrilled removable glad plate to accommodate compression-type glands provided by the Employer shall be supplied. Each terminal box shall have an earthing stud for earthing of the incoming cable screens.

4.8.1.2.11 Wiring and Terminal Blocks

The contractor shall lay and connect control and power cables from the indoor control and switchgear to the local cabinets described above. All internal cabling between the transformer primary points and local cubicles and cabinets shall be provided by the Contractor. The cable laying and fastening shall be as described in general technical specifications.

4.8.1.2.12 Manufacturing, Inspections and Tests

The Contractor shall document the progress in factory with photographic records of the progress included in the progress reports. These colour photographs shall upon completion of the works be submitted in bound form together with explanatory description to the Employer.

4.8.1.2.12.1 Inspection/Witnessing of Tests

The Employer and the Project Manager, reserves the right to inspect the transformer at any stage of manufacture or to be present at any of the tests specified. Such inspection shall not relieve the Contractor of his responsibility for meeting all the requirements of the specification, and it shall not prevent subsequent rejection if such material or equipment is later found to be defective.

The contract shall include financial provision for participation by the Employer in Factory Acceptance Tests as described in scope of works. The Contractor shall in good time inform when testing will take place and shall give the Employer/Project Manager not less than twenty eight days' notice in advance. No transformer shall be tanked, or dispatched from the Contractor's works without approval of Project Manager. Based on the Contractor's manufacturing Programme, factory inspection will take place as required by the Project Manager.

4.8.1.2.12.2 Factory Tests

Transformer Tests

Bushing Tests

The Contractor shall submit for approval test records and data for all bushings. These records shall show the test performed on the bushings including but not necessarily restricted to the following tests:

- Standard one minute, 50 Hz dry withstand tests for all bushings.
- Type test of impulse withstand voltage.

All recorded test figures shall be given with the bushings serial number.

a) Routine Tests

Routine tests as far as applicable shall be carried out according the IEC Publication 60076.
The following routine tests shall be applied to all power transformer:

- Resistance measurements of all windings at all tappings.
- Ratio tests for all tappings and vector relationship tests.
- Measurement of no-load losses and currents.
- Measurements of impedance voltages (at maximum, principal and minimum tappings), short circuit impedances and load losses. Load losses shall be measured at both rated currents when ONAN and ONAF cooling are specified.
- Determination of efficiencies at 50%, 75%, 100% and 120% load at maximum temperature of the winding and 0.8 power factor lagging and unity power factor for all ratings (ONAN, ONAF ratings).
- Zero sequence impedance measurement.
- Induced voltage and separate source voltage withstand power frequency, dielectric tests on all windings on all phases including neutral points.
- Full wave impulse withstand tests. The transformer shall be subjected to a complete series of tests. Such tests shall be applied to the HV winding line terminal of each phase as well as to the neutral points.
- Tests on on-load tap changers.
- Routine tests on all transformer accessories such as motors, contactors wiring, etc.
- Partial discharge measurements.
- Measurements of capacity between the windings and each winding and ground.
- Oil leakage test. The complete oil filled transformer with bushings and radiators fitted and any other attachment normally in contact with oil shall be tested at a positive pressure measured at the tank bottom of twice the column of oil in the transformer when the transformer is cold, but in any case not less than 70kPa. Alternatively the radiators may be tested separately with the same pressure.The test period shall be not less than 12 hours.
- Core insulation test, 2 kV, 50 Hz for one minute.

b) Special tests

- Chopped wave impulse test on each transformer. The test shall be carried out in conjunction with the full wave test as described in IEC 60076-3.

c) Type Tests

The following type tests shall be carried out on one transformer of each type:

- Temperature rise test. Details of the test procedure shall be agreed between Contractor and Project Manager before testing commences.
- Noise measurements.
- Vacuum test. The transformer tank and radiators filled with oil shall be subjected to a vacuum test. Bushings need not be fitted and the radiators and conservator may be tested as separate units.

4.8.1.2.12.3 Site Tests

Testing at site by the Contractor shall be carried out to prove that the transformer in all respects complies with provisions and guarantees set forth in the Contract.

Tests shall include but not be limited to the following:

- Dielectric oil tests.
- Insulation dryness by an agreed method.
- Electrical and functional control of voltage control equipment and cooling system.
- Core to tank insulation.

4.8.1.2.13 Erection

Erection shall be carried out on foundations made by the switchgear contractor or by the Contractor under supervision by the Project Manager. The Contractor shall ascertain that the transformer has been erected according to the Terms of Contract before commissioning takes place.

All heavy erection equipment like lifting cranes and other equipment to be used for erection purpose shall be provided by the Contractor. The Contractor shall also provide all special equipment for erection and testing purpose. Such equipment shall be listed in the Bid.

4.8.1.2.14 Delivery and Transport

The transport to site is the Contractor's sole responsibility. Under road part of the transport, the transport must be in accordance with the rules for road transport in the respective countries. If any special investigations, permits or arrangements are necessary for the road transport these has to be arranged for by the Contractor. Cost for such shall be included in the price.

Shipment of transformer in any position other than the upright one is not permissible.

All shafts, bearings and machined surfaces exposed for transport to the site shall be given a temporary protective coating to prevent corrosion.

If it is necessary to remove bushings or radiators for transport blanking-off plates and a spare set of gaskets shall be provided.

Where the supply of oil is included in the contract, and transport weight limitations permit, the transformer shall preferably be transported with sufficient oil to cover the core and windings. The tank shall be sealed for transport to prevent all breathing. The remainder of the oil shall be supplied separately at the time of delivery.

Alternatively, where the above method is not applicable or practicable, the transformer shall be transported filled with dry nitrogen under slight positive pressure. This pressure and the temperature at the time of filling shall be communicated to the Project Manager and a pressure gauge suitably protected is to be fitted to each transformer to facilitate inspection of the gas pressure on arrival at site. Every precaution shall be taken to ensure that the transformer arrive at site in a satisfactory condition so that subsequent to oil filling, they may be put into service without the necessity for further drying out. Should the positive gas pressure disappear during transport and the transformer allowed to breathe, additional drying out at site if required shall be the responsibility of the Contractor.

All accessories and spares which are shipped separately must be clearly marked for identification with the transformer for which they are intended. All pipe work and valves shall have further markings showing the correct points of assembly which shall also be shown on assembly drawing to be supplied.

Full details must be supplied on methods of drying out the windings, if found necessary, on arrival and on the method to be adopted for oil filling and oil purification on site. Any special apparatus required for oil filling must be supplied as part of this contract.

The transformer shall be shipped with an impact recorder having capacity of four months recording. Full details of the proposed methods of transport shall be submitted for approval.

4.8.1.2.15 Evaluation of Losses and capitalization

4.8.1.2.15.1 Guaranteed Output and Losses, Liquidated Damages

Failure to meet the guaranteed outputs and losses will be dealt with as follows:

4.8.1.2.15.2 Transformer Output

If the guaranteed continuous output at rated voltage of any transformer has to be reduced below the guaranteed value in order to maintain the temperature rises of any part of the transformer within the guaranteed limits, liquidated damages shall be paid at the rate of USD 2577 per kW, interpolated for 25 years the minimum transformer life span.

4.8.1.2.15.3 Transformer Losses

If the total transformer losses of any transformer, as determined by these, without any tolerances, at rated voltage, frequency and 100% rated kVA (on principal tapping) exceed the guaranteed total losses, the excess in losses shall be capitalized at the rates stated in below and the resulting amount shall be paid as liquidated damages.

The payment on account of failure of one or more transformer to meet the guaranteed output and guaranteed losses shall be applied individually, as the case may be, and shall therefore be understood to be cumulative.

4.8.1.2.15.4 Rejection Limits

Should any transformer fail to meet the guaranteed output by more than 5% (five per cent) or the total losses should exceed the total guaranteed losses by more than 1/5 (one fifth), and should the Contractor fail within a reasonable time to modify the transformer in order to increase the output and/or reduce the losses sufficiently, the Purchaser shall have the option to reject the transformer.

4.8.1.2.15.5 Evaluation of Losses

Transformer losses will during tender evaluation be evaluated based on the following figures (ref Bid data Sheet):

Load losses:	USD 2577/kW for 25Years
No load losses:	USD 4339/kW for 25 years

If nothing other is specified in Scope of Work, Load losses will be evaluated based on the **ONAF** rating for transformer with combined ONAN/ONAF cooling. The Bidder must submit losses in the Guarantee Schedules without tolerances.

4.8.1.2.16 Transformer Drawings

The following shall be included with the Bid:
(Note: if complete design drawings are not available, drawings should be submitted of an existing design equivalent in all essential detail to that being offered).

c. Dimensioned outline drawings of the transformer and any auxiliary plant showing:
- The arrangement and position of all fittings and accessories.
- Any section to be removed for shipment and their separate dimensions and weights.
- Principal dimensions and minimum clearances (phase/phase and phase/earth).
- Weight, sling angles and height from ground level to crane hook applicable for lifting:
- The tank cover
- The complete transformer
- The cores and coils out of the tank
- Position and function of all valves.
- Position and function of all access openings.
- Total weight and distribution of weight to enable foundations to be designed (to be designed by the Employer).

d. Drawings showing the arrangement of the core and windings including core clamping arrangement.

(b) Detailed drawings of the tapping switch showing internal details of switch and mechanism, tapping connections and change-over link board.
(c) Fully dimensioned drawings of all proposed bushings including cross-sections and full electrical characteristics.
(d) Schematic wiring diagrams of automatic voltage control, cooler control, and protection systems with fully detailed description of the operation.
(e) Drawings of proposed rating and diagram plates.
(f) Catalogues of all accessory equipment and fittings.

4.8.1.3 Distribution (Auxiliary) Transformers

4.8.1.3.1 General

This specification covers the manufacture; testing, supply and delivery of pole mounted distribution type transformer and spares for the substation auxiliary supply.

4.8.1.3.2 General Design

Transformer shall be of the mineral oil immersed "core" (wound core or shell type shall not be provided) type suitable for outdoor use with Oil Natural Air Natural (ONAN) cooling. Primary and secondary bushings shall be located on top cover

Transformer shall be designed to deliver full rated power continuously on any tapping within the specified tapping range under the following conditions: -

i) With the voltage of the untapped winding at rated value, without the need to de-rate the transformer at the extreme tap positions and without exceeding IEC temperature limits.

ii) With voltage applied up to 10% in excess of the rated tapping voltages and without injurious overheating.

Transformer shall be connected in accordance with IEC 60076 or equivalent: three phase transformers to Vector Group reference Dyn11.

All L.V. neutrals shall be brought out of the tank to a readily accessible terminal and shall not be earthed inside the tank, unless otherwise specified in the enquiry.

Transformer on a particular contract with similar voltage ratios and connections shall be suitable for parallel operations on all relevant taps under which conditions they should share the load in proportion to their ratings subject to the tolerances on impedance laid down in IEC 60076.

Low impedance transformer are preferred, a maximum of 5% being envisaged on any size with no plus tolerance.

When requested in the enquiry, sealed designs shall be offered and the following details shall apply:

i) Unless otherwise approved, sealing shall be effected by means of a bolted cover design employing nonstandard bolts on the top cover (keys shall be supplied for each transformer).
ii) Any holes or plugs used to facilitate vacuum/pressure testing, leak testing or oil filling of the transformer shall finally be sealed by welding.
iii) The expansion of the oil level shall be accommodated by the tank itself (i.e. no gas filled pillow will be accepted). The bidder must submit documentation showing tests simulating 40 years of expansion and contraction of the tank without impairment of the rib welding.

An oil level gauge shall be provided.

Pressure valves, pressure/vacuum gauges, non-return valves and drain valves shall not be fitted. Earth stud required at both H.V. and L.V. ends of transformer.

The transformer shall operate without undue noise and every care shall be taken in the design and manufacture to reduce noise to the level of that obtained in good modern practice. The noise level of the transformer shall not exceed 60 dB (A) when tested in accordance with IEC Publication 60551.

4.8.1.3.2.1 Windings

Tapping shall be provided in the H.V. windings, preferably in the centre of the windings, to permit variation of the number of H.V. turns without significant variation in the kVA rating.

The variations shall be effected by means of a manually operated tapping switch (tapping ganged mechanism) to be provided.

The HV windings shall be made from grade 3 enameled copper wires, whereas LV windings shall be made from copper foil/strips. Graded windings insulation and Aluminium windings shall not be accepted for this project.

All windings and terminations shall be fully insulated and those for service above 1000 volts shall be designed for impulse voltage tests. Conductor material shall be c0pper. No foil windings shall be used.

Designs shall be such that electrical stresses are as uniform as possible throughoutthe windings under impulse conditions.

Windings shall be vacuum impregnated and insulating materials shall not be liable to soften, shrink, become brittle, carbonise, deteriorate, or collapse in any way during service.

4.8.1.3.2.2 Cores

The magnetic circuit shall be earthed to the core clamping structure, at one point only, and the core assembly to the tank. Where transformers are not sealed readily accessible removable bolted links shall be employed for the earthing connections.

The general construction of the cores, framework and the clamping arrangements shall be robust and such that they will be capable of withstanding completely any stresses which may occur due to handling, transport or service. All cores and yokes shall be terminated and clamped by means of a suitable framework. Suitable means shall be provided for lifting the cores from the tanks.

It shall not be possible for the core to move relative to the tank during handling or transport.

The core shall be made from high permeability material Class C.22 grain-oriented steel laminations.
Particular attention shall be paid to maintaining low core loss consistency with sound design.

4.8.1.3.2.3 Tapping Switches

The transformer shall be provided with approved off-circuit type tap changing equipment. Tapping ranges shall be ±2 x 2.5% with a maximum of 5 tap positions.

A fully insulated off-circuit, externally manually operated ganged tapping switch shall be supplied, capable of withstanding the specified impulse voltage when connected to the transformer windings.
Clearly visible tap position indication shall be provided. The tapping switch shall be operated by means of an external handle that can be positively located and locked in each operating position.

The switch shall be mechanically robust and provided with a device between the handle and the switch to permit operation without strain in the event of imperfect alignment between switch and handle; the switch operating shaft shall be fully insulated as between tank and switch and shall be provided with a suitable oil and vacuum tight gland where it passes through the tank.

The use of wood shall be avoided wherever possible and all the supports and terminal boards shall be completely unaffected by hot oil and non-moisture absorbent.
High grade insulating materials shall be used in the construction of tapping switches which shall be designed with special attention to the elimination of points where tracking is likely to occur.

Tapping switches shall be mounted on supports made of suitable high strength insulating material and shall be provided with self-aligning spring loaded wiping contacts capable of maintaining good electrical contact without the need for periodic maintenance.

All clearances between tapping switch contacts and leads shall be indicated on drawings submitted at the time of Bidding and such clearances shall be sufficient to prevent tracking or flashover in the event of carbon or sludge deposits forming on leakage paths.

H.V. tapping: Minus 2.5% - 0% - Plus 2.5% - Plus 5% - Plus 7.5%.

4.8.1.3.2.4 Outdoor Bushings

All line terminals and neutral connections where specified, shall be brought out to porcelain outdoor type terminal bushings in accordance with DIN 4253 with minimum creepage distance 31mm/kV in Coast and industrial area and 25mm/kV in inland installations. Arcing horns shall be fitted on all transformer bushings. As an alternative factory mounted surge arresters are acceptable.

4.8.1.3.3 Tanks and Conservators

4.8.1.3.3.1 General

Drain valves may be either screwed or flanged whilst conservator isolating valves shall be flanged. Drain valves shall be complete with captive plugs that shall be either of non-ferrous metal or galvanised.

All internal steel surfaces or tanks and conservators shall be shot blasted and cleaned, and a coat of protecting compound, unaffected by hot oil, should be applied.

All external surfaces and parts made of steel are to be thoroughly shot blasted and cleaned, after which two coats of priming paint, preferably of zinc chromate, one intermediate coat and one coat of finishing paint are to be applied. the final color of the exterior surfaces shall be dark admiralty grey color No. 632 as per BS 381C with a total dry film thickness of between 100 - 130 microns.

Transformers on which the paints are found to flake off or deteriorate within the guaranteed period shall be suitably cleaned and repainted free of charge by the supplier.

4.8.1.3.3.2 Tanks

Each transformer shall be housed in a tank of welded steel plate construction suitably stiffened where necessary but with a flat base. Wheels or rollers are not required.

Each tank shall be provided with the accessories specified Table 1, the lifting lugs called for shall be suitable for lifting the transformer bodily by means of a hoist or crane when it is completely assembled and ready for service.

All transformers shall be provided with four fixing lugs on the base drilled with 15 mm holes for bolting to a platform. The fixing holes shall project beyond the ends of the tank and be placed to provide the most practical stable arrangement.

No radiators or tube coolers shall be used ribbed tanks shall, if needed, be supplied in order to achieve the necessary cooling under the conditions prevailing at site.

4.8.1.3.3.3 Conservators

Conservators shall be of dimensions such that oil expansion may occur over the working range temperature from no load with the transformer cold at minus 5ºC ambient air temperature to full load at plus 45ºC ambient air temperature while the sump pipe remains covered and the oil level is visible or indicated.
The fittings detailed in Table 1, shall be provided on all transformer conservators.

Drain plugs shall preferably incorporate approved sampling facilities, and shall be mounted at the lowest part of the conservator tank and so designed that the sampling device can be readily cleared in the event of its being blocked by an accumulation of sludge etc., without the necessity of having to dismantle the device completely.

Oil level gauges on conservator tanks shall be of the refracting plate glass or other approved type, marked with the level at 20º C at no-load and capable of indicating the level of oil over the specified working range.

Where dehydrating breathers are specified they shall be of the Silica gel type (cobalt free), in accordance with DIN 42567, which give indication of moisture absorption by change in colour of the charge. The breather shall be covered by a metal tube to avoid vandalism. An inspection window shall be provided and mounted in a position convenient for inspection. The breather is to incorporate an oil seal to prevent contact with the external air when breathing is not taking place. The breather shall be fitted on the L.V. end of the transformer.

Where only a vent pipe without a breather and incorporating a filling hole is specified, it shall preferably be fitted with a cap and provided with very fine mesh in corrodible anti-vermin gauze.

4.8.1.3.3.4 Accessories and Fittings

All transformers shall be provided with accessories and fittings in accordance with Table 1, unless otherwise specified.
Rating and diagram plates shall be engraved steel, brass or other approved in corrodible material.
Where a thermometer pocket is provided, it shall be of a thin walled metal mounted in the tank cover.
The pocket shall project 25 mm outside of the tank and shall be threaded along the whole projecting portion, a screwed cap shall be provided to cover the pocket when not in use.

Lightning arresters equipped with galvanised brackets suitable for bolting to a vertical surface shall be mounted directly on to the transformer tank. The mounting surface shall be such that the centre lines of the arresters are parallel with the centre lines of the associated bushings, and at the same spacing as the bushings.

Table 1: Accessories and Fittings for distribution transformers

Distribution transformers: 50 to 315 kVA	
Transformer Tank Fittings	
1. Conservator (Sealed type)	N
2. Drain valve with captive sealing plug	N
3. Lifting lugs	Y
4. Thermometer Pocket	N
5. Rating and diagram plate	Y
6. Hanger irons	N
7. Platform mounting lugs	Y
8. Earthing Terminal	Y
9. Lightning arrester brackets	Y
10 Arcing Horns	Y
11. HV Surge arrestors	Y
11.Dial type thermometer	Y
12 Jacking pads 1000 kg or more transformer mass	N
13.Oil gauge	Y
14. Pressure relief device	Y
15.Lashing down facilities	Y
16.Marshalling box for Item 10 of Tank	N
fittings and Item 7 of Conservator fitting	N
Conservator Fittings	
1. Drain plug	Y
2. Sampler	Y
3. Separate filling hole with cap.	Y
4. Dehydrating breather	Y
5. Plain breather	N
6. Oil gauge	Y
7. Gas & oil actuated relay	N
8. Conservator isolating valve	N

Y = Required **N = Not Required**

4.8.1.3.3.5 Insulating Oil

The transformer shall be filled with low viscosity mineral insulating oil, which complies in every respect with the provision of IEC 60296.

4.8.1.3.4 Tests

The following tests shall be carried out:

a) Factory routine test results shall be submitted, immediately after completion of tests in the factory, for each and every transformer.
b) As a type test, temperature rises test on each different rating of transformer.
c) As a special test, an impulse voltage withstands test including chopped waves on each different rating of transformer.

Note:
If tests b and c above have been carried out satisfactory on designs identical in all essential details, these tests may be waived on the production of acceptable covering test results.

4.8.1.3.5 Packing and Transport

Transformer shall be transported to destination with their tanks full of oil up to the service level.

Bushings and any accessories or fittings likely to be damaged shall be protected adequately against damage in transit.

4.8.1.3.6 Transformer drawings and diagrams

4.8.1.3.6.1 To be submitted with Bid

The following drawings shall be supplied with Bid unless identical drawings have been previously supplied, in which case a statement in the Bid of the applicable drawing subjects, numbers and revisions will suffice together with details of the references under which previous supply was made:

(a) General arrangement drawing of each rating of transformer offered showing: -
   i) Minimum clearance (phase to phase and phase to earth) on H.V. and L.V. bushings including clearance H.V. to L.V.
   ii) Positions and identification in a separate legend of all fittings with type numbers.
   iii) Size and position of all fixing holes.
   iv) Total weights with and without oil and core lifting height and weight.

(b) Detail dimensioned drawings of tapping switch illustrating type of material, clearances, between tapping points and to earth and method of operation.
(c) Detailed dimensioned drawing of bushings, silica gel or plain oil seal type breather, and conservator.

Note:
Where sealed transformers are offered, a cross-arrangement drawing shall be submitted with the Bid showing, in particular, details of the tank construction and internal tank finish and the depth of the expansion space above the oil.

4.8.1.3.6.2 To be submitted with Contract

Latest issues of the drawing shall be supplied under the contract; if no modifications are applicable to the drawings supplied with the Bid, this shall be confirmed in writing under the contract and further drawings need not be supplied.

Rating and diagram plate drawing shall be supplied.

4.8.1.3.7 Evaluation of Losses

The loss evaluation/ capitalization shall be as for the Power transformers

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SUBSTATION AUTOMATION, CONTROL AND PROTECTION

TABLE OF CONTENT

5 Substations Automation, Control and Protection.....95
5.1 Control, Protection and Metering.....95
5.2 Overview of Substation Automation System – SAS.....95
5.3 Design of SAS.....96
5.4 Substations typical SAS Layout.....96
5.5 Signal list.....98
5.6 Station HMI.....98
5.7 SAS Equipment.....99
5.8 Control stations.....101
5.8.1 Distributed Control Units.....101
5.8.2 Interface with Supervisory Control and Data Facilities.....101
5.9 Automatic Voltage Regulator.....102
5.10 Indicating and Metering Instruments.....102
5.11 Factory Acceptance Test.....103
5.12 Training.....103
5.13 Spare Parts and Tools.....103
5.14 System Maintenance.....103
5.15 Protection.....103
5.15.1 General Requirements.....104
5.15.2 Relay Construction and Mounting.....104
5.15.3 Relay Testing Facilities.....105
5.15.4 Fault Clearing Time.....105
5.15.5 Trip Circuits.....105
5.15.6 Fault Recorder and Fault Locators.....106
5.15.7 Supervision.....106
5.16 Protection of HV System.....106
5.16.1 132, 66 and 33kV Line Protection.....106
5.16.2 11kV Line Protection.....113
5.16.3 Line protection of 33/11KV 2.5MVA station.....114
5.16.4 Transformer Protection (7.5MVA).....115
5.16.5 Transformer protection (2.5MVA).....119
5.17 Bus coupler-Bypass Trip logic.....119
5.18 Relay test equipment.....119
5.19 Relay Settings.....119
5.20 Metering.....120
5.21 Metering of 33kV and 11kV Lines.....120
5.22 Synchronizing Equipment.....120
5.23 LV Cables and Cable Racks.....120
5.23.1 Cable technical requirements.....121
5.23.2 Cable laying.....121
5.23.3 Diagrams and Calculations.....121
5.23.4 Tests.....121
5.24 Earthing (Grounding) System.....122
5.24.1 Technical requirements.....123
5.24.2 Earthing system under the Control Building.....123
5.24.4 Earthing system for the Switch yard.....124
5.25 Site and Commissioning tests.....125
5.25.1 Test of wiring.....125
5.25.2 Tests of relays.....125
5.25.3 Test of DC circuit.....126
5.25.4 Test of Instrument.....126
5.25.5 Tests on the Switchyard.....126
5.25.6 On Load test.....127

5 Substations Automation (SCADA), Control and protection

5.1 Control, Protection and Metering

General

The sections below cover the technical requirements for the systems of control, protection, metering and signaling of the sub-stations. The control and relay boards shall include all equipment as specified in Scope of Works, needed for complete installations. Any computer solution proposed shall be based on hardware and software well proven in HV installations. All data storage media shall be checked for internal faults and virus before delivery.

The supplied and installed instruments, relays, switches and other equipment shall properly match the equipment to which it shall be connected, and which is included in the sections dealing with the different types of switchgear for transformers, transmission lines and other items.

The complete and detailed scheme of control, protection, alarms, etc., shall be proposed by the Contractor for each individual sub-station project. In this detailed planning the Contractor shall carefully consider the future extension of the plants. The Bidder shall guarantee the availability of spares in 10 years from cessation of normal production. This shall be demonstrated in the bid

The control, metering and protection equipment can be placed in common panels but not as integrated functions. The panels shall not be unnecessarily crowded but have space for moderate extensions. All control functions and status indications shall be clearly arranged in a mimic diagram. The bay control unit shall have a mimic diagram for all the equipment in the bay. The equipment shall be on a modular basis connected to terminals inside the panels and easy to replace. For indoor MV switchgear the control and protection can be located in the instrument compartment in the switchboard.

All data and parameters specified to the individual distributed control units, shall be stored in a non-volatile memory so no local logic or information will be lost due to power supply failure.

The Contractor’s scope shall comprise the design, manufacture, factory testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KPLC’s personnel and warranty of the system.

5.2 Overview of Substation Automation System - SAS

This Substation Automation System (SAS) comprises full station and bay protection as well as control, monitoring and communication functions and provides all functions required for the safe and reliable operation of the substations.

It shall enable local station control via a Personal Computer (PC) by means of a human machine interface (HMI) and control software package, which shall contain an extensive range of system control and data acquisition (SCADA) functions. It shall include communication gateway, inter-bay bus, intelligent electronic devices (IED) for bay control and protection.

The communication gateway shall secure the information flow with Regional Control Centres. The inter-bay bus shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions.

In order to meet the requirements of this specification the detailed design of the SA is in the scope of contractor, subject to approval by Project Manager.

5.3 Design of SAS

The Substation Automation System (SAS) shall be suitable for operation and maintenance of the complete substation including future extensions. The offered products shall be suitable for efficient and reliable operation of outdoor or indoor substations for distribution and transmission.

The systems shall be of the state-of-the art based on IEC61850-3-2013 and IEC60870-104 for operation under industrial conditions present in high-voltage substations, follow the latest engineering practice, and ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Regional Control Centre via gateways.

The system shall be designed such that personnel without any background knowledge in microprocessor-based technology are able to operate the system easily after having received some basic training.

Cubicles shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and disturbance recording. The basic control functions are to be derived from a modular standardized and type-tested software library.

For safety and availability reasons the Substation Automation System shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information of the station shall be stored in distributed databases.

5.4 Typical SAS architecture for Substation

The typical SAS layout shall be structured in two levels, i.e. in a station and a bay level. The system shall accommodate control, data acquisition, alarm handling and trend analysis. The figure below illustrates the main principles. However, the Employer wants to keep a conventional back up control facility with indication at bay level (local control). i.e. control of motorised breakers and switches, status indication of all breakers and switches, analogue or digital indication of measurands (I and I_{max} all phases, MW and MVAr) and alarm annunciation shall be presented by discrete components.

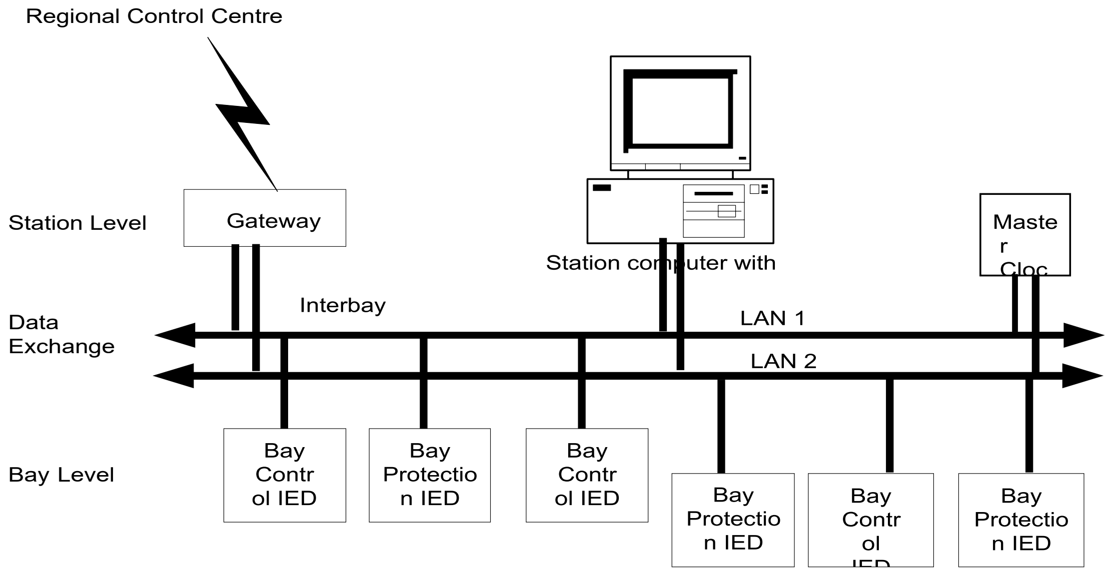
The control of high and medium voltage circuit breakers, isolating switches and tap changers shall take place in a hierarchy with four levels as described in Project Specific Data Section. From each level one may block access from higher levels:

The control units shall take auxiliary voltage form the station battery and be equipped with self-supervision systems giving alarm by internal faults.

The system shall be fail-safe keeping all equipment in the last status by loss of communication to higher systems.

The Gateway and Station Industrial Computers shall be housed in panels while the HMI monitors and CPUs shall be installed in the substation control room/office.

System Architecture of Substation Automation



Layout is for 23 MVA substations and above, for 7.5 MVA Substations redundancy is reduced

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the inter-bay bus. The bus shall be realized using fibre-optic cables or Ethernet.

At station level, the entire station shall be controlled and supervised from the station HMI. It shall be possible to control and monitor the bay from the bay level equipment, in the event that the communication link fails. The station wide interlocking shall also be available when the station computer fails.

To provide highest reliability the station HMI and the gateways shall work completely independent meaning retrieving the process data directly from the bay level devices.

Additionally, the gateway and the station HMI shall be configured fully redundant to ensure full functionality in case of single point of failure.

Clear control priorities shall prevent that operation of a single switch can be initiated at the same time from more than one of the various control levels, i.e. SCADA, station, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

A dedicated master clock for the synchronization of the entire system shall be provided. This master clock should be independent of the station computer and of the gateway, and should synchronize all devices via the inter-bay bus.

The SAS shall contain the following main functional parts:

(i) Human Machine Interface (HMI) with process database
(ii) Separate gateway for remote supervisory control via SCADA
(iii) Hot Standby Gateways for stations with transformation capacity of 23 MVA and above.
(iv) Master clock (GPS receiver)
(v) Collection of the relevant data concerning the substation and distribution of the data where needed
(vi) Bay and station level devices for control, monitoring and protection
(vii) Bay-oriented local control and protection panels.

5.5 Signal List

The signal list shall be agreed between the KPLC and the Supplier and shall comprise the following;

- Commands for all Circuit Breakers and motorized switchgear
- Status Indications
- Alarms and Trips
- Set Point regulation
- Measurands
- Energy meter readings
- Reset by SCADA for all Master Trip Relays

The design shall include mapping of the Signal list from the supplier (as addressed & used in the HMI) to the requirements of the Regional Control Centre (supervisory level) signal requirements.

The design of the SAS system shall include the following;

- Control mode selection
- Select-before-execute principle
- Command supervision: Interlocking and blocking
- Double command Auto reclosing
- Monitoring pole discrepancy and trip function
- Transformer tap changer control
- Display of interlocking and blocking
- Breaker position indication
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Data storage for at least 200 events

Select-before-execute

For safety reasons the command is always given in two stages: selection of the object and command for operation.

These two commands are realized with one contact each; only when both contacts are closed, is the final command (open or close) executed.

5.6 Station HMI

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks on soft-keys.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
SAS shall include the following displays &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 SAS from the Central Control Centre via the SCADA system
- Remote communications
- Indication of automatic tap changer relay status
- Manual local and remote setting of tap changer relay
- 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.
- Also, all required signals related to the control, status indications and monitoring of the switchgear and other relevant equipment shall be provided to the SAS.
- Time Tagging

The configuration of the station HMI shall be made using the operator station in the Windows environment. The various functionalities shall be customized by easy-to-use interactive configuration tools. The configuration shall include the visual presentation of the object, adaptations needed in the process database, and adaptations of the communication configuration data.

5.7 SAS Equipment

All SAS equipment shall be of industrial type conforming to IEC 61850-3-2013 standards

5.7.1 Substation Computer

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

- Alarm Grouping
- Event Logging
- SAS 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 SAS functionality. The Tenderer shall state how this is achieved.

5.7.2 Substation Local Area Network

Local substation communications shall use Ethernet LAN to connect the components ofthe SAS using open international IEC 61850 GOOSE protocol. The LAN may be of star-coupler configuration. Fiber optic can be used only in instances where the lengths are too long to be handled by Ethernet LANS. No single point of failure of the substation LAN shall result in any loss of substation control functionality.

The station controller must be able to receive and transmit information from future extensions on an IEC 61850 protocol.

5.7.3 Operator Workstation

The Operator workstations / HMIs shall consist of high performance computer and monitor with computer desk. It shall be fully integrated into the SAS 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.

5.7.4 Printers

- Two high performance printers shall be provided, each capable of connection to the substation LAN.
- 1 off Matrix printer Logger, for events and for operator log.
- 1 off Color Printer to print screen shots or other information

5.7.5 Satellite Clock

Time synchronization and event time tagging with resolution of at least 1ms shall be provided by a satellite GPS clock signal as the Master clock, the secondary clock shall be provided via the SCADA system.

5.7.6 Audible Alarm

- One common sounder should 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 SAS (Local/Remote). An auto-silencing scheme shall be provided for the alarm and the sounder shall be controlled by distinctly labeled “Audible alarm ON/OFF” control switch.
- The complete unit may be mounted in suitable relay/control panel.

5.7.7 Common Bay Unit

- The Common Bay Unit (CBU) shall be provided for monitoring of common services. The CBU shall be located in Control/Relay Room.

5.7.8 Data Transmission

- The SAS shall be able to communicate with the ABB type SCADA system using a variety of open protocols. The RCC shall be capable of remote access to the SAS via the SCADA system. The protocols currently supported are IEC 61850-3-2013 & IEC 60870-104.
- This communication link must be via an approved communication mode complete with the terminal equipment all supplied, installed & commissioned by the Contractor.

5.7.9 Cyber Security

The SAS system shall have protection against malicious, accidental and hacking attempts in accordance with applicable IEC standards.

5.8 Control Stations

5.8.1 Distributed Control Units

Outdoor switchgear shall have a control and relay panel in the control room with facilities for Local Control. The local control for indoor breakers can be located in the instrument cabinet. The protection and control functions can also be combined in one unit. Signals from protection equipment can alternatively be hardwired to bay control unit.

The Bay control unit shall handle position indications from Circuit Breakers, Disconnectors, Earthing switches and transformer tap changer. It shall control closing and opening of circuit breakers and receive time tag, store and display alarms and measurements.

The position indication from the on load tap changer shall be taken from a potentiometer switch supplied and mounted on the transformer.

The alarm handling capacity must be sufficient to handle all normal alarms from the switchgear, the protection, the transformer and the tap changer.

All commands from the remote and supervisory control can be given to bay control unit, which execute the commands. Conventional interlocks should be retained.
All microprocessor based control equipment such as bay control units shall be galvanically isolated from the environments outside panels, using opto couplers or interposing relays for signals, galvanic isolated measuring transducers for measurements and relays or contactors for commands.

All data and parameters specified to the individual distributed control units, shall be stored in a non-volatile memory so no local logic or information will be lost due to power supply failure.

Editing and input of local data and parameters shall be performed locally by suitable programming equipment to be included in the supply. Preferably it should also be possible to edit any such local data at higher control level and download this information.

5.8.2 Interface with Supervisory Control and Data Facilities

In order to interface and achieve the desired functionality of the SCADA/EMS system, data concentrators in substations shall be based on standard IEC 60870-104 protocol.
The following SCADA facilities shall be available from the substation.

- Supervisory control of all circuit breakers and motorized line and bus bar isolators and remote control of on-load tap changers.
- Status Indications of all circuit breakers, isolators, positions of on-load tap changers and ‘local/remote’, ‘Automatic/ Manual’, Main/Follower mode of automatic voltage regulators where applicable. These shall be reported by exception, but system shall allow scan by demand.
- Alarms; Bay alarms, Transformer alarms, Bus bar alarms, station alarms and warning shall be collected by the SCADA.
- Measurements; bus bar voltages, frequency active & reactive power, 48 & 110 V DC voltages and line currents.
- Energy measurements, this shall be at interconnection points and feeders.

Where data concentrators will capture and process data for transmission to the control centres it is expected that the following functions shall be provided:

- Single command outputs, double command outputs for supervisory (on/off) control of circuit breakers, isolators etc. with check-before-execute function.
- Regulation command outputs e.g. raise/lower command outputs for transformer tap changer control and set point transmission with validity check before execution.
- Resetting of Lock out Trip Relays on individual circuits.
- Single and double state digital inputs. Each status (open/closed) of two state devices such as circuit breakers or isolator position should be acquired independent from each other and checked for validity. Undefined states like open and closed or neither open nor closed shall be alarmed with run-time monitoring adapted to the HV equipment operation parameters.
- Transformer tap changer position indication should be processed as coded signals, by digital measurement input modules.
- Analogue measured inputs with pre-processing including validity check, local limit supervision and measurement transmission on exception (only if a significant individually selectable change occurs).
- Measurement transmission with a resolution of at least 10 bit plus sign as this is the most economical way to increase the overall accuracy of the measurements.
- Metering pulse inputs for acquisition of energy values with internal storage to allow cyclic acquisition of meter readings.
- Sequential event recording with time stamping of events (time stamp 10ms, resolution 1 ms)
- Selectable priority levels for data acquisition to speed up the acquisition of circuit breaker status changes and important measurements.

5.9 Automatic Voltage Regulator

The transformer bay shall be equipped with an automatic voltage regulator acting on the on load tap changer. The automatic voltage regulation function shall pursue to keep a constant (but adjustable) voltage on the low voltage side of the transformer by raising or lowering the tap changer (however, an appropriate hysteresis shall be included to avoid over-frequent tapping). The regulation shall be achieved either by a freestanding relay or as a function in the control system.
If connected in parallel, in order to prevent circulating current or negative reactance system: the transformers shall be regulated in a master-slave mode, where each transformer can be selected as master. If the master transformer is out of service another transformer shall take over as master.

Manual switchover to conventional tap changing (local and remote) shall be accommodated.
Necessary blocking by out of range stepping (including inappropriate difference between parallel units) and disconnected transformer shall be included. The actual tap position shall be displayed locally and remote as well as the identification of the master unit.

5.10 Indicating and Metering Instruments, and Transducers

Remote indication of measurands shall take place on the station controller's VDU. Where local instruments are used, they shall be of the dial type which is easily legible, with black graduations and numerals on a white background. The instruments shall have a dimension of 96x96 mm. The error of the instruments shall be maximum 1.5% reckoned on the total length of the scale. All instruments shall be of a narrow frame type.

Preferably the measurements shall be performed directly in the SAS or in the protection relays. However, if needed, the metering transducers (converters) shall be installed in the boards and shall be suitable for connection to the potential and current transformers. The cases shall be hermetically sealed against moisture and dust. Transducer output shall be an impressed DC current of 0-10 mA output. The maximum meter reading at the receiving end shall be equivalent to 30% overload of the source value.

The permitted resistive load shall be at least 1000 Ohms. The accuracy class shall be minimum 1%. The auxiliary voltage, if required (preferably not) shall be 48VDC.

The W and VAr measurements shall be of the three-element (three-wattmeter) type when connected to primary systems with grounded neutral. W and VAr measurements for transmission lines, shall be such that the direction of the power flow is indicated by negative direction towards the substation and positive direction out of the substation. The voltage shall be measured phase-phase voltage, one reading is sufficient.
The scale on the different types of instruments shall be proposed by the Contractor and be subject to approval by the Project Manager.

5.11 Factory Acceptance Test

The Control system with Station Control Unit and Field Units shall undergo a factory acceptance test where the total system is connected and all indications, measurements commands and controls are simulated.

5.12 Training

An in-depth training in the application, fault finding and maintenance of the control system shall be provided. The training must include but not be limited to the following:

- System configuration
- Programming tools
- Picture editing
- Operating system
- System maintenance
- Any other training regarded necessary by the Bidder
- Communication protocols, IEC 60870-103/104, IEC 61850-3-2013
- Protection device settings and configurations

5.13 Spare Parts and Tools

The Contractor shall furnish a list of recommended spare parts and test equipment for the purchased system to maintain reliable SAS operation. The spare parts list shall be short-term spare parts that are necessary for two (2) years of operation.

These spare parts shall be included in the contract and shall comprise at least one spare module for supplied equipment and basic tools for system maintenance as provided for in the mandatory spares.

5.14 System Maintenance

Editing and input of local data and parameters shall be performed locally by suitable programming equipment to be included in the supply. Preferably it should also be possible to edit any such local data at higher control level and download this information. The programming equipment shall also be suitable for fault diagnostic.

- Laptop Computer for maintenance, information transfer and emergency HMI
- A Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. This service unit shall be used for documentation, testing, commissioning & future maintenance work on the SAS.
- Licenses for configuration of supplied equipment shall be in scope of supply.

5.15 System Protection

5.15.1 General Requirements

The protection relays/IEDs to be installed for the protection of power lines, transformers and other HV/MV equipment shall be Numerical type and it shall be possible to use compatible and supported non-proprietary Communication protocols including but not limited to IEC 60870-5-103/104, Modbus serial, Modbus TCP/IP, IEC 60870-5-101/104 and DNP3. Shall also support IEC 61850-9-2 GOOSE messaging. Relay shall be robust type, insensitive to changes of temperature, vibration, etc.

Input from the measuring transformers shall be based on 1A, 110Vac. The relay's power supply must accept a rated operating voltage input range from 24-240VDC without the use of external resistors and without external reconnections and shall be designed to withstand the high voltage interference which is normally experienced in high voltage switching stations.

There shall be galvanic isolation on all inputs and outputs including power supply input. Isolated opto inputs must accept a rated operating voltage from 24-240VDC/VAC without the use of external resistors and without external reconnections.

The Contractor shall endeavour to standardise the equipment by using as few different types of instruments, relays, switches and other devices as possible.

5.15.2 Relay Construction and Mounting

The relays shall comply with the requirements of IEC 60255. Modular constructed equipment shall be tested as a complete assembly and details of such tests shall be agreed with the Project Manager when details of the construction are known.

Constructional details shall satisfy the following requirements as appropriate:

- Relay contacts shall be suitable for making and breaking of the maximum currents which they require in normal service: The protective relays shall be provided with sufficient contacts for circuit breaker tripping. All protective relays, which initiate tripping, shall have not less than two independent pairs of contacts of which one shall operate the tripping relay or circuit breaker trip coil without the interposition of auxiliary contactors and without the use of reinforcing contactors.
- A watchdog relay must detect internal fault including low auxiliary voltage. The auxiliary voltage supply to each discriminative relay unit shall be continuously monitored and an alarm shall be given whenever the voltage exceeds the limits for reliable protection operation.
- The measured service currents and/or service voltages must be visible at the front display of the relay. In order to see all values at the same time, a four-line front display must be used. It shall also be possible to select default display.
- The relay must store a record of the fault-trip values to facilitate post fault analysis including, such as currents, voltages, operating time identification of the faulted phase and faulted zone etc. The values must be available at the front display of the relay and transferable to the supervisory system. The storage must not be dependable of the auxiliary supply.
- It must be possible to do all settings both from the relay front panel and/or with a PC through connection in the front panel of the relay
- The relay must have a complete number keyboard in the front panel for settings and downloading of measured values on the front panel display
- Wherever practicable the design of the relay schemes shall be based on the "fail-safe" principle. For example, care shall be taken to ensure that loss of DC supply or an open circuit does not cause incorrect opening or closing of circuit breaker. Circuit breaker or disconnector repeat relays should be of the on-latching type and a discrepancy alarm shall be provided to check correct operation of the relays following a circuit breaker or disconnector operation.

- The lockout tripping relays shall be of the latching type and shall be hand and electrically reset.
- In order to achieve a high degree of security in function, the protection system of each high voltage main component (lines, power transformers, shunt reactors, etc.) shall consist of two separated protection sets, main 1 and main 2 where applicable. Where two protection sets cover the same fault they shall be divided into two electrically and mechanically separate parts by means of:
  - separated DC power supply,
  - separated boards,
  - separate current transformer cores,
  - separate voltage circuits,
  - separated tripping devices,
  - separate tripping coils,
  - separated cables,
  - separated relay protection channels.
- The restricted earth fault and differential functions for the transformers shall also follow the same principle for separation as outlined above.
- The Auxiliary relays for protection trip shall have operating speed of less than 7 millisecond.
- Strict requirements shall be given on selectivity in isolation. Only the minimum possible part of the plant shall be tripped to isolate the fault or clear the abnormal conditions.
- The Contractor shall for each substation carry out the protection plan for relay settings. The plan shall be submitted to the Project Manager for approval.
- All necessary intermediate current and voltage transformers, converters and auxiliary power supply units shall form part of the supply.
- The user manuals must be user-friendly and divided into one general hardware and software description and one setting manual describing only the specified functions and necessary settings for the different types of relays

5.15.3 Relay testing facilities

Each protection relay shall be provided with facilities for the connection of relay testing equipment. The facilities shall include plugs for connecting the testing equipment and switches for disconnecting the primary circuit of the relay, short circuiting current transformer circuits (make before break) and disconnecting the tripping circuit.
Programmable relays shall be delivered with software and software licenses needed for testing, Laptop for setting and reconfiguration of the relays. If hardware other than laptop is required for this such shall be included in the supply.

Commissioning laptop is mandatory and shall be supplied by contractor with pre-installed necessary software for protection/control and SAS system.

5.15.4 Fault Clearing Time

The protection system plus the circuit breakers shall have fault clearing time of not more than 60ms for system voltages 132 kV and above and 100ms for lower system voltages.

5.15.5 Trip Circuits

All trip circuits shall be duplicated with one group tripping the circuit breaker directly and the other routed via a trip relay with heavy duty contacts. All lockout trips shall be routed via a hand reset/electrical reset relay with heavy duty contacts. Closing of circuit breakers from substation control systems or local operation cubicle shall be inhibited if the lockout trip relays are not reset. The trip circuit supervision shall be independent of the protection relays and provided to monitor each pole of each trip circuit on circuit breakers with separate mechanism per pole with the circuit breaker in both the open. The status of the trip circuit shall be indicated on the panel.

An alarm shall be given to signal faulty trip circuits. The alarm shall be time delayed to prevent operation during momentary dips in the DC supply.

5.15.6 Fault Recorder and Fault Locators

Fault recorders and fault locators must be integrated in the line protection relays and use the same input parameters as the main protection function. The fault locators must provide records for fault analysis in the "Standard Common Format for Transient Date Exchange (IEEE-COMTRADE)" Necessary signals from the transformers shall be included.

5.15.7 Supervision

An Engineering Work Station (EWS) shall be supplied and installed with a licensed software to make it possible to communicate with the relays for remote setting, supervision, control and data acquisition over the LAN network installed in each substation using the standard communication protocols which includes but not limited to Modbus TCP/IP, IEC 60870-5-101/103/104 and DNP3. The EWS will be installed with the latest windows operating system and shall be compatible with the licensed software. The Contractor shall supply, install, connect the relays and test the complete system.

5.16 Protection of HV and LV System

5.16.1 132kV, 66kV and 33kV Line Protection

Facilities shall be provided to enable one protection (main or backup) to be taken out of service for maintenance or testing without affecting the operation of the other in any way. The facilities shall include duplicate breaker trip coils, separately MCBs DC circuits and the use of separate CT and VT windings. The protection relays shall be arranged to initiate a single set of auto-reclosing equipment. The protection relays / IEDs shall be visible from the front of the panel without having to open the panel door.

The line protection schemes shall contain the following protection functions:

(i) Distance Protection function (Main A)
(ii) Differential Protection (Main B -for 132kV and above)
(iii) Bay Control and Protection Unit (BCPU)
(iv) Three phase unidirectional over current and Earth fault function (Backup)
(v) Sensitive Earth fault function
(vi) Auto reclose relay function
(vii) Trip circuit supervision
(viii) Auto reclose IN/OUT Switch
(ix) Breaker failure function

The distance/differential and Overcurrent & Earth protection functions shall be in separate relays/IEDs.

Protection functions (iii, iv, v, vii and viii) shall be incorporated in BCPU as one IED for the 66kV and 33kV Line protection.

(a) <u>Numerical Distance Protection IED</u>

One complete distance relay with full scheme non-switched type for phase/earth and phase/phase faults and with up to four measuring zones. In addition to the above the numerical relays must have the following functions:

- Ratings: AC Inputs: 110VAC, 1Amp (three phase).
- Power Supply Voltage shall be universal 24-240VDC

- The relays shall be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850
- The relay shall also have auto reclose function.
- Impedance criteria.
- Three zones phase –phase Protection.
- Three zones phase –earth Protection
- Additional Zone 4 Protection
- Automatic Switch on to fault.
- Independent settings for each zone.
- Distance to fault measurement.
- Display: On operation, the relay should display the faulted phase(s), time and zone of operation and distance to fault.
- Power Swing detection: Blocking/non-blocking selectable by user.
- Scheme communication logic and residual current compensating.
- IDMT Three Phase/Over current & Earth fault Protection.
- Fuse failure supervision.
- Auto- reclose logic 1phase and/or 3 phases.
- Three pole tripping logic.
- Disturbance and event records including software for disturbance analysis.
- Fault record should be incorporated.
- At least six (6) Binary inputs.
- Mho/Quadrilateral characteristics.
- Stability against Switching inrush currents and Reverse faults.
- Clear faulted phase indication.
- Clear fault identification even for boundary conditions.
- Software necessary for all above functions shall be provided.

All these functions must be integrated in a compact package and a user-friendly menu driven interface should be available to enable the setting and testing of the relays.
Three sets of Installation, Commissioning and maintenance manuals and settings software shall be provided.

(b) <u>Line Differential IED</u>

The comprehensive protection functions make it ideal for utility, industrial, marine and off-shore differential protection applications. The device features the following protection functions:

- Ratings: AC Inputs: 110VAC, 1Amp (three phase).
- Power Supply Voltage shall be universal 24-240VDC
- The relays shall be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850
- Three phase biased differential stage with inrush blocking dI>, dI>>
- IDMT Three Phase/Over current & Earth fault Protection
- Impedance criteria.
- Three zones phase –phase Protection.
- Three zones phase –earth Protection
- Additional Zone 4 Protection
- Automatic Switch on to fault.
- Independent settings for each zone.
- Unbalance protection I2>, I'2>,
- Thermal overload protection T>
- Circuit-breaker failure protection CBFP
- Programmable stages

- Distance to fault measurement.
- Display: On operation, the relay should display the faulted phase(s), time and zone of operation and distance to fault.
- Power Swing detection: Blocking/non-blocking selectable by user.
- Scheme communication logic and residual current compensating.

Further the device includes a disturbance recorder and arc supervision unit. The manage communicates with other systems using common protocols, such as the Modbus RTU,
Modbus TCP, Profibus DP, IEC 60870-5-103, SPA bus and DNP 3.0. In addition, each relay is expected to interface directly with a single mode optical fibre.

Note: *Relay/IEDs should come with 20m fibre patch cords to connect with optical fibre cable at the ODF where applicable.*

(c) Three Phase Directional/Unidirectional Over Current & Earth Fault Relay

Should incorporate the following functions:

- Ratings: AC Inputs: 110VAC, 1Amp (Three phase).
- Power Supply Voltage shall be universal 24-240VDC
- In addition of Overcurrent and Earth fault, the relay shall also have auto reclose function
- Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
- Current setting range for over current relay 0.5In-2.4In
- Current setting range for earth fault relay 0.05In-0.8In
- Quadrature connection for polarising voltage (Vn=110)
- Applicable on the LV side of a Dyn1 transformer
- High set Element, with a setting range of 1-32In
- The phase and earth directional elements should be individually selectable.
- I.D.M.T characteristics according to BS142 or IEC60255 and Definite time characteristic
- The normal operating boundary shall be +/-90 degrees from relay characteristic angle Relay sensitivity should be 1% of rated value of current and current polarising voltage at an angle equal to the relay characteristic angle.
- Time setting multiplier 0.05 - 1.0
- Broken conductor protection feature
- Negative sequence Protection Feature
- High set Element for both over current and earth fault Protection, with a setting range of 1-30In.
- Thermal Protection.
- Dedicated Breaker Fail Protection.
- Circuit Breaker Maintenance
- Incorporate Fault records, Event Records and disturbance records.
- Configurable output relays with ability to output starting elements to control Tripping of other upstream Protection relays.

Three sets of Installation, Commissioning and maintenance manuals and settings software shall be provided.

(d) Sensitive Earth Fault Relay.

Should incorporate the following Features;

- Ratings: AC Inputs: 1Amp
- Power Supply Voltage shall be Universal power supply of 24- 240VDC
- Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
- Current setting range for earth fault relay 0.005In-0.8In
- I.D.M.T characteristics according to BS142 or IEC60255 and Definite time delay characteristic; setting range, 0- 30 Seconds.
- Circuit Breaker Maintenance
- Fault records, Event Records and disturbance records.
- Drop off /pickup ratio >90%
- Low transient overreach < 10%

Three sets of Installation, Commissioning and maintenance manuals and settings software shall be provided.

(e) Auto reclose function

- The autoreclose function shall be enabled in the distance relay and in the overcurrent and earth fault relay, and there shall be no need of independent autoreclose relay for 66kV lines and below.
- Selectable 1 - 3 autoreclose shots
- Independent set dead time for each shot
- Autoreclose inhibit after manual close
- Separate input for over current high set element and I.D.M.T element
- Autoreclose inhibition for over current high set element.

For 33kV lines, the Three Phase Overcurrent, Earth fault & Autoreclose functions shall be combined in one IEDs (BCPU)

(f) Bay Control Protection Unit (BCPU)

The relay shall have the following functions and features: -

i. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
ii. Power Supply Voltage shall be Universal power supply of 24- 240VDC is preferred.
iii. The relay shall be suitable for flush mounting
iv. The relay will have a large LCD screen measuring at least 7cm x 7cm where a mimic of the switchgear arrangement and status of the switchgear for the bay shall be displayed.
v. The position of the switchgear i.e. Circuit Breaker and Disconnectors shall be indicated.
vi. The switchgear close and open push key buttons with symbols and colour codes as per the IEC standards shall be provided on the relay as well as switchgear selection key.
vii. A Local/Remote key selector switch shall be provided on the relay and the selected status of the selector switch indicated by means of an LED.
viii. The Relay offered shall have at least the following protection functions; -

- Three Phase Overcurrent & Earth Fault
- Sensitive Earth fault
- Broken Conductor detection
- Auto reclose function
- Circuit breaker maintenance
- Circuit breaker Failure protection

- Under and over frequency protection as well as rate of change of frequency protection
- Over/under voltage protection
- Synch Check Function

ix. The Relay shall measure and display (Metering) on the LCD screen following power system parameters; Current (I), Voltage (V), Active Power (P), Reactive Power (Q), Frequency (HZ) and power factor (P.F).

x. The relay shall store at least twenty (20) fault records, Fifty (50) events and ten (10) disturbance records. The disturbance record shall have capacity to monitor Eight (8) analogue and ten (10) digital channels.

xi. It shall be possible to display instantaneous measurands on the screen alongside the bay mimic.

xii. The unit shall have an L.E.D to indicate relay healthy status (green colour) and relay faulty status (red colour). A separate Red L.E.D to indicate operation (Trip) of the protection functions.

xiii. The relay shall have at least Eight (8) programmable LEDs for displaying Protection function operations and other alarms.

xiv. The template for writing the alarm labels shall be provided with the relay

xv. The relay shall have at least twelve (12) binary inputs

xvi. The Relay shall have at least six (6) output relays

xvii. The relay shall be provided with IEC 61850-8-1 Communication protocol, and the corresponding communication port.

xviii. The Relay terminals shall be of screw type terminals large enough to accommodate at least 2x2.5mm2 cable and shall be located at the back of the relay.

xix. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance record for analysis.

Note:

- *All the protection functions shall meet the requirements of each function as included in this specification.*
- *Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied.*
- *Earth Fault and Sensitive earth fault shall have separate CT inputs.*
- *Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in these specifications.*

(g) Under frequency relay

Where required, in 33kV bus bar, each Bus bar shall be equipped with a separate under frequency relay for load shedding of all outgoing feeders. Each feeder trip circuit from the under frequency relay shall be equipped with a clearly marked isolating link.

The relay shall be numeric having two independently time delayed settings in the range 50- 47Hz with a resolution of 0.1Hz. The rate of change of frequency function shall be included.

(h) Bus bar Protection relay for 66kV and above Voltages

Bus bar protection schemes shall be provided at bus bars for voltages from 66kV and above. Low impedance schemes will be acceptable provided full bus bar protection coverage to include single phase and phase to phase faults can be achieved. The type of tripping criteria has to be fully described and preference will be given to systems with at least two (2) criteria checks before tripping.

Bus bar Protection relay shall have the following minimum and functional features:

i. Power Supply Voltage shall be 24-240VDC universal.
ii. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
iii. AC Inputs of 110VAC and 1Amps (In) 50Hz three phase per circuit.
iv. It should be able to carry 4xIn current continuously
v. Shall have extensive self-supervision and diagnostic facilities.
vi. Incorporate a check feature
vii. Incorporate continuous supervision for CT secondary circuits against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm
viii. Be of phase segregated and triple pole type and provide independent zones of protection for each bus
ix. Provide 100% stability up to 50kA fault level and shall have immunity against system transients.
x. Be of high impedance, biased differential type and have operate and restraint characteristics with typical tripping time: 10 to 20ms
xi. The HMI should graphically display the bus bar configuration and the bus bar image and shall permit read out of a minimum of the following information:
xii. Phase currents (and optionally, phase voltages) in each bay
xiii. Differential currents in each Bus bar zone and each phase on line as well as at the time of fault.
xiv. Alarm conditions and Trip conditions
xv. State of all the inputs and outputs setting values
xvi. Positions of the breakers in each bay
xvii. Resetting of output relays
xviii. Shall include Protection Enable / Disable feature
xix. It shall have sufficient number of programmable opto coupler binary inputs (Min of 10 No. per bay) and output relays with heavy duty & signaling contacts (Min of 10 No. per bay)
xx. It shall include a Disturbance Recorder function
xxi. It shall include an Event Recorder function
xxii. The Disturbance Recorder and Event Recorder buffer memory shall be of non-volatile type and shall not require the use of batteries.
xxiii. Programmable LED indications.
xxiv. The relay shall have front and rear communication ports for settings/configuration and integrating with the local station automation or to a station monitoring system.
xxv. One of the protocols offered for the communication port shall include IEC 61850.
xxvi. Time synchronization via IRIG-B and SNTP.
xxvii. Be supplied along with all suitable Original Customized licensed software & communication cable for local and remote communications, analysis of fault etc.
xxviii. The bus bar protection relay shall have built-in Breaker Failure feature.

xxix. The relay shall have CT supervision function.

xxx. There shall be trip command lockout with manual reset (local and remote by binary input.)

(i) Breaker fail Protection relay for 66kV and above Voltages

Where an independent Circuit Breaker fail (CBF) protection relay is required shall be of the numerical design and shall have following minimum features and functions: -

i. Power Supply Voltage shall be 24-240VDC universal

ii. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2

iii. AC Inputs of 1-Amps (In) 50Hz three phase per circuit.

iv. Relay should be able to carry 4xIn continuously.

v. Shall have extensive self-supervision and diagnostic facilities.

vi. Detection shall incorporate current check feature and a timing element.

vii. The current check function shall comply with IEC 60255-151 and timing element IEC 60810-1.

viii. The relay shall have programmable initiating inputs and tripping outputs.

ix. It shall have sufficient number of programmable opt-coupler binary inputs (Min of 10 No.) and output relays with high speed heavy duty & signaling contacts (Min of 10 No.)

x. The HMI should permit read out of a minimum of the following information:
- Phase currents
- Alarm conditions and Trip conditions
- State of all the inputs and outputs setting values
- Resetting of output relays

xi. Shall include Protection Enable / Disable feature

xii. It shall include a Disturbance Records, event record function

xiii. The Disturbance Recorder and Event Recorder buffer memory shall be of non-volatile type and shall not require the use of batteries.

xiv. Programmable LED indications.

xv. The relay shall have front and rear communication ports for settings/configuration and integrating with the local station automation or to a station monitoring system. One of the protocols offered for the communication port shall include international standard protocol IEC 61850. Time synchronization via IRIG-B and SNTP.

xvi. Be supplied along with all suitable Original Customized licensed software & communication cable for local and remote communications, analysis of fault etc.

The breaker fail protection shall only isolate the bus bar to which the faulty breaker is connected i.e. the station shall, as far as possible, remain in operation after a breaker failure. The bus bar protection can be used for selection of breakers to be tripped.

5.16.2 11kV Line Protection

- The main protection for 11kV lines shall be three phase Overcurrent & Earth fault, Sensitive earth fault and auto reclose function combined in one IED/BCPU.

(a) <u>Bay Control & Protection Unit (BCPU)</u>

The relay shall have the following functions and features: -

i. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
ii. Power Supply Voltage shall be Universal power supply of 24- 240VDC is preferred.
iii. The relay shall be suitable for flush mounting
iv. The relay will have a large LCD screen measuring at least 7cm x 7cm where a mimic of the switchgear arrangement and status of the switchgear for the bay shall be displayed.
v. The position of the Circuit Breaker, i.e. racked-in or withdrawn shall be indicated.
vi. Circuit Breaker close and open push key buttons with symbols and colour codes as per the IEC standards shall be provided on the relay as well as switchgear selection key.
vii. A Local/Remote key selector switch shall be provided on the relay and the selected status of the selector switch indicated by means of an LED.
viii. The Relay offered shall have at least the following protection functions; -
   - Three Phase Overcurrent & Earth Fault
   - Sensitive Earth fault
   - Broken Conductor detection
   - Autoreclose function
   - Circuit breaker maintenance
   - Circuit breaker Failure protection
   - Under and over frequency protection as well as rate of change of frequency protection
   - Over/under voltage protection
   - Synch Check Function
ix. The Relay shall measure and display (Metering) on the LCD screen following power system parameters; Current (I), Voltage (V), Active Power (P), Reactive Power (Q), Frequency (HZ) and power factor (P.F).
x. The relay shall store at least twenty (20) fault records, Fifty (50) events and ten (10) disturbance records. The disturbance record shall have capacity to monitor Eight (8) analogue and ten (10) digital channels.
xi. It shall be possible to display instantaneous measurands on the screen alongside the bay mimic.
xii. The unit shall have an L.E.D to indicate IED healthy status (green colour) and relay faulty status (red colour). A separate Red L.E.D to indicate operation (Trip) of the protection functions.
xiii. The relay shall have at least Eight (8) programmable LEDs for displaying Protection function operations and other alarms.
xiv. The template for writing the alarm labels shall be provided with the relay
xv. The relay shall have at least twelve (12) binary inputs
xvi. The Relay shall have at least six (6) output relays
xvii. The relay shall be provided with IEC 61850-8-1 Communication protocol, and the corresponding communication port.
xviii. The Relay terminals shall be of screw type terminals large enough to accommodate at least 2x2.5mm2 cable and shall be located at the back of the relay.
xix. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop

computer for relay configuration and parameter settings and download of fault records, events records and disturbance record for analysis.

Note:

- *All the protection functions shall meet the requirements of each function as included in this specification.*
- *Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied.*
- *Earth Fault and Sensitive earth fault shall have separate CT inputs.*
- *Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in these specifications.*

(b) Sensitive Earth Fault Function.

Should incorporate the following Features;

- Current setting range for earth fault relay 0.005In-0.8In
- I.D.M.T characteristics according to BS142 or IEC60255 and Definite time delay characteristic; setting range, 0- 30 Seconds.
- Drop off /pickup ratio >90%
- Low transient overreach < 10%

(c) Auto reclose function

- The autoreclose function shall be enabled in the BCPU relay, and there shall be no need of independent autoreclose relay for 11kV lines and below.
- Selectable 1 - 3 autoreclose shots
- Independent set dead time for each shot
- Autoreclose inhibit after manual close
- Separate input for over current high set element and I.D.M.T element
- Autoreclose inhibition for over current high set element.

For 11kv lines, the Three Phase Overcurrent, Earth fault, Sensitive Earth Fault & Autoreclose functions shall be combined in one IEDs (BCPU)

(d) Under frequency relay

Where required, in 11kV bus bar, each Bus bar shall be equipped with a separate under frequency relay for load shedding of all outgoing feeders. Each feeder trip circuit from the under frequency relay shall be equipped with a clearly marked isolating link.

The relay shall be numeric having two independently time delayed settings in the range 50- 47Hz with a resolution of 0.1Hz. The rate of change of frequency function shall be included.

The 11kV line protection shall also incorporate;

- Auxiliary relay to indicate/lockout circuit breaker for low SF6 gas pressure
- Trip circuit supervision relay that is visible from front of panel without having to open any panel compartment door.
- Front panel mounted Auto reclose IN/OUT switch.
- Front panel mounted Sensitive Earth Fault ENABLE/DISABLE switch.

5.16.3 Line Protection of 2.5MVA 33/11kV Substation

5.16.3.1 33kV overhead line protection

The 33kV line protection schemes for 2.5MVA 33/11kV substation shall contain the following protection functions:

(i) Distance Protection function (Main protection for long lines) or line differential for a short line
(ii) Three phase Over current and Earth fault function(Back up protection)
(iii) Sensitive Earth fault function
(iv) Auto reclose relay function
(v) Trip circuit supervision visible from the front of the panel without having to open the panel door.
(vi) Auto reclose IN/OUT Switch
(vii) Sensitive Earth Fault ENABLE/DISABLE switch
(viii) Breaker failure function
(ix) Bay Control Functions

The distance and Overcurrent & Earth protection functions shall be in one IED.
Protection functions (iii, iv, v, vii and vii) shall be incorporated the same IED

5.16.3.2 11kV Overhead line protection

i) Three phase Overcurrent & Earth fault Protection
ii) Sensitive earth fault protection
iii) Bay control functions
iv) Auto reclose function
v) Trip circuit supervision visible from the front of the panel without having to open the panel door.

5.16.4 7.5MVA 33/11kV and above Power transformer Protection

The protection on HV side shall contain the following protection relays:

(i) Biased differential protection relay for two winding Transformer.
(ii) HV Three-Phase directional/unidirectional Over current & Earth fault Protection
(iii) LV Three-Phase directional/unidirectional Over current & Earth fault Protection
(iv) Auxiliary relays in a annunciator IED for the following transformer functions

- Tx Buchholz gas Alarm
- Tx Buchholz surge Trip
- OLTC Surge Trip
- Pressure relief Valve Trip
- Winding temperature Alarm
- Winding temperature Trip
- Oil temperature Alarm
- Oil temperature Trip
- Tx Oil level low Alarm
- OLTC Oil level low Alarm

(v) Master trip for both HV and LV
(vi) Trip circuit supervision relay for the HV and LV breaker, visible from front of panel without opening relay compartment door.
(vii) Breaker fail protection function
(viii) Restricted earth Fault: It shall include stabilising resistor and voltage dependent resistor (metrosil)
(ix) Standby Earth fault Protection
(x) Bay Control Function

(a) Biased Differential Protection for Two Winding Transformer

Overall differential protection equipped with over current stabilizing for external faults and insensitive to in-rush current. The operating time of the IEDs (Protection relay) shall be less than 20ms. This is considered Main 1 transformer protection and shall incorporate the following features:

- Ratings: AC Inputs: 1Amp
- Power Supply Voltage shall be 24-240VDC universal.
- Relay Must be of Numerical design and supports communication protocols IEC 60870- 5-103a-104 and IEC 61850-9-2
- Pick up setting range, 0.1 to 0.5In
- Should incorporate a high-set Element with a setting range of up to 20In.
- Magnetizing current inrush restraint
- Integral CT ratio compensation (0.1-2) and vector group compensation
- Measurement and indication on the MMI, of phase, differential and bias currents
- Storage of Fault records and Event records; the Fault flags should be accessible on the relay LCD screen without opening the relay cover.
- Over fluxing restraint
- Over fluxing protection with Alarm and Trip functions
- 5th harmonic restraint feature on the differential Element.
- Appropriate Dual Bias characteristic to ensure relay stability
- Should incorporate a disturbance recorder feature.
- Red L.E.D to indicate Tripping
- Relay Self diagnostic and Alarm feature
- Ability to Latch output contacts to prevent TX re-energizing before carrying out investigations.

(b) Three Phase Directional/Unidirectional Over Current & Earth fault relay

The IED shall incorporate the following Features;

- Ratings: AC Inputs: 1Amp
- Power Supply Voltage shall be 110VDC or universal supply 24-240Vdc.
- Relay must be of Numerical type and supports communication protocols IEC 60870-5- 103-104 and IEC 61850-9-2
- Current setting range for over current relay 0.5In-2.4In
- Current setting range for earth fault relay 0.05In-0.8In
- I.D.M.T characteristics according to BS142 or IEC 60255 i.e. SI, VI, EI, LTI, including definite time for the high-set Elements.
- Time setting multiplier 0.05 - 1.0
- Broken conductor protection feature
- Negative sequence Protection Feature
- High-set Element for both over current and earth fault
- Protection, with a setting range of 1-30In.
- Thermal Protection
- Dedicated Breaker Fail Protection.
- Circuit Breaker Maintenance

- Fault records, Event Records and disturbance records.
- Configurable output relays with ability to output starting elements to control Tripping of other upstream Protection relays.
- Drop off /pickup ratio >90%
- Low transient overreach < 10%

(c) Bay Control Protection Unit

The relay shall have the following functions and features: -

i. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2

ii. Power Supply Voltage shall be Universal power supply of 24- 240VDC is preferred.

iii. The relay shall be suitable for flush mounting

iv. The relay will have a large LCD screen measuring at least 7cm x 7cm where a mimic of the switchgear arrangement and status of the switchgear for the bay shall be displayed.

v. The position of the switchgear i.e. Circuit Breaker and Disconnectors shall be indicated.

vi. The switchgear close and open push key buttons with symbols and colour codes as per the IEC standards shall be provided on the relay as well as switchgear selection key.

vii. A Local/Remote key selector switch shall be provided on the relay and the selected status of the selector switch indicated by means of an LED.

viii. The Relay offered shall have at least the following protection functions; -

- Three Phase Overcurrent & Earth Fault
- Sensitive Earth fault
- Broken Conductor detection
- Autoreclose function
- Circuit breaker maintenance
- Circuit breaker Failure protection
- Under and over frequency protection as well as rate of change of frequency protection
- Over/under voltage protection
- Synch Check Function

ix. The Relay shall measure and display (Metering) on the LCD screen following power system parameters; Current (I), Voltage (V), Active Power (P), Reactive Power (Q), Frequency (HZ) and power factor (P.F).

x. The relay shall store at least twenty (20) fault records, Fifty (50) events and ten (10) disturbance records. The disturbance record shall have capacity to monitor Eight (8) analogue and ten (10) digital channels.

xi. It shall be possible to display instantaneous measurands on the screen alongside the bay mimic.

xii. The unit shall have an L.E.D to indicate relay healthy status (green colour) and relay faulty status (red colour). A separate Red L.E.D to indicate operation (Trip) of the protection functions.

xiii. The relay shall have at least Eight (8) programmable LEDs for displaying Protection function operations and other alarms.

xiv. The template for writing the alarm labels shall be provided with the relay

xv. The relay shall have at least twelve (12) binary inputs

xvi. The Relay shall have at least six (6) output relays

xvii. The relay shall be provided with IEC 61850-8-1 Communication protocol, and the corresponding communication port.

xviii. The Relay terminals shall be of screw type terminals large enough to accommodate at least 2x2.5mm2 cable and shall be located at the back of the relay.

xix. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance record for analysis.

Note:

- *All the protection functions shall meet the requirements of each function as included in this specification.*
- *Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied.*
- *Earth Fault and Sensitive earth fault shall have separate CT inputs.*
- *Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in these specifications.*

(d) Restricted Earth Fault Relay

The relay shall be used for protection of one winding of a power transformer, and shall have following minimum functions and features: -

i. Relay must be of Numerical type and supports communication protocols IEC 60870-5-103-104 and IEC 61850-9-2

ii. Ratings: AC Inputs: 1Amp

iii. Power Supply Voltage shall be 110vdv or 24-240VDC universal supply

iv. The Relay shall operate on high impedance principle.

v. The relay shall be suitable for flush mounting on panel front.

vi. The relay shall be of an independent relay and not a function in the differential relay.

vii. Relay shall reject harmonics produced by the system particularly third harmonics.

viii. Stabilizing resistor and voltage dependent resistor (metrosil) of suitable rating shall be offered with the Relay based on maximum through Fault of 40kA.

ix. The relay current setting range shall be 0.05- 0.8 x rated current (In) as a minimum and an operating time < 25ms at 5 times the setting.

x. The relay shall have at least four (4) LEDs for relay status indication and for trip and alarms annunciation as a minimum and two (2) binary inputs as a minimum

xi. The relay shall have four (4) Binary Outputs as a minimum with LCD screen where the settings and measurands can be read

xii. The relay's REF operate current shall be displayed on the LCD screen and keypad for manual programming of settings and data access

xiii. The relay shall have serial RS232, USB or Ethernet Front Port for relay configuration and programming of parameter settings and data download using a laptop computer.

xiv. The relay shall have an event recorder with capacity to store the last fifty (50) events

xv. The relay shall have fault recorder with capacity to store the last ten (10) fault records

xvi. The relay shall have a disturbance record with capacity to store the last four (4) disturbance records

xvii. The relay terminals shall be screw type terminals large enough to accommodate at least $4mm^2$ cable and shall be located at the back of the relay

xviii. Relay must be of Numerical type

xix. Relay should reject harmonics produced by C.T saturation

xx. The offer should include the associated stabilising resistor and voltage dependent resistor (metrosil)

xxi. Current setting range 0.05-0.8In

xxii. Operating time < 25ms at 5 times the setting

Restricted earth fault and differential protection functions shall be provided in separate IEDs.

(e) Stabilizing resistor

Each REF relay shall be supplied with an adjustable stabilizing resistor. For dimensioning of the stabilizing resistor consider maximum through fault phase–earth current of 25 kA.

Restricted earth fault and differential protection functions shall be provided in separate units

(f) Voltage dependent Resistor (Metrosil)

Each REF relay shall be supplied with a voltage dependent resistor (VDR) or Metrosil to limit voltage across the REF high impedance circuit.

The basis for the rated voltage of the VDR is the maximum phase-earth through fault of 25 kA.

Note: *The Stabilizing resistor and the Voltage dependent resistor shall preferably be housed in a box with terminals that allow connection of the REF relay to the resistor and VDR in the box. Several terminals will be provided to allow selection of required stabilizing resistor. The single box will be suitable for panel mounting.*
The Protection Functions Offered shall satisfy the detailed specifications as included elsewhere in this specification for each of the protection and control functions.

5.16.5 2.5 MVA 33/11KV Power transformer protection

The protection on HV and LV side shall contain the following protection functions:

(i) HV and LV three Phase Directional/Unidirectional Over current & Earth fault Protection IED
(ii) Restricted earth fault protection function
(iii) Standby earth fault protection function
(iv) Auxiliary relays in an annunciator IED for the following transformer functions
- Tx Buchholz gas Alarm
- Tx Buchholz surge Trip
- Pressure relief Valve Trip
- Winding temperature Alarm
- Winding temperature Trip
- Oil temperature Alarm
- Oil temperature Trip
- Tx Oil level low Alarm

(v) Master trip for both HV and LV
(vi) Trip circuit supervision relay for the HV and LV breaker, visible from front of panel without opening relay compartment door.
(vii) Bay Control functions

REF shall include stabilizing resistor and voltage dependent resistor (metrosil)

The characteristics for Restricted Earth Fault and Standby Earth Fault and Three phase Directional/Unidirectional Overcurrent & Earth faulty relays shall be as described in the clauses 5.16. above.

5.17 Bus Coupler - Bypass Trip Logic.

Where bus coupler is specified or already installed, the trip signals of any by passed circuit breaker shall be instantaneously transferred to the bus coupler.

Electrical interlocks shall be provided to ensure that only one circuit can be put on bypass at any one time. This is only possible through the reserve bus bar.

The bus coupler protection shall in addition to possible bypass consist of a 3-pole IDMTL overcurrent relay and one IDMTL earth fault relay, all with standard inverse characteristics as well as breaker failure back-up protection.

5.18 Relay test equipment

The relay test equipment shall be a portable three phase unit with facilities for testing of impedance relays, over current relays, negative sequence relays, differential relays, earth fault relays both directional and non-directional as well as auto reclosing equipment.
All sources of test units shall be integrated in the unit digital display for volt and amps shall have 1% accuracy whereas the digital timer shall have a resolution not less than 1ms. It shall be possible to connect the unit to a personal computer and necessary software for data recording and data handling shall be included.

5.19 Relay Settings

The Contractor based on network and equipment requirements shall provide the protection setting. The Contractor, prior to making all commissioning tests, shall apply the settings to the equipment.

5.20 Metering

All metering equipment shall meet the requirements in IEC 60687 and IEC 61036. Meters shall be designed for 110V$\pm$15/25%, 50(47-53) Hz and 1A secondary voltage/current from measuring transformers. Auxiliary supply for the meters shall be 110Vac/50Hz from the voltage transformers, or 110VDC from the DC supply system.

5.21 Metering of 33 and 11kV Lines

Electronic meters for active power, reactive power (Wh and VArh) and data recording units shall be provided for each outgoing feeder for registration of power irrespective of the direction of power flow. The Whr meters and recorders shall be of class 0.2 and class 0.5 for the VArh. The scale on the different type of instruments shall be proposed by the Contractor and be subject to approval by the Project Manager. The meters shall be able to communicate with the control system with pulses and on an IEC 61850 protocol.
The energy meters for all the circuits shall be housed in one modular metering panel whose front door is a transparent glass.

5.22 Synchronizing Equipment

Circuit breakers and the secondary side transformer circuit breakers at 66 kV and above shall have synchronism check equipment (controlled closure).
Closure of the circuit breaker shall only be possible when the phase angle, slip and voltage difference between the measured voltages are within pre-set ranges. Permitted phase angle difference shall be adjustable in the range of 5 to 100 degrees, the slip shall be adjustable in the range of 0.05 to 0.5% and the voltage difference shall be adjustable from 2 to 20%.

5.23 LV Cables and Cable Racks

General

This chapter covers the technical requirements of the external cables and appurtenance, cable laying, supply and erection of cable racks, etc., for all installations described under these Specifications except for the cables included in Domestic Installations (light, small power, etc.), which is described under Civil Works.

The supply and installation of the internal cables between the various parts of equipment shall be included in the Chapters in which the relevant equipment is specified.

The cable trenches including trench covers as well as conduits and cable racks shall be furnished and installed by the Contractor. Other necessary materials and equipment for laying, fixing, terminating, etc. of the cables shall also be provided by the Contractor.

For calculation of the length of cables, cable racks, etc., the Bidder shall use the measurements computed from the Drawings. No alteration in the lump sum prices shall be made due to possible rearrangement of any installation, changes in the building constructions, or any other reason, which may influence the quantity of cables and appurtenances to be supplied.

If, however, a considerable change in location of a switchyard should be made, the price shall be reduced or increased proportionally to the amount of reduction or increase in the distance between the switchyard and the control building. No price adjustment shall be made for deviations of less than 25 metres.

The cables shall be delivered in full lengths, and consequently no joints are permitted. All accessories shall be provided, such as potheads, galvanised and painted steel supports, clamps, etc.

5.23.1 Technical requirements - Cables

The design, manufacture, rating and testing of all cables shall comply with the provisions and requirements of the applicable IEC recommendations, supplemented by recognised national standards if necessary.

40°C maximum design ambient temperature shall be applied for all cables internally in the switchyard, between the switchyard equipment and the control building and inside the control building. All cables shall be of termite proof design, e.g. by brass tape or equal approved techniques.

Wherever the risk of inductively transferred disturbances during abnormal (short-circuit, earth fault) conditions as well as during normal conditions exists, the cables shall be screened.

In order to have a minimum number of types of cables, all cables shall be standardized as much as possible as regards cross-sections, number of cores and marking of cores.

The phase colour identification code to be applied shall be made known to the Contractor shortly after the award of the Contract.

For the three-phase low-voltage system, four wire grounded neutral system shall be used.

The low voltage power cables (AC and DC) and all cables for control, measuring, etc., shall be PVC insulated and PVC-sheathed with an earthed concentric copper screen.

The conductors shall be of electrolytic copper, and all cables shall be steel wire armoured.

Further requirements are stated in General Specification of Works, "Wiring and Terminal Blocks".

5.23.2 Cable Laying

The main guidelines and general requirements for the cable laying are stated in General Specification of Works, Cable Laying and Routing.
Medium-voltage, low-voltage power cables and control and measuring cables shall be segregated from each other throughout the plant.

The cables shall be laid in an orderly manner and crossings in the same plane shall be avoided.
All cables shall be laid on cable racks where they are not running in cable ducts or trenches, or in protecting tubes.

The cable racks shall be designed to allow the laying of the cable from the side(s) without pulling through. All racks and fixing devices shall be hot-dip galvanised.

The Contractor shall supply trenches and conduits of concrete.

The last section of a cable on the switchyard may be laid in a conduit or a pipe, they shall be laid in such a way that cables easily can be exchanged without digging.

5.23.3 Diagrams and Calculations

The Contractor shall deliver cabling plans and diagrams showing each cable connection. Drawings for the cable racks, fixing features, etc., shall also be provided by the Contractor. All dimensioning calculations shall be submitted to the Project Manager for approval.

The Bidder shall in his Bid give detailed information about the different types of cables proposed.

5.23.4 Tests

Factory tests and site tests shall be performed in accordance with the applicable IEC recommendation, and their type test reports shall be submitted as well.

5.24 Earthing (Grounding) System

General

This chapter covers technical requirements of the earth electrode systems and the Earthing conductors for the connection of metallic parts, of lightning arresters and of the system neutrals, designed to protect persons and material and to allow for the correct service, operation and maintenance of the installations.
The substation earthing system shall be designed principally according to ANSI/IEEE 80- 1986 Guide to Safety in AC Substation Grounding.
The Earthing system shall consist of the earth electrode system in the ground under the switchyard, and of the Earthing conductors, over-ground and in the buildings.

The Contractor shall design the complete Earthing system. He shall measure and verify the specific earth resistance at all places where Earthing electrodes will possibly be buried, he shall make drawings of the Earthing electrode grids, calculate the resulting earth electrode resistance, and supply all information about the planned Earthing electrode systems. He shall also make drawings of the Earthing conductors, over ground and in the buildings and make the necessary calculations for the dimensioning of the Earthing conductor systems. All the above shall be submitted to the Project Manager for approval.
For Biding purposes the earth resistivity shall be taken as 2300 ohm-metres.

The contractor shall be responsible for providing and installing the underground Earthing system of the switchyard and for the connecting of all related equipment to this Earthing system and shall furnish all required materials for this purpose. The Earthing system shall earth operational electric systems of any type and voltage such as transformer neutrals, lightning arresters, secondaries of instrument transformers, etc.

Moreover, the Contractor shall take the necessary measures and furnish the required material for the safe Earthing of:

- All steel structures, metal parts and overhead ground wires of the switchyard.
- All fences of the station, whereby for outer fences special care shall be taken to avoid injurious step and touch voltages for personnel standing outside and inside these fences.
- All metal parts, even if these do not constitute a conducting part of an electric system of the plants, such as machinery, operating desks, piping, sewers, rails, metal tanks, lighting, fixtures, cable racks, etc.
- All operational electric systems such as power and instrument transformers, lightning arresters etc.

All connections between equipment and the Earthing network shall be exposed (not embedded) and easily accessible for checking of the transition points. Bare conductors, as part of the Earthing system, embedded directly in the concrete will not be accepted. Similarly, bolted connection of metallic constructions, do not form an acceptable Earthing connection.

The layout drawings, the detailed calculations for the Earthing system and the relevant data, which the Contractor will use as basis for his design, shall be submitted to the Project Manager for approval. The Contractor shall also be responsible for performing all measurements and final checking of the whole of the Earthing system.

Further requirements related to the Earthing system are specified in Particular Specifications.

5.24.1 Technical requirements

The Earthing system shall be constructed and installed to comply with the requirements of local regulations and of the applicable Standards.

More specifically and independent of (or in addition to) the regulations and standards, the Earthing system shall provide:

- Adequate protection for personnel against dangerous voltages, currents and arcs
- Safe touch voltages and step voltages
- A low Earthing impedance for the lightning arresters
- A low Earthing impedance for the transformer neutrals and a sufficiently low neutral conductor impedance
- Limitation of the induced, or capacitive transformed voltages on low voltage, low current and electronic cables, circuits, panels and other equipment.
- That short circuit, earth fault and double earth faults currents will flow through the Earthing systems and not through other conducting parts or building constructions to a hazardous extent.

The maximum resistance of the earth electrode grid in the switchyard and under the control building shall be 0.5ohms during the dry period. In addition, the earth electrode system as

well as all other Earthing systems shall be designed and constructed for the operating voltages, the design short circuit capacities and the corresponding short circuit and earth fault currents which are specified in General Specification of Works, and in the other Sections of these Specifications for the respective voltage systems.

The overall resistance between the Earthing grid system and the surrounding soil shall be in the range of 10 Ohms. If necessary, additional Earthing rods shall be applied to achieve the specified value.
The dimensioning shall be coordinated with the relay protection scheme of the various parts of the plant. In any case, however, the Earthing conductors shall be dimensioned for carrying the earth fault current and double earth fault currents of the various parts of the plant for at least 1(one) second without any harm to the conductors or connections.
The conductors shall be reliably protected against mechanical damage and corrosion.

Buried connection shall be made by compressed clamps or by approved welding process. No bolted clamps may be used underground surface. Connections above earth shall be screwed and shall be easily accessible for control. All connections shall be protected against corrosion.

5.24.2 Earthing System under the Control Building

The conductors shall be of electrolytic copper with dimensions at least 30 x 3 mm for flat bar or at least 95mm^2 stranded wire. Copper-weld with approximately the same conductivity may be used.

Risers shall be copper stranded bare earth wire at least 95 mm^2.

The conductors shall be placed on the ground after the excavation is completed and just before the concreting starts. Care must be taken that the earth wire is in good contact with the soil and preferably embedded into it.

Under the building the grid of conductors shall be placed with an average distance between conductors of not more than 10m. At all crossings the conductors shall be interconnected by brazing or welding. The grid shall also be connected to the concrete reinforcement at several places as well as to the Earthing grid of the switchyard area. Vertical risers shall be brazed or welded to the conductors.

The risers shall be placed in the concrete shuttering, and led out of the shuttering at appropriate places approximately 30cm above the floors. Care shall be taken to protect the risers against damage during shuttering and concreting.

Connecting terminals for the screwed connections between the risers and the above-floor main Earthing conductors shall be placed at easily accessible places and protected against mechanical damage.

The above information describes the minimum requirements. The final design and construction for the achievement of the total requirements of the earthing systems shall be made by the Contractor.

5.24.3 Earthing System for the Switchyard

The conductors shall be of electrolytic copper with dimensions at least 30 x 3 mm for the flat bar or at least 95mm^2 stranded wire. Copper-weld with approximately the same conductivity may be used.

The risers shall be of at least 95mm^2 stranded copper wire or equivalent copper-weld.
The conductors shall be placed forming a grid covering the whole switchyard area. The average distance between the conductors shall not be more than 20 m.

A conductor shall also be placed outside the fence along the whole length of the fence at a distance and at a depth suitable for the potential gradation needed to avoid dangerous touch voltage between the fence and the ground.

Trenches for the Earthing grid shall be excavated in the ground to reach soil of good conductivity and a layer of at least 25cm of the same material shall be placed over the conductor. The conductor shall at no place be less than 80cm below the ground level.
Where advantageous for achieving low resistance to ground, vertical copper-weld Earthing rods may also be used, in addition to the horizontal grid.

Connecting terminals for the screwed connections between the risers and the on-ground Earthing conductors shall be placed in easily accessible locations.

The above information describes the minimum requirements. The final design and construction for the achievement of the total requirements of the Earthing system shall be made by the Contractor.

5.24.4 Earthing conductors

In the control building a main Earthing bus shall be installed on each floor in the cable trenches.

The conductors for these main Earthing buses shall be of electrolytic copper with dimensions of at least $95mm^2$ for stranded conductor.

All the risers from the Earthing electrode systems shall be connected to these main buses by disconnecting screw connections. At appropriate places at the end of the buses they shall be interconnected, thus to the greatest extent forming interconnected grids or loops.

Branch-offs to switchgear, panels and other parts, which shall be earthed, shall be of electrolytic copper with adequate dimensions for each item to be earthed.

Each item shall be directly connected to an Earthing conductor and not through a series connection of other metallic parts. Where rows of switchgear cubicles, boards and panels occur, each cubicle, board or panel shall be earthed individually.

The fence of the switchyard shall be earthed at distances of not more than 20 meters. Earthing conductors for low current and electronic systems shall be insulated and shall be run from the systems, panels, etc., directly to a main Earthing bus close to a connection to the Earthing electrode system, These Earthing conductors shall not be mixed with the Earthing of the high power systems.

Earthing switches and lightning arresters shall have a riser directly connected to the current carrying part in addition to a riser connected to the structure. All outdoor Earthing conductors shall be insulated with spacers or conduits against contact with galvanised steel structures.

5.25 Site and Commissioning tests

General

Tests as described below shall be used as a guideline and may be changed or varied after written agreement from the Project Manager, due to changes of design manufacturing of construction techniques.

5.25.1 Test of Wiring

a. Insulation Resistance Test at 2.5kVac for one minute shall be carried out on all AC and DC Protection, control, alarm and indication circuit to ensure that wiring is in satisfactory condition. Ocular inspection shall be made on cable glands, cable jointing, fuse or circuit breaker ratings and small panel items, such as indicating lamps.

b. Static equipment which may be damaged by the application of test voltages shall have the appropriate terminals disconnected.

c. Inter-relay, inter-unit and cubicle wiring carried out at site is to be checked to the appropriate circuit and/or wiring diagram. This may be done by using bells or buzzers. D.C. supplied from the station battery may also be used. Where it is found necessary during re-commissioning work to effect site modification to the secondary wiring, site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with the Project Manager before the circuit is commissioned.

d. Loop resistance measurements are to be done and on all current transformer circuits. Separate values are required for current transformer and lead resistances and all measurements are to be recorded on lead resistance diagrams.

e. Pilot cable impedance and phase angle measurements shall be made when pilot cable is to be used with unit type protection. The Contractor providing the pilot cables shall measure these values.

5.25.2 Test of relays

a. All relays are to be examined to ensure that they are in proper working conditions and correctly adjusted, correctly labelled and that the relay case, cover, glass and gaskets are in good order.

b. Secondary injection shall be carried out on all a.c. relays, using voltage and current of sinusoidal waveform and rated power frequency. For circulating current protection employing high impedance voltage setting test shall be across the relay and stabilizing resistance. The operation setting for the type of protection is to be established by secondary injection, where it is not possible to ascertain this value.

5.25.3 Test of DC Circuits

Tests are to be carried out to prove the correctness of all DC polarities, the operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indications and alarm.

5.25.4 Test of Instruments

Instruments and instrument transformer circuits shall be checked for polarity of direction and for calibration including any interposing transformers or transducers. These checks shall be made on all current transformer ratios where applicable.

5.25.5 Tests on Conductors, Insulators and Accessories

None required.

5.25.6 Tests on the Switchyard

All electrical equipment and installations shall be tested for correct connections of the high-voltage circuits and shall be subjected to a complete operation test to check the correct operation thereof in terms of the operational requirements specified in these specifications. The resistance to earth of the Earthing system of the switchyard shall be measured. The Earthing systems shall be checked for conductivity and reliable connections.

5.25.7 On Load test

On load tests are required, but due to the hazards inherent they shall be carried out under the direct supervision of the Project Manager and/or the Employer. The following tests are required:

a. An operation and stability test shall be carried out for on-load commissioning.
b. Test for restraint shall be carried out to prove the characteristic of protective and measuring systems with directional characteristics.
c. On-load checks shall be made after the protective gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed, as well as to confirm the integrity of the current transformer circuits. Where necessary, voltage readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete. Special attention shall be paid to broken delta voltages and residual current circuits were zero voltage or current respectively may not be proof of the completeness of the circuit.

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SUBSTATIONS CIVIL WORKS

TABLE OF CONTENTS

6 Particular Specification for Substation Civil Works 130
6.1 General 130
6.1.1 Summary and location of major Civil Works 131
6.1.2 Sequence of Construction 133
6.1.3 Construction stages 132
6.1.4 Documentation, drawings and designs 132
6.1.5 Use of site 132
6.1.6 Plan of operation and temporary works. 133
6.1.7 Site Office 133
6.1.8 Contractors Office 133
6.1.9 Dealing with water 133
6.1.10 Liaison with security agents 133
6.1.11 Explosives and blasting 133
6.1.12 Works executed by employer or other contractors 134
6.1.13 Water supplies 134
6.1.14 Employer’s approval of finished works 134
6.1.15 Preservation of trees 134
6.1.16 Survey Beacons 134
6.1.17 Basic survey and setting out 135
6.1.18 Design life and service conditions 135
6.1.19 Spare parts and tools 135
6.1.20 Facility handover to employer 135
6.2 Particular Specifications for Construction Materials 135
6.2.1 Materials for works 135
6.2.1.1 General 135
6.2.2 Preliminary survey 135
6.2.2.1 Topographical survey 135
6.2.2.2 Geotechnical investigation 135
6.2.3 Earth works 136
6.2.3.1 Bush clearing 136
6.2.3.2 Removal of top soil 136
6.2.3.3 Classification of materials 136
6.2.3.4 Order of work 136
6.2.3.5 Fill materials 136
6.2.3.6 Spoiled materials 137
6.2.3.7 Expansive materials 137
6.2.3.8 Surplus materials 138
6.2.3.9 Side drains 138
6.2.3.10 Excavation in “Rocks” 138
6.2.3.11 Setting out and preparation of earth works 138
6.2.3.12 Earth work formation 139
6.2.3.13 Unsuitable materials 139

6.2.3.14 Embankment and fills……………….. 139
6.2.3.15 Drainage of works………………………...139
6.2.3.18 Grassing of slopes and Pitching………… 140
6.2.3.19 Burrow Pits……………………….. 140
6.2.3.20 Soil sterilization……………………… 140
6.2.3.21 Earth electrode……………………… 140
6.2.3.22 Platform areas……………………….. 140
6.2.4 Drainage 141
6.2.4.1 Storm water drainage 141
6.2.4.2 Foul water drainage... 143
6.2.4.3 Transformer Burnt Oil disposal 143
6.2.5 Roads... 143
6.2.5.1 Earth work on roads and road subgrade.…………………….............. .143
6.2.5.4 External Access roads 143
6.2.5.5 Internal Access roads 144
6.2.5.8 Gravel wearing course roads... 144
6.2.5.8.1 Materials requirements……………………………………………………144
6.2.5.8.2 Pavement…………………….. 145
6.2.5.8.3 Drainage……………….. 146
6.2.5.8.4 Road marking……………….. 146
6.2.6 Fencing.. 146
6.2.6.3 Chain Link fence 147
6.2.6.4 Gates……………………………………………………………………..147
6.2.7 Switchyard………………………………………………………………...149
6.2.7.5 Water harvesting and reticulation……………………………………...…149
6.2.7.6 Lightning protection……………………………………………………...149
6.2.7.7 Switchyard Lighting……………………………………………………...149
6.2.7.8 Structures…………………………………………………………………150
6.2.7.8.7 Backfilling and Compaction……………………………………………...150
6.2.7.8.8 Depth of concrete structures……………………………………...……...151
6.2.7.8.9 Materials specification for Concrete work………………………….....151
6.2.7.8.10 Concrete work…………………………………………………………….151
6.2.7.8.15 Cable ducts and trenches………………………………………………....154
6.2.7.8.16 Equipment foundation structures……………………………...………..155
6.2.7.8.17 Equipment steel structures…………………………………...………...156
6.2.8 Control Building and Guard house……………………………………..157
6.2.8.1 Architectural design……………………………………………………...…157
6.2.8.1.3 Superstructure……………………………………..…………………...158
6.2.8.1.4 Structural design……………………………...………………………..165
6.2.8.1.7 Electrical services…………………………………………..…………166
6.2.8.2 Battery room…………………………………………………..…………166
6.2.8.3 Fire Protection…………………………………………………………..…167

6. PARTICULAR SPECIFICATION- SUBSTATION CIVIL WORKS

6.1 General

6.1.1 Summary and Location of Major Works

6.1.1.1 33/11KV Substations with 2.5MVA to 7.5MVA Transformers

a. Site clearance and disposal of spoil from site.
b. Earthworks (cut, back fill, compaction, area grading and ballasting) of entire plot.
c. Transformer plinth shall be designed for 7.5 MVA transformer complete with a transformer oil interceptor pit and burnt oil separator.
d. Steel support structure for 2.5 MVa transformer to achieve min ground clearance
e. Equipment foundations in reinforced concrete.
f. Erection of substation equipment steel support structures and bay gantries
g. Control building with a minimum floor area of 120 sqm meters
h. Internal and external access roads (acceleration and deceleration lanes) with paving blocks
i. Reinforced concrete cable trenches and ducts at crossings
j. parking lot and offloading bay (2 lorries and 5 vehicles)
k. Rainwater harvesting and storage system (5,000 liters elevated and 10,000-liter ground mounted water tank with connection to nearby county water supply system with metering
l. Drainage (storm water and foul water/sewerage drainage including septic tank)
m. Ballasting layer of 100 mm thickness
n. Site restoration and landscaping work
o. Masonry boundary wall for the entire plot.
p. Demarcated guardhouse with washroom facilities and furniture floor mounted storage facility for PPEs (shall have a locking facility).
q. Lightning protection and earthing system
r. Switchyard lighting
s. Fire protection system
t. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope**.**

6.1.1.2 33KV Switching stations

a. Site clearance and disposal of spoil from site.
b. Earthworks (cut, back fill, compaction, area grading and ballasting) of entire plot.
c. Equipment support structures and bay gantries.
d. Prefabricated or Control building adequate for the facilities
e. Access roads
f. Reinforced concrete cable trenches and ducts
g. Area drainage
h. Ballasting layer of 100 mm thickness
i. Site restoration and landscaping work
j. Chain-link fence for the entire plot
k. Lightning protection and Earthing system
l. Switchyard lighting
m. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope

6.1.1.3 Control Building

(a) 132/66/33/11 KV Substations with 10 MVA and above Transformers

The control room building shall contain the following rooms:

a) Control and protection panel room with space for future expansion (One transformer bay and two line bays).
b) Battery room (to accommodate both protection and communication batteries)
c) AC and DC distribution boards and battery charger room
d) Office room with furniture (document storage cabinets, chairs, key rack, and office tables) minimum
e) Kitchen with cabinets, dish rack, oven cooktop and sink
f) Communication equipment room
g) 2 no. washrooms with Gender Separation and showers
h) Store room for spares
i) Electrical system, Plumbing, air conditioning system and Fire protection system
j) Appropriately placed emergency doors
k) Sloped roof with fire retardant ceiling, insulation and water harvesting system
l) Fireproof doors and tempered burglar proof windows

All the rooms shall be pressurized to avoid dust.

(b) 33KV Substations with 2.5MVA to 7.5MVA Transformers

The control room building shall contain the following rooms:

a) Control and protection panel room with space for future expansion (One transformer bay and two line bays).
b) Battery room (to accommodate both protection and communication batteries)
c) AC and DC distribution boards and battery chargers room
d) Office room with furniture (document storage cabinets, chairs, key rack, and office table) minimum
e) Kitchen with cabinets, dish rack, oven cooktop and sink
f) Communication equipment room
g) 2 no. washrooms with Gender Separation and showers
h) Store room for spares
i) Electrical system, plumbing, air conditioning system and Fire protection system
j) Appropriately placed emergency doors
k) Sloped roof with fire retardant ceiling, insulation and water harvesting system
l) Fireproof doors and tempered burglar proof windows
m) Electrical, plumbing, water Supply, foul water Management, AC system and fire detection and suppression system.

All the rooms shall be pressurized to avoid dust**.**

6.1.2 Sequence of Construction

The Contractor must complete all the civil works in time to provide a clean and complete site for the mechanical and electrical erection. The Contractor shall be responsible for timely delivery of materials to site and for compliance with the specified or agreed construction program.

The contractor shall prepare a civil worksite methodology before commencement of works. An updated works program to be always availed on site

6.1.3 Construction stages

The following shall guide:

- Preliminary Design (Topographical Survey, Geotechnical Investigations, Statutory Approvals, Civil Works Methodology, Standard Operating Procedures, Quality Management Plan, Safety, Health and Environment Plan, Organogram)
- Design Stage (Relevant Standards and Specifications, Drawings and Designs, Revision of Drawings, Statutory Approvals/Requirement)
- Construction Stage (Mandatory inspections, Routine inspection, Factory and site acceptance tests, Hold points, Works Program, Communication plan, quality assurance)
- Closure (As-built drawings, Water Supply and Electricity Supply account transfer to KPLC.)

An updated works program to be always available on site.

6.1.4 Documentation, Drawings and Designs

Any drawings issued with these documents are for tendering purposes only. The Contractor's obligations with regard to preparation and submission of drawings, calculations, samples, patterns, models etc. are stated in the Conditions of Contract. The Contractor shall prepare and submit to the Project Manager for approval dimensioned general and detailed design drawings and other pertinent information of all the Civil works specified in the Bid Documents accompanied by relevant design calculations. Designs shall be carried out in accordance with standards and specifications applicable in Kenya, including but not limited to British Standards, Eurocodes, ASTM, The National Building Code 2024, Kenya Roads Design Manual etc.

Drawings shall be submitted in soft and hard copies as per Conditions of Contract. A laminated hard copy of approved designs shall be displayed in the site office for access by the Project Manager. The Contractor shall also provide relevant design software with a laptop to the Project Manager for Civil works design.

On completion of the project, As-built documents shall be submitted for filing and to allow Operations and Maintenance and shall at least contain the following information as described under "Final Documentation" of GCC:

- Detailed description of the civil works, the individual components, relevant clearances, tolerances, allowable temperatures, settings, sizes etc.
- Descriptions of main civil works including earthworks, subsurface structures, terrestrial structures, drainage, cabling, road layouts, lightning protection, substation lighting, fire protection systems etc.
- Operational instruction. These shall illustrate the operational sequences in a clear and concise way.
- Test reports

6.1.5 Use of Site

The Contractor will restrict his activities to within the Sites. Access for others to work on the site concurrently with this Contract shall be maintained as far as possible. The Contractor shall provide warning signs on either side of the Work and flagmen if necessary to guide such persons safely across the Site. The cost of maintaining access for others and assisting the passage of others across the Site shall be deemed to be covered by and included in the rates entered by the Contractor in the Price Schedules.

6.1.6 Plan of Operations and temporary works

The Contractor shall, in accordance with Conditions of Contract and before commencing work on Site, submit to the Project Manager a fully detailed program showing the order of procedure and method by which he proposes to carry out the construction and completion of the Civil Engineering works, and particulars of the organization and staff proposed to direct and administer the performance of the Works.

The information to be supplied to the Project Manager shall include Drawings showing the general arrangements of his temporary offices, camps, storage sheds, buildings and access roads, and details of construction plant and temporary works proposed.

The contractor shall provide a design for a Works signboard for review by the Project Manager

6.1.7 Site Office

The contractor shall provide a suitable temporary office, with a room capable of holding meetings, a Project Managers office (furnished with desk, cabinet, phone, printer), and clean toilet facilities. Drinking water, site instruction book, visitors book, weather chart and safety occurrence/ toolbox minutes book, and PPEs shall be provided on site for access to Project manager within all working hours. Approved working drawings shall be laminated and displayed on site.

6.1.8 Contractor's Office and Accommodation, etc.

The Contractor shall be responsible for his offices, accommodation, storage and workshops. The Contractor may fence this area for his own security for the duration of the Contract but any such fence erected together with all buildings, plant and materials shall be removed, all holes filled in and the site left in a tidy and level condition upon completion of the Contract.

6.1.9 Dealing with Water

The Contractor shall keep the whole of the Works free from water and he will be deemed to have included in his rates in the Price Schedules for all pumping, shoring, temporary drains, and sumps and other measures and provisions necessary for such purposes and for clearing away and making good to the satisfaction of the Project Manager.

The Contractor shall keep all existing drainage channels clear and shall not obstruct the passage of water to or away from any such drainage channels.

6.1.10 Liaison with Police and Other Officials

Contractor shall cooperate closely with the Police and other officials of the area concerned regarding their requirements in the control of workmen, movement of traffic, or other matter.

6.1.11 Explosives and Blasting

The Contractor shall use explosives for blasting in connection with the work only at such times and places and in such a manner as the Project Manager may approve, but such approval shall not relieve the Contractor from his responsibility for injury, loss, inconvenience and annoyance to persons, the Work and adjoining structures, roads, places and things and injury or damage to animals and property consequent on the use of such explosives. The Contractor shall be entirely liable for any accident that shall occur and shall save the Project Manager harmless and indemnified from all claims arising from such use of explosives.

The Contractor shall keep in his office at the Site copies of Laws applying to the transport, storage and use of explosives and shall also submit to the Project Manager a copy of any instructions or notices which the Contractor may issue to his staff or workmen or post about the site in compliance with such Laws.

The Contractor shall submit to the Project Manager details of the explosives, which he proposes to use, and of his proposals for the transport and storage of explosives.

6.1.12 Works Executed by the Project Manager or by Other Contractors

The Project Manager reserves the right to execute on the site, works not included under this Contract and to employ for this purpose either his own employees or other contractors.

The Contractor shall ensure that neither his own operations nor trespass by his own employees shall interfere with the operations of the Project Manager or his Contractors employed on such works and the same obligations shall be imposed on the Project Manager or his contractors in respect of work being executed under the Contract.

The Contractor shall provide unhindered access to all parts of the site to the Project Manager, authorized representatives of the Project Manager and of public bodies and corporations, and to contractors employed by the Project Manager, and he shall make available to such authorized persons the use of all temporary access tracks in or about the site.

Where works are being carried out concurrently in one area careful co-ordination of operations will be required so that interference can be minimized. The Project Manager shall have the power to regulate and rearrange the order of execution of the Works under this Contract to achieve the best co- ordination practicable. The Contractor's program shall take into consideration all information on co-ordination available at the time of its preparation and it shall be flexible enough to allow for subsequent changes that may become necessary. The rates tendered for the Works shall include the costs of complying with the requirements of this Clause.

6.1.13 Water Supplies for the Works

The Contractor shall make his own arrangements for the supply of palatable water for his staff on site, the Project Management Team and water for the Works.
The Contractor must make all arrangements including the supply of pumps and motors, labor and the like to abstract water and must pay royalty to the owners. These costs shall be included in his prices. If the Contractor fails to obtain permission to utilize existing water sources, he may have to drill boreholes near the sites at suitable locations.
The Contractor shall obtain the Employer's or the Project Manager's prior approval before utilizing any water source for the Works. The contractor shall connect the site to main water supply on completion of works.

6.1.14 Employer's Approval of Finished Works

The Contractor shall obtain the approval of the Project Manager for each section and each stage of construction. Approval of any section of any stage will not be given, and the Contractor shall not proceed with any subsequent stage, until all tests required by the Project Manager have been carried out, and the results have shown that the section complies with the Specification. Any works rejected by the Project Manager as not complying with the Specification shall be replaced by the Contractor at his own expense.

6.1.15 Preservation of Trees

No tree shall be removed without prior permission of the Project Manager who will limit the removal of trees to the minimum necessary to accommodate the permanent Works.

6.1.16 Survey Beacons

During the progress of the Works, the Contractor shall not remove, damage, alter or destroy in any way any permanent beacons or survey beacons. Should the Contractor consider that any survey beacon will be interfered with by the Works, he will notify the Project Manager, who, if he considers necessary, will make arrangements for the removal and replacement of the beacon. If the Contractor removes or disturbs a beacon without the prior permission of the Project Manager, he shall be liable for the full cost of its replacement together with the full cost of re-establishing the data relevant to it. The contractor shall establish the beacons once handed over the site.

6.1.17 Basic Survey and Setting Out

The Contractor shall appoint a suitably qualified Surveyor to set out the Works from the beacons and shall plot cross sections at 10 m intervals and submit to the Project Manager for approval. The Contractor will survey the sites provided in detail, and the exact locations shall be agreed with the Project Manager. The details of beacons and benchmarks shall be provided in the site survey drawings.

6.1.19 Design life and Service Conditions

The Contractor is required to design and construct the works so that they are fit for the purpose specified by the Employer to satisfy a level of durability and functionality that extends over a minimum of 50 years or as specified by the design life of the station transformer or relevant critical equipment. Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice and shall comply to Local and Regional codes of practice. Necessary safety factors shall be included. The service conditions shall be as per the conditions of contract

6.1.20 Spare parts and Tools for operations and maintenance

The Contractor shall provide mandatory civil spares as per the Employer’s requirement

6.1.21 Facility Handover to the employer.

The contractor shall submit water and electricity accounts documents closure or transfer to the employer project manager during facility handover or before issuance of completion certificate.

6.2 PARTICULAR SPECIFICATIONS FOR CIVIL CONSTRUCTION MATERIALS

6.2.1 MATERIALS FOR WORKS

6.2.1.1 General

All materials shall comply with appropriate local or regional standards unless otherwise required hereinafter. Such standards shall be to the approval of the Project Manager.

The Contractor shall before placing any order for materials or manufactured articles for incorporation in the Civil Works, submit details of the manufacturers or suppliers for the approval of the Project Manager. The manufacturer or supplier shall submit samples, technical data sheets, type tests or all necessary details for approval as required by the Project Manager.

6.2.2 PRELIMINARY SURVEY

6.2.2.1 Topographical survey

The contractor shall carry out a detailed land survey to demonstrate the shape, elevation and features of the site, including both natural and man-made elements. The contractor shall collect data on the spatial locations, coordinates and elevations of relevant features within the site plot and the surrounding area. Important information to include neighboring plots, data for terminal drainage points, nearest main road and capture all existing services (overhead, terrestrial and underground).

6.2.2.2 Geotechnical survey investigation

The contractor shall collect all data he deems necessary for preparation of his bid. The Contractor shall include in his prices the price of rock if encountered.

The contractor shall carry out a detailed examination of the site's surface and subsurface soil and rock conditions to assess its suitability for construction. This survey shall involve collection and analysis of material samples, and assessment of groundwater levels to guide earthworks, drainage and foundation designs. The contractor shall submit a method statement for the investigations, procedures, depths, analysis methods, tools and equipment and identifying locations for sample collection and tests. This shall be reviewed by the Project Manager before commencement of works.

The sub-soil tests shall be carried out by any method as stated hereafter under the supervision of a qualified person, who shall be subject to approval of the Project Manager. Any boulder rocks encountered shall be removed completely.

6.2.3 EARTHWORKS

6.2.3.1 Bush Clearing

The areas of the platform and borrow pit shall be cleared of all trees, vegetation and roots. These shall be neatly stockpiled within 3 km of

the site at locations agreed with the Project Manager and shall remain the property of the land owner. Any structures on site to be demolished and removed by the contractor and to be included in the price schedule.

6.2.3.2 Removal of Top Soil

The top soil within the areas of platform and shall be stripped to an approximate depth of 200 mm and stockpiled at locations agreed with the Project Manager for later use on embankment slopes. Any top soil that shall not be reused shall be dumped at the designated local authority dump sites. Overburden in the borrow pit shall also be stripped to a depth specified by the Project Manager and stockpiled for later use in rehabilitation.

6.2.3.3 Classification of Materials

Earthworks shall be under the contractors' scope and considered fully priced by the contractor. The contractor shall familiarize with site conditions before tendering.

6.2.3.4 Order of Work

The construction of cuttings, side drains and embankments shall proceed in a methodical and orderly manner. It shall be solely the Contractor's responsibility to arrange his methods and programme of work so as to ensure that the earthworks are carried out by the most efficient and economical method possible with the type of plant employed on the Works.

All trimming of cuttings, and embankments, drains and shoulders to the specified slopes and shapes, shall be carried out concurrently with the earthworks that are being carried out at that particular site and level.

6.2.3.5 Fill Material

"Fill-material" shall mean material deposited in accordance with these specifications from any of the classes specified in order to build up an earthworks construction to formation level as shown on the Drawings or as ordered by the Project Manager. The Contractor shall obtain the fill material from a source approved by the Project Manager.

Fill materials will generally be obtained from cuttings. If the material obtained from this source is insufficient or unsuitable extra material shall be obtained from borrow areas. All fill material (other than rock fill in lower layers) shall pass 75mm BS sieve size.

The following materials are generally unsuitable for construction of fills.

- All materials containing more than 5% by weight of organic matter (such as top soil, materials from swamps, plants and vegetable matter)
- All expansive soils such as black cotton soils with swells of more than 3% as measured in the CBR test.
- All clay soils with plasticity index exceeding 50.
- All materials having a moisture content of 105% of the optimum moisture content (standard compaction)

Rock fill can be used provided that boulders greater than 0.2 m^3 in volume or 600 mm in size are not used and that this material is not placed within the top 600 mm to formation level. The best materials from cuttings or borrow areas should be reserved for the upper layers of the fill.

- **Compaction of fill**

Materials other than rock fill shall be placed in layers of compacted thickness not exceeding 300 mm. Thicker layers can only be permitted where very heavy compacting equipment is available and trial sections have proved that the required compaction will be readily achieved over the layer depth. The minimum layer thickness shall be twice the maximum particle size of the compacted material.

Fill material shall be compacted throughout to a dry density of at least 95% MDD at OMC (standard Compaction AASHTOT99) except the top 300 mm of the fill which shall be compacted to 100% MDD (AASHTO T99).

Where rock fill is used it should be placed in the bottom of the embankment. The largest sizes shall be placed in layers of 1.0 meter thick. The interstices shall then be filled with smaller rocks and approved filler material. The whole layer shall then be compacted until the interstices are completely filled or until the required settlement is obtained. Heavy vibratory rollers are generally the most suitable machines for compacting rock fill.

The specified compaction shall be achieved over the full width of the embankment.
Any area inaccessible to the roller shall be consolidated and compacted using approved mechanical tampers.

- **Compaction of in situ Sub grades**

After removing the top soil and/or 600 mm minimum thickness (or as determined by geotechnical report) of unsuitable /expansive soils and before placing fill, improved sub grade or gravel wearing course, the upper 300 mm of in situ sub grade will be compacted to 100% MDD standard compaction. Compaction in cuts without improved sub grade will likewise be compacted to 100% MDD standard compaction

6.2.3.6 Spoil Material

"Spoil-material" shall mean material excavated in accordance with these specifications from any of the classes specified, and which, being obtained from the excavation of side drains, cuttings or below the road embankment is unsuitable for the requirements of the Works. Spoil material shall be removed from the Site to a spoil tip which should be to a site acceptable by respective local authorities and shall be approved by the Project Manager.

6.2.3.7 Expansive Material

When expansive material is encountered, it shall be removed to a minimum depth 600 mm (or as determined by geotechnical report) below the formation or the existing ground level, whichever is greater. Material removed shall be stockpiled for later use in slope protection or spoiled to a tip as instructed by the Project Manager.

6.2.3.8 Surplus Material

"Surplus-material" shall mean material excavated in accordance with these specifications from any of the classes specified and which is temporarily surplus to the fill requirements and shall be carted to a designated stockpile for re-use later elsewhere in the Works, or to an approved spoil tip.

6.2.3.9 Side Drains

Where side drains are required excavating the lines, slopes and widths as designed by the Contractor and approved by the Project Manager shall shape them. The side drains shall be finished off so that the formation levels and camber or super elevation of the formation, level and cross fall of the shoulders, and shape and invert levels of the side drains are everywhere in accordance with the Drawings.

Any excess depth or width excavated from the side drains shall be backfilled and made good to the satisfaction of the Project Manager at the Contractor's expense.

All other types of drains are specified separately in this Specification.

6.2.3.10 Excavation in "Rock"

a) Excavation Level
Unless otherwise directed, the formation of the platform can be founded on rock. However, rock shall be excavated to an average level 150 mm below the formation and in no place less than 100 mm below the formation. Any boulder rocks encountered shall be removed and disposed of.

b) Backfilling for Surfaces
Any excess excavation in rock below the formation shall be backfilled and compacted using approved fill material. Excess excavation in the invert of drains shall not be backfilled, but the rock surfaces shall be trimmed, and all loose particles removed, to allow laying of drainage blocks or as

may be required.

c) Excess Excavation of Slopes

Where side slopes are over-excavated no backfilling will be required but the slopes shall be trimmed to a neat shape and safe angle as is acceptable to the Project Manager. The sloping sides of all cuttings shall be cleared of all rock fragments, which move when pressed with a crowbar.

d) Hard Material

The provisions of this Clause do not apply to hard and common materials, which materials shall be excavated to the lines and levels shown on the Drawings or as instructed, within the permitted tolerances.

6.2.3.11 Setting Out and Preparation for Earthworks

The Contractor shall set out the earthworks and the tops of cuttings and toes of embankments at intervals 10m. Reference pegs shall be provided clear of the earthworks and at right angles to the centre lines, from which the centre lines and levels can be re-established at any time.

Before the construction of any earthworks in the fills, the levels of the existing ground shall be agreed between the Contractor and the Project Manager. If the Contractor fails to take the requisite levels then the ground levels determined by the Project Manager shall be taken as correct.

6.2.3.12 Construction of Earthworks to Formation

All earthworks up to formation shall be formed and completed to the correct lines, slopes, widths and levels shown on the Drawings and with the sub grade parallel to and at the correct depth below the profile, camber, cross fall or super elevation shown for the finished level, unless otherwise directed by the Project Manager.

Embankments and fills shall be constructed only of suitable material obtained from the excavation of cuttings. If the Contractor encounters material which he considers unsuitable for earthworks, then he shall forthwith inform the Project Manager, who shall instruct the method of use or disposal of such material. If insufficient material can be obtained from the cuttings, additional material may be borrowed from approved borrow pits.

The Project Manager may direct that certain soils be excluded from certain layers and other soils set apart or obtained from borrow and used only for these layers, in which case the Contractor shall comply with the Employer's or the Project Manager's directions and shall allow in his price for such selection of materials.

6.2.3.13 Unsuitable Material Information

Where, in the opinion of the Project Manager, unsuitable material occurs in cuttings, the Contractor shall excavate it to the depths and widths directed and replace it with selected fill material to form an improved formation.

6.2.3.14 Spreading and Compaction of Embankment and Fills

Embankments and fills shall be laid out and compacted to achieve a stable platform with sufficient bearing capacity and stability. Tests shall be carried out as per local regulations and standards for compaction design.

6.2.3.15 Drainage of Works

All cuttings, embankments and borrow pits shall be kept free of standing water and drained during the whole of the construction.

Should water accumulate on any part of the earthworks, either during construction or after construction, until the end of the maintenance period, giving rise to soaking or eroding conditions in the earthworks, the Project Manager may order the Contractor to remove and replace at the

Contractor's expense any material which has been so affected.

All drains shall be maintained throughout the Contract in proper working order.

The Contractor must allow in his price for draining the earthworks satisfactorily at all stages during the construction and arrange his methods and order of working accordingly. The entire platform shall be adequately drained and all cable trenches including those in switchgear building should be well drained. The minimum slope of drain channels shall be 1:200.

6.2.3.16 Tolerances

The following tolerances will be permitted in the finish of the formation to roads and platform:

a) The level of the formation should be within +/- 100 mm of that specified.

b) On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.

c) The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

6.2.3.17 Protection of Embankment Slopes

The top soil and expansive material removed from the Works shall be placed on embankment slopes as directed by the Project Manager. The slopes shall be trimmed to form a gradient not less than 1 on 5 unless otherwise directed.

6.2.3.18 Grassing of Slopes /Slope Protection/Stone Pitching

The surface of embankment slopes, after placing of top soil, shall be planted with grass or best suited method as per Project Manager's approval. Unless instructed otherwise by the Project Manager, the type of grass shall be indigenous. While planting, the area shall be irrigated for as long as necessary to ensure that the grass is properly established and has completely covered the ground. Grass should only be planted in the rainy season. Slope protection and Stone pitching shall be provided as per the designs.

6.2.3.19 Borrow Pits

Where it is necessary to borrow material for construction, suitable pits shall be provided by the Contractor to the approval of the Project Manager. All borrow pits must be carefully cross sectioned before and after excavation in order to determine the quality of earth excavated.

After removal of material for use, the area must be rehabilitated by the Contractor so that it will not prove a hazard to man or beast or a source of erosion. The sides of the excavation must first be sloped and then any previously stockpiled top soil spread as far as possible. At some borrow pit locations, further cleaning and fencing etc., may be required.

6.2.3.20 Soil Sterilization

In order to stop the growth of vegetation and incidence of pests, the Contractor shall apply an approved herbicide and pesticides over the platform area. A damp-proof membrane shall be applied to the entire switch yard before placement of ballast. Long term pesticides shall be used around control building and any other required area.

6.2.3.21 Earth Electrode

The Contractor shall install Earthing electrodes in trenches as outlined in the Specifications for earthing in Particular specifications.

6.2.3.22 Platform Areas

The substation platform areas shall be at least 1.5 times the area required by the facility developed area.

6.2.4 DRAINAGE

The Contractor shall design for area drainage of the works in compliance with local or regional standards and codes of practice to the approval of the Project Manager (BS 8301, BS 6031, CP 2005, etc). The Contractor shall be responsible for carrying out data collection for design calculations working with relevant Local Authorities. The designs shall be sufficient for a 50-year design life and shall incorporate surface and subsurface drainage mechanisms.

The contractor shall obtain approvals from relevant authorities to connect exit channels or pipes to the public systems. The Employer's Safety Health and Environment policy shall apply to the quality of effluent released from the site. The Drainage designs shall consider potential future substation additions and shall avoid discharging excessive water into existing drainage areas.

6.2.4.1 Stormwater Drainage

The Contractor shall carry out stormwater drainage design focusing on collecting and managing rainwater runoff to prevent flooding and water damage. It shall involve a system of pipes, channels, and other infrastructure designed to handle the volume of water expected from rainfall events. The design process shall include calculating runoff rates, sizing drainage components, and ensuring the system can safely convey water away from the area. The Site shall remain self-draining once construction is complete.

The Contractor shall determine levels of the terminal point outside of the site where site stormwater shall drain. The terminal point shall be the lowest point in the geographical area and site levels shall be established with respect to this reference level.

A surface and subsurface water drainage system covering the entire substation shall be installed. The system shall typically involve a network of drains, channels and attenuation basins to collect and discharge water safely. The Contractor shall provide cleanout and outlet structures, accessible for maintenance and inspection.

The number of runs and outfalls and pipe sizing must be sufficient to cope with the severest precipitation (based on hydrological factors and meteorological data), with a factor of safety of 1:2 within the substation site and other areas in which maintenance will be carried out. The drainage must allow uninterrupted access. Open drains shall be avoided at the switchyard.

Materials used in the drainage system such as pipes, trenches and filters shall meet relevant standards and specifications, shall be non-metallic and with adequate strength for purpose.

To maintain flow, the finished floor level of the buildings shall be a minimum of 600mm above the external finished ground level. The top of equipment foundations shall be a minimum of 200mm above finished ground level. The top of cable trench walls to be minimum 150mm above finished ground level. The finished ground level to be graded such that no flooding can occur and shall be to project manager's approval. For below ground levels, the top of internal cable trench finished floor shall be minimum 300mm above the top of external cable trench finished floor with a sloped transition at building junctions.

All levels shall remain above the external terminal drain point. The level and location of the burnt oil separator tank shall allow natural drainage from the Transformer oil interceptor sump.

<u>Roof Drainage</u>

For buildings, roof water gutters and downpipes shall be designed to meet the requirements of relevant standards and national building code and BS EN 12056-3. Materials and components for rainwater goods shall conform to the relevant BS or Eurocodes. Manufacturer Data sheets shall be submitted to the Project Manager for review and approval. Gutters shall be adequately supported and not sag. Gutters and downpipes shall, unless otherwise shown on the drawings, be approved plastic coated steel or heavy gauge PVC of diameters 200mm and 150mm respectively. One downpipe shall be provided for approximately every 50sqm of roof area. Gutters and downpipes including supports shall be designed for a concentrated load of 100 kg. Screens or strainers shall be provided to prevent debris from clogging the down pipes. Joints shall be lapped 150 mm in the direction of the flow and soldered. Slip joints shall be provided to allow for expansion.

Stormwater from the switchgear building roof shall be drained to the main water reservoir tank and main drainage.

Surface water from roofs of buildings other than the switchgear building shall be drained to down pipes with catch pits, which shall be connected to a suitable underground drainage system. For buildings with air-conditioning, the external unit drains shall be extended to discharge away from the paved apron.

Paved areas Drainage

For paved areas, drains shall be provided adequately to ensure timely removal of accumulated water that could cause potential safety hazard or damage equipment. These shall include roads and parking areas, building aprons, tops of equipment foundations etc. whose tops shall have sufficient slope. There shall be no obstructions in the drains.

Cable trench Drainage

External cable trenches shall be sloped at a minimum of 1:250 slope and drain pipes or channels adequately placed to allow flow of water. Internal cable trenches shall be adequately sealed to prevent any backflow of water. The transition from building to yard in cable trenches shall be sloped away from the building to avoid backflow.

Area Drainage

The formation level of the site is to be formed with uniform cross-falls of minimum 1:300 in the same direction as the natural drainage path of the surrounding environment. Drainage channels minimum slope shall be 1 in 200 and subsurface drains installed where appropriate or necessary. All storm water to be drained outside of the station.

Embankments and cuttings are to have drainage facilities at their top or bottom. In areas where there is a risk of water runoff the substation shall be protected from failure by means of gabions, retaining walls, and stone pitching or otherwise to the employer’s approval. Stone for pitching to drains, inlets and outlets of culverts, to embankments and around structures shall consist of sound un-decomposed rock. Precast concrete tiles may also be used.

The contractor shall install concrete culverts of minimum diameter 900mm for stormwater drainage (with 200mm thick concrete haunching) for the purpose of providing free flow of storm water at the substation entrances and or exits. The contractor shall also provide 200mm thick reinforced concrete plastered head walls. At the main gate, cut off drainage with grating may be provided to ensure external water does not flow into the Site.

Sub-surface Drains

The Contractor shall provide subsurface drains, especially within the switchyard where open drains are not applicable. These shall be designed with a minimum slope of 2% and diameter as per design data and guiding standards. These shall be laid in trenches of minimum depth 300mm from finished ground level. Perforations shall be provided on the drain pipe and Filter shall be provided in form of geotextile membrane used together with a filter layer. The filter backfill for Sub-soil Drains shall be graded crushed stone as for platform surfacing. Outlets and inlets shall be protected to prevent soil erosion and ensure proper drainage. Drain design shall be informed by data on specific site conditions, soil type, topography, groundwater levels, local building codes and historical hydrological data for the area.

6.2.4.2 Foul water Drainage

The Contractor shall carry out foul water drainage design leveraging on collecting and safely transporting wastewater from substation facilities to a treatment facility. It shall involve a system of pipes, channels, and other infrastructure designed to handle the volume of foulwater and flowrate estimated from the use of facilities. The design shall consider site characteristics, wastewater volume and flow rates, pipe materials and size, sustainability and local regulations.

In areas where a public sewer system is unavailable, treatment plants (septic tank/biodigester) shall be installed to remove pollutants from wastewater before discharge.

6.2.4.3 Transformer Burnt Oil Drainage

The Contractor shall design an oil collection pit below the Transformer to trap burnt oil. The volume of this pit shall be 120% of transformer oil capacity. The Contractor shall use the specifications for the transformer plinth applicable. The pit shall be done in reinforced concrete around the transformer plinth and shall have galvanized steel grating with inert crushed rock in a layer of minimum thickness of 200mm. The size of the gravel to be 60-120mm.

The Contractor shall design for minimum spec, galvanized steel pipes to be used from oil collection pits to the Burnt Oil separator tank. Design must also ensure that no oil is released to the environment, subject to Local Authority requirements. The design must allow for exit of water naturally without use of pumps

6.2.5 ROADS

Where necessary access roads to the substation sites shall be constructed to gravelling / murram standards. Substation land next to paved roads shall have access road and acceleration-deceleration lane to paved standard. All connections to main roads shall be approved by the relevant authority. Roads shall be designed and constructed with regards to the relevant standards, specifications and codes of practice such as the Kenya Roads Design Manual, and design shall be informed by the expected traffic load

6.2.5.1 Earthworks and Road Subgrade

The Contractor shall design for roads earthworks to formation level as per the Kenya Roads Manual earthworks. Formation material layers shall be designed to achieve respective strength and dimensional requirements of the governing standards. The road layers shall conform to the requirement of the Kenya roads design manual and shall be subject to routine and mandatory tests approved by the Project Manager.

6.2.5.2 Geometry

The Contractor shall design roads with minimum width of five (5) meters with the alignments allowing for low loader trailers

6.2.5.3 Subgrade Materials

The Contractor shall design for substation road to be compacted to 100% MDD and OMC after grading and shall have final paving layer of minimum standard paving blocks to meet estimated load weight.

6.2.5.4 External Access Roads

The horizontal alignment and geometric design shall be to relevant road design manuals. The Contractor shall design access to the station from the main feeder road to the substation plot. All roads shall have road drainage respectively. The external access roads shall have provisions for acceleration and decorrelation.

6.2.5.5 Internal Access Roads

Internal substation road shall be compacted to 100% MDD after grading and shall have final paving layer of minimum standard paving blocks to meet estimated load weight. The paving blocks shall have minimum thickness of 80mm, with a minimum strength class of 49N/mm2.

The road shall also be lined with kerbs and channels, with adequate provisions for drainage of water and shall be constructed to a fall that will allow proper drainage of the road. All roads shall have road drainage respectively.

6.2.5.6 Parking and Offloading Lot

The contractor shall design for a parking lot area that shall also be used as the offloading bay. This area shall be adequate to accommodate the Employer's staff and maintenance vehicles, with sufficient room for turning of maintenance trucks.

6.2.5.7 Damage and making good

Any damage occasioned to the road network by whatsoever cause during construction shall be repaired accordingly and handed over defects free

6.2.5.8 GRAVEL WEARING COURSE ROADS

6.2.5.8.1 Materials Requirements

Gravel standard roads comprise of a single layer of selected granular material placed directly on the sub grade to serve as a pavement and as surface-wearing course. The gravel for the single layer should be of adequate quality to guarantee the following:

a) General

In general gravel wearing course materials should comply with the following:

- They should have sufficient cohesion to bind the particles together and prevent the surface from raveling and becoming corrugated in the dry season.
- The amount of fines and plasticity should be limited so as to avoid the occurrence of dusty and slippery conditions in dry during the dry and wet weather respectively.

b) Grading Requirements:

Grading curve of the gravel should be within the class 1 envelope (initial daily number of commercial vehicles less than 150) to guarantee good stability. The grading to consider is that obtained after processing and compaction.

Grading after Compaction		
Size (mm)	**% passing by weight**	
	Class 1	**Class 2**
37.5	-	100
28	100	95 – 100
20	95 – 100	85 – 100
14	80 – 100	65 – 100
10	65 – 100	55 – 100
5	45 – 85	35 – 92
2	30 – 68	23 – 77
1	25 – 56	18 – 62
0.425	18 – 44	14 - 50
0.075	12 - 32	10 - 50

c) Plasticity Requirements

Plasticity index of the gravel should not exceed 15 and shall not be less than 5 in wet areas (annual rainfall greater than 500 mm per year). In dry areas (annual rainfall less than 500 mm per year) maximum plasticity index shall be 30 but subject to a minimum of 10.

d) Bearing Strength Requirements

A minimum CBR (after 4 days soak) of 20% at 95% MDD and OMC (Modified AASTO T180) is required

e) Construction Procedures

Gravel materials are excessively coarse in their "as dug" state. Appropriate processing is therefore necessary to bring them to the required gradation. This is normally done on the road by using grid, cleat or sheep's foot rollers. Oversized particles which cannot be broken down to the required size shall be removed. The minimum thickness of a compacted layer shall not be less than 125 mm.

f) Sub-grade Layer

During this process the sub grade layer shall be graded to level, parallel to the cross fall or chamber and profile shown on the approved design drawings or directed by the Project Manager and to agreed tolerance.

g) Tolerances

The following tolerances will be permitted in the finish of the formation to roads and platform:

a) The level of the formation should be within +/- 100 mm of that specified.

b) On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.

c) The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

6.2.5.8.2 Pavement

The single gravel layer should consist of a minimum thickness necessary to avoid excessive compressive strain in the sub grade and to compensate for the expected gravel loss under traffic during the period between re-gravelling.

Where the top 300 mm layer of the formation level embankment or natural ground sub grade has a CBR greater than 5%, the following thicknesses shall be provided:

- Roads within the Switch Yard not subjected to heavy commercial vehicles– The minimum compacted thickness of 125mm.
- Access roads outside the Switch Yard and roads within the Switch Yard likely to be subjected to heavy commercial vehicles during construction and during periodic maintenance. – Provide a 250 mm thick compacted layer.

In addition to the above, where the in-situ sub grade or the embankment material has CBR strength of less than 5% then:

- Top 300 mm layer of the fill / embankment shall be made with selected imported material with CBR (after 4 days soak) of between 7 and 13%.
- Where in situ sub grade an improved sub grade 300 mm thick of imported materials with CBR (4 days Soak) of between 7 and 13% shall be laid.

The above thickness shall extend to cover the shoulders to a minimum of 1m. A cross fall of 4% shall be provided. Compaction will be in layers not thicker than 200 mm and will achieve compacted densities of 95% MDD (Modified AASHTO T180) at compaction moisture contents of between 80% and 105% OMC.

6.2.5.8.3 Drainage

The Contractor's design shall provide for adequate and timely removal of stormwater. The drainage system shall comprise a network of trenches, pipes, culverts etc.

6.2.5.8.4 Road marking and Furniture

The contractor shall use thermoplastic road marking paint on the road kerbs to the Employer's approval. The Contractor shall also demarcate the parking area as per the designs approved by the Project Manager. The Contractor shall provide well marked safety balustrades, road signs and all relevant road furniture for the Works. Paint to be used for shall be black and yellow meeting employer's corporate color scheme. It shall have a minimum life span of two years in adverse weather conditions.

6.2.5.8.5 Existing Bitumen Standard Access and Internal Roads

All shall be reinstated to their original standard of materials and construction.

6.2.5.8.6 Quality Control

The Contractor's Quality Management Plan shall describe in detail all the tests and procedures to be carried out on materials and works. These shall adhere to relevant standards, Codes of practice and local regulations and shall be carried out by approved accredited laboratories. These tests shall be witnessed by the Project Manager and results shall be submitted routinely and periodically.

6.2.6 FENCING

6.2.6.1 Boundary Establishment

The Contractor shall construct fencing along the perimeter of the land/plot handed over. The fence shall include gates and shall comply with the requirements of the following clauses.

The perimeter fence shall be constructed to ensure boundary establishment from beacon to beacon. No part of the structure shall breach the boundary. The height of the perimeter wall shall maintain a minimum height of 2700mm from FGL. The perimeter wall shall be built of weatherproof materials and protected from the elements.

6.2.6.2 Masonry wall

The contractor shall design substation fence in masonry with adequate structural integrity to meet the design life of the substation. The masonry shall be dressed Natural stone of $10N/mm^2$ minimum compressive strength as per British standards. The wall shall have a structural framework of reinforced concrete beams and columns at minimum 3m spacing. The contractor shall provide a reinforced concrete beam at finished ground levels.

Structural designs shall be carried out for the wall, and shall be informed by the geotechnical and topographical surveys.

The fencing shall be mounted with an electric fence and razor wire. The electric fence shall be designed to have minimum 8 Strands separated at 50-100mm spacing. The strands shall be minimum 2mm diameter made from galvanized high tensile steel wires or zinc and aluminum coated, with tensile strength of minimum $1200N/mm^2$. Posts for the electric fence shall be galvanized steel anchored minimum 350mm within the reinforced concrete columns. The electric fence energizer shall adhere to IEC 60335-2-76.

The top of the wall shall have coping to protect the stonework. The contractor shall provide razor wire of minimum 450mm diameter placed together with the electric fence. Expansion joints shall be provided at every 30m with adherence to local regulations.

6.2.6.2.1. Masonry Wall Gates

The minimum width of the gate from post to post shall be a minimum of 6m to allow for heavy vehicles. The gate shall have two leaves on the main road for vehicular traffic, and a separate pedestrian access gate for pedestrian traffic. The design of the leaves shall allow opening in either direction and shall have adequate hinges to carry the weight of the gates. The gates shall be provided with wall passes and anchored on RC columns designed for the purpose.

The gate shall conform to the Employer's standards including but not limited to:

i. Material specifications such as leaf materials, paint, joinery, structural support etc.: to match the substation design life
ii. Color to match the Employer's Corporate colors

6.2.6.3 Chain-link fence

Where the plot covers more than 1-acre, chain-link fence shall be used to demarcate the switchyard area. Chain-link fence shall be used to demarcate the guardhouse from the switchyard. The chain link shall be constructed on concrete posts subject to project manager approval. The binding wire to be used shall be flexible aluminium wire of steel galvanized wire of right gauge.

Dimensions

Height of chain link fabric: 2 000 mm if within substation, 2700mm for perimeter

Barbed wire: 3 wires above fabric, height of 300 mm, on supporting arms facing outwards from Site at 450 angles.

Maximum distance between posts or columns: 3000 mm, except where interrupted by gate.

Terminal posts: including end, corner and straining posts; 89 mm outside diameter 114 mm outside diameter at gates.

Embedment lengths of terminal posts:

- Corner and straining posts 1100 mm
- End posts 1200 mm
- Gate posts 1400 mm

Tension bars and bands: locate at terminal posts to fix fabric, bottom wire and barbed wire.

Top rail: "extra-strong" pipe, 43 mm outside diameter.

Braces: "extra-strong" pipe, 43 mm outside diameter for attaching end and gate posts to adjoining posts. Use two braces at corner and restraining posts.

6.2.6.4 Gates

6.2.6.4.1 Chain link fence gate

Gate width: free distance between 2 gate posts, 1500 mm for single gate, 5000 mm double gates. Separate pedestrian gate to be provided.

Double gates: one leaf for normal traffic, another leaf to remain closed by means of drop bolt locking into center rest, inoperable from exterior.

Gates: able to open in either direction to 180^0. Gates to be hinged on a kingpost and not directly hinged on the concrete column.

Gate hardware: three hinges, latch with padlock accessible from either side of gate, latch catch. Gates to be of solid panel, gauge 16 and designed to Project Manager's approval.

Top of posts and uprights: weatherproof tops.

6.2.6.4.2 Materials

Fabric: ASTM A 392, 2 000 mm high, 3.8 mm diameter (No. 9 gauge) steel wire, 50 mm diamond pattern, twisted and barbed finish at top, knuckled wires at bottom, zinc coated.

Pipes: ASTM A 120, steel pile, hot-dipped zinc coated after welding, diameter and weight size as shown on drawings, unthreaded ends, free from burrs.

Fence fittings: ASTM F626, hot-dipped zinc coated according to ASTM A123.

Barbed wire: ASTM A121, 2.51 mm diameter wire in strand (No.12-1/2 gauge), 2 strands with 4-point barbs spaced at 125 mm, Class 3 zinc coating.
Bottom wires: 5 mm (No. 6 gauge) steel wire, 500 g/m2 zinc coating. This shall be surrounded by a concrete beam (C20) as shown on the drawings.

Fence fittings: ASTM F 626, steel tension bars and bands, nuts and bolts, weather proof tops of commercial aluminium alloy, malleable cast iron, or rolled or pressed steel, cast iron and steel fittings hot-dipped galvanised with 500 g/m2 according to ASTM A123.

Concrete: 25MPa at 28 days

6.2.6.4.3 Installation

Install fencing and gates according to ASTM F 567 unless otherwise indicated, and to drawings and this Specification.
Level ground surface so that space between finished ground surface elevation and bottom of fabric does not exceed 50 mm.
Plumb and align posts to within 10 mm.

Install posts of a gate at same elevation regardless of difference in ground level.

Set posts in concrete footings in form of truncated cone, according to ASTM F 567, and as follows:

FOUNDATIONS	ORDINARY SOIL		SOLID ROCK	
(Dimensions)	Line Posts	Terminal Posts	Line Posts	Terminal Posts
Depth	1000 mm	1600 mm	300 mm	500 mm
Diameter at top	250 mm	300 mm	150 mm	150 mm
Diameter at bottom	350 mm	400 mm	150 mm	150 mm

Make joints in fabric at terminal posts. Fasten as follows:

a) Every 450 mm along top rail, braces and bottom wire;

b) Every 300 mm on line posts.

Secure barbed wire to terminal and gate posts with tension bands, and to gate uprights with hooks. Install bottom wire in middle of last line of mesh

6.2.7 SWITCHYARD

6.2.7.1 Site Setting Out

The Contractor shall carry out setting of the site before commencement of works. He shall ensure application of current technology to ensure accuracy to establish control points, transfer design coordinates and mark out key features. The contractor shall keep detailed records of these setting out activities and copies shall be submitted to the Project Manager.

6.2.7.2 Site Layout

The Contractor shall prepare the arrangement of elements in the site to ensure flow of construction activities, proper and safe placement of routes and facilities, reduction of clutter and compliance to local regulations. The layout shall also allow safe maintenance of facilities and shall provide for future expansion. The layout shall consider the site topography, traffic flow, space allocation, stakeholder coordination and environmental impact. The Contractor shall submit a site layout with temporary facilities indicated to the Project Manager before commencement of works.

6.2.7.3 Area Grading

The substation shall be levelled and shaped to ensure a stable and safe uniform surface suitable for equipment placement, earthing systems and access to equipment. The area shall remain well drained with no pooling of water.

6.2.7.4 Stone for Platform Surfacing

The stone shall be hard and durable crushed rock with a maximum particle size of 40-60 mm and not more than 15% shall pass a 9.5 mm sieve. The stone layer to be spread uniformly over the finished surface of the platform shall have a thickness of 100 mm.

6.2.7.5 Water Harvesting and Reticulation

The design of the substation shall allow for rainwater harvesting, a storage and reticulation system. The design shall provide for collection of rooftop rainwater to meet the station needs. The Employer’s minimum specifications include provision of gutters on buildings, with downpipes leading to a ground mounted water storage tank of minimum volume 10,000litres. The water shall then be pumped to elevated storage of minimum 5,000 litres to enable reticulation to all wet areas including but not limited to Kitchen, washrooms, battery room, guardhouse and an external tap.

The design shall incorporate alternative supply where available. The contractor shall seek approval and apply for an account if supply is available nearby which shall be transferred to the Employer’s name upon completion of works.

6.2.7.6 Lightning Protection

The substation shall be designed for lightning protection, and the contractor shall provide structural designs for lightning protection structures/ lightning arrestors. All steel support structures shall be grounded to the earthing system (refer to electrical specification).

6.2.7.7 Switchyard Lighting

The Contractor’s designs shall include designs for illumination of the perimeter wall and the switchyard. (refer to electrical specification)

6.2.7.8 STRUCTURES

6.2.7.8.1 Excavations

The Contractor shall carry out excavations for reinforced concrete foundations in accordance with the approved designs and to the approval of the Project Manager and to fit in with the programme of construction. The contractor shall also prepare a Works Methodology for excavation.

6.2.7.8.2 Shoring and Timbering of Excavation

The Contractor shall be entirely responsible for the safety of all excavations, for the prevention of injury to workmen and for the stability of the faces of the excavation.

The adjacent road surfaces must remain trafficable, and cracking or cave-ins must be avoided. All shoring and timbering shall be done to the approval of the Project Manager, who may order such shoring or timbering to be strengthened or altered if he considers this necessary in the interests of the work or to safeguard against accidents to workmen or cave-ins.

6.2.7.8.3 Bottom of Excavations

In no case shall broken stone for under drainage or concrete be placed in an excavation until the surface on which such materials are to be placed has been approved by the Project Manager. The Contractor shall advise the Project Manager whenever the bottom of any excavation is ready for inspection or whenever it is necessary to cover up the work. In default of such notice the foundation shall on the order of the Project Manager be uncovered by the Contractor and reinstated without extra charge.

6.2.7.8.4 Dewatering

The whole Works shall be constructed in dry and the Contractor shall be held responsible for keeping all excavations free from water, whatever the source or cause may be, and shall properly deal with and dispose of water by use of sufficient temporary works, plant and appliances so as to ensure that the whole Works is executed in a satisfactory dry and safe manner, and costs for all dewatering operations shall be included in the price for civil works.

6.2.7.8.5 Disposal of Excavated Material

All material excavated under this Contract shall be disposed of in accordance with the instructions issued by the Project Manager. Selected material required for back-filling shall be removed to a tip found by the Contractor and the Contractor shall be responsible for ensuring that the required amount of spoil is set aside.

6.2.7.8.6 Other Services

Where trenches pass near or across other services, the Contractor shall take every precaution against damaging such services. These services shall be properly supported in the trench until back-filling is complete and the back-filling shall be thoroughly compacted under and around such services.

6.2.7.8.7 Backfilling and Compaction

Back-filling shall be carried out either with selected spoil as set aside, or with imported selected spoil, or other material to the approval of the Project Manager. No back-filling shall be done until all the formwork has been removed together with pieces of timber, cement bags, vegetation and or other rubbish.

All back-filling shall be compacted in layers not exceeding 150 mm thick and shall be sprayed with water to bring the moisture content to the optimum to achieve designed values of compaction according to the designs, standards and codes of practice.

6.2.7.8.8 Depth of Concrete Structures

The contractor shall design for all concrete structures with reference to site geotechnical report. These include foundations to Transformers, equipment pedestals, boundary wall and building works. The depth of these foundations shall be designed at a depth not less than 1200 mm from the existing ground level. All equipment foundations shall be designed as the base and pedestal type.

The transformer pedestal shall cover the entire mounting of the transformer base. Its foundation shall allow for oil collection pit draining to an oil separator. The depth of the oil separator shall allow for self-draining of water.
Where necessary, Firewalls shall be introduced and shall be made of reinforced concrete as guided by the electrical designs.

6.2.7.8.9 Material Specifications for Concrete works

- **Aggregates**

a) Shall conform to BS 882 requirements.
b) Shall be stored in separate heaps on hard, self-draining surfaces.

- **Water**

Shall be fit to drink/ potable and inert.

- **Reinforcement**

Shall conform to BS 4449.

- **Reinforced Concrete**

Shall conform to BS 8110 and BS 8004

- **Steel**

Shall conform to BS 5950

- **Cement**

Shall conform to BS 12

Shall be determined based on purpose and application area, with minimum of 42.5N as the standard. Special cements shall be only be used subject to the Project Manager's approval. For example, in coastal environments, cement shall be sulphate resistant.

Cement shall be used within 6 weeks of manufacture, and the Contractor shall make storage arrangements to ensure use of earliest consignment. It shall be stored in a moisture free environment. Different types of cement or different manufacturer cement shall not be mixed in a single cast or for a single element.

Additives shall not be used in this project.

6.2.7.8.10 Concrete work

6.2.7.8.10.1 Work Method Statement

The Contractor shall provide a detailed work statements with specific procedures and quality management plan for all concrete works specific to the site.

6.2.7.8.10.2 Formwork

Formwork shall be sufficient to achieve smooth finish free of projections, voids, etc. This shall be specified on drawings and be within the tolerances specified in the following table as well as to provide an acceptable surface for applied finishes, where required.

- Line and Level 1mm per meter not exceeding 5mm
- Pockets, Sleeves etc. +/- 5 mm
- Bases +/- 50 mm

The type of ties to be used shall be such that the required finish is achieved and does not become marred by subsequent corrosion. Ties to be set out to definite pattern to the Project Manager's approval. Rubbing down is allowed only after the Employer's or the Project Manager's approval of the surface to be treated.

All concrete works including foundation bases must have formwork. No casting shall be done direct to earth sides.

6.2.7.8.10.3 Reinforcement

Reinforcement shall not be heated or re-bent for this project. It shall be of strength specified in BS 8110 and of ribbed type only. It shall be free from any material likely to impair bond or initiate corrosion. It shall be bent and fixed according to the bending schedules as per BS 8110 detailing. Reinforcement shall be tied with soft iron wire to Project Manager’s approval and shall be supported to maintain the following minimum cover as per BS 8110.

The Contractor shall inform the Project Manager in good time to allow inspection before concreting.

NOTE: Holding down bolts shall be supplied under the civil works part or by the main contractor if he so decides, and in any case be included in the turnkey price.

6.2.7.8.10.4 Design Mix

Not less than 2 weeks before the start of concrete work, the Contractor shall submit to the Project Manager for his approval a statement of proposed mix proportions for the various grades required in the project. (Note: the grade is the characteristic strength or the cube strength below which not more than 5% of the result may be expected to fall when tested at 28 days).

The statement shall include proportions of cement, fine and coarse aggregate, and water, the maximum and minimum slump and the target strength for each grade. A certificate from an accredited laboratory that the proposed mix will meet the requirements must accompany the statement.

The proportions stated and the materials used may not later be altered without the written approval of the Project Manager. Cost of mix designs to be borne by the Contractor.

6.2.7.8.10.5 Batching

Shall:

a) Be by mass in accurately calibrated scales or by volume in soundly constructed gauge boxes making due allowance for bulking of the fine aggregate.
b) Be in proportion to whole sacks of cement.

6.2.7.8.10.6 Mixing

Shall:

i. Be done mechanically in a machine (concrete mixer) in good condition, large enough to carry the whole mix, controlled by a competent experienced operator.

ii. Carry on for sufficient time to ensure complete mixing of the ingredients.

6.2.7.8.10.7 Placing

Shall:

a. Be under the control of a competent, experienced overseer.
b. Be in a manner to prevent separation of the ingredients.
c. Be a continuous process until the pour is complete.
d. Be complete within the time stipulated in BS 8110

6.2.7.8.10.8 Compaction

i. Shall be done by immersion (poker) vibrator in the hands of experienced operators.
ii. Concrete shall not be moved by vibrator.
iii. Shall be sufficient to remove all air pockets and honey-combing and to ensure complete dense concrete cover to all reinforcement

iv. Shall comply to BS 8110

6.2.7.8.10.9 Sampling and Tests

The Contractor shall prepare concrete cubes as per BS 8110 for No of samples, size of samples and procedure. The Contractor shall then cure the concrete cubes in the environment stipulated in BS 8110 and arrange for transport of cubes to approved testing laboratories. The results of these tests shall be submitted to the Project Manager routinely and in a timely fashion.

6.2.7.8.10.10 Curing

a) Shall commence early on the morning following the placing of the concrete.
b) Shall be affected by keeping the concrete in a permanently wet state.
c) Membranes shall not be used.
d) Shall continue for a minimum of seven (7) days or such longer time as may be required by the Project Manager.
e) Water used shall meet requirement of BS 8110

6.2.7.8.10.11 Stripping of formwork

i. To soffits shall not be struck until 7 days after placing of concrete (but see below for (props).

ii. To vertical faces shall not be struck until 14 days after placing concrete.

iii. Props to soffits shall not be struck until 14 days after placing concrete.

iv. Shall not be stripped without the Employer's or the Project Manager's approval who may vary the above item in special circumstances.

6.2.7.8.10.12 Patching

i. To defective work shall not be undertaken before the item has been shown to the Project Manager.

ii. Is a sign of poor work-manship. The Project Manager shall have the right to reject the complete element if an unreasonable amount of patching has to be done, or if patching will spoil the appearance of the finished concrete.

6.2.7.8.11 Records

Shall be kept by the Contractor, showing date and time of each concrete pour, the weather conditions, the temperature, the number of the cubes which represent the concrete, the slump and any other items which the Contractor and/or the Project Manager consider relevant. These records are to be made available for the Project Manager inspection when required.

6.2.7.8.12 Construction Joints

Shall be avoided, if possible, but if inevitable shall be pre-planned in consultation with the Project Manager and temporary stop ends inserted. Before placing of concrete against a construction joint, the formed face shall be hacked down to expose the coarse aggregate, kept continuously wet for 24 hours. Vertical faces should be covered with cement/water slurry and horizontal faces should be covered with 15 mm layer of cement/sand grout. New concrete should then be placed immediately.

6.2.7.8.13 Camber

To formwork shall not be at the expense of the overall depth of the concrete.

6.2.7.8.14 Weather conditions

Concrete shall not be placed if temperatures above 30 degrees Celsius or below 0 degrees Celsius are expected during concreting.

6.2.7.8.15 Cable Ducts and Trenches

The Contractor is responsible for all civil engineering works required for the cable runs between switchgear and buildings. The Contractor's design shall provide separate cable trenches for power and control cables to achieve separation as specified in Cable laying particular specifications. All cable trenches shall be designed in reinforced concrete with minimum thickness of 150mm.

The Contractor shall design for the trench dimensions depending on the type and size of cables, the load requirements, turning radii of cables and local regulations. Serviceable cable trenches shall allow access for installation and maintenance without pulling, and this shall be provided for by maintaining minimum width and depth of 800mm.

Power and control cables shall be laid on suitable hot dip zinc galvanized cable racks and perforated cable trays and in separate trenches. The anchorage of cable racks shall be adequately designed for to allow the weight of a person and the load from all cables.

The trench bottom shall be designed to allow free drainage by sloping a minimum of 1:200 and provision shall be made for a serviceable sump at the lowest level. The cable trench walls shall be raised a minimum of 150mm above the final ground level to prevent stormwater entry. Cable trenches shall be provided with exit drains and sumps as necessary. Concrete cable trenches shall be adequately drained to open drains,or where necessary soak pits of adequate capacity or shall be connected to the general drainage system such that they will remain as dry

Cable trench entry points shall be sealed to prevent the entry of dust, vermin water, etc., using suitable materials. The transition between building and external trenches shall adequately slope away from the building. Cable entries into buildings and road crossings shall be through 150 mm diameter heavy gauge ducts or in reinforced concrete cable trenches Two (2) lines of 150 mm diameter heavy gauge of spare ducts shall be provided. All road crossings shall require a reinforced concrete duct with provisions for spare ducts. The ducts shall be constructed in such way that they will be able to withstand the weight imposed on them at a minimum depth of 1.2m. Drainage shall be provided at duct terminal points.

The Contractor's design shall provide construction joints at 30m or less along the cable trench. These shall be adequately sealed to prevent ingress of moisture.

Cable trenches in the switchyard shall be covered using reinforced concrete covers, designed for the maximum likely imposed loads appropriate to their location. The trench covers shall have steel angle line protecting the edges. The trench covers will be constructed such as to allow easy access to the trench by means of handles or otherwise installed for every fourth cover. The top of cable trench walls shall be raised a minimum of 150mm above the finished ground level to prevent water from flowing in..The trench covers will be fitted into grooved sides of the trench walls for a flush top of trench and covers.

Cable trench covers inside the building shall be designed with equivalent of 6mm thick metal chequer plates or higher specification material. This shall be reinforced with 25x25x4mm angle iron welded underneath along the edges and across in 'X" formation with allowance for easy handling on removal (provide drop-down handles for easy handling and non-trip safety). In areas where heavy traffic is expected, trench covers shall be recommended to be concrete finished with terrazzo to match the floor finish.

Cable Galleries

Where cable galleries are deemed necessary, anchorage of support brackets and clamps shall be adequately designed for.

Cable entries to be 150mm below the finished internal cable trench level.

6.2.7.8.16 Equipment Foundation Structures

The Contractor shall design equipment support structures to comply with relevant design manuals and local regulations. The equipment support structures shall be designed to endure substation loads and operational stresses. Their design shall also adhere to safety and testing requirements. The Steel support structures for the substation equipment shall be hot formed, hot dip galvanized, with a minimum zinc coating thickness > 110 microns and shall adhere to BS 5950. All steel support structures for equipment to be tubular, and for gantries to be in lattice angle channels.

Design calculations and shop drawings shall be submitted to the Project Manager for his approval prior to fabrication of members. Structural steelwork shall be shop-fabricated from structural shapes of steel in lengths suitable for easy transport and erection. All workmanship and fabrication shall be in accordance with the best practice and shall comply with the requirements of B.S. 5950. The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc. Steel structures shall be designed to anchor in the reinforced concrete foundations. The design for anchor bolts shall incorporate pull out strengths.

Other steel structures not made for equipment support (MKs and LV boards supports) shall have a coating > 100 microns. The Project Manager shall prefer bolts for joinery on site. Welding on site shall be minimized and cold galvanized. All steelwork shall be transported, handled, stored on site and erected so that members are not damaged or subjected to excessive stresses.

All steel support structures shall be grounded to the earthing system.

6.2.7.8.17 Equipment Steel Structures

The Contractor shall design Steel support structures for the outdoor substation equipment in hot formed galvanized steel to BS 5950. The equipment support structures shall be designed to endure equipment loads, wind and earthquake loads and operational stresses. Their design shall adhere to safety and testing requirements as per standards, specifications and codes of practice for substation equipment support structures.

The Project manager shall approve use of tubular or lattice angle channels steel structures for equipment support. Steel structures shall be designed to anchor in the reinforced concrete foundations. The design for anchor bolts shall incorporate pull out strengths.

The contractor shall incorporate in his design all elements that support equipment from steel support structures, their anchorage and concrete foundations. All steel support structures shall be grounded to the earthing system.

6.2.7.8.18 Erection and Commissioning of equipment support structures

The Contractor shall carry out erection of steel structures as per design and erection manual guide.

6.2.8 CONTROL BUILDING AND GUARDHOUSE

6.2.8.1 ARCHITECTURAL DESIGN

6.2.8.1.1 Substation Building Size

The Contractor shall design a Control Room Building to house control facilities and associated gear as per Scope of Works. The Contractor shall design room numbers and size as per the specific equipment, with consideration for operating conditions, access, safety and maintenance as well as provide spare room for future expansion.

Where applicable, the contractor shall also design a guardhouse for security personnel. The guardhouse design shall include washrooms with showers. The design for substation buildings shall conform to relevant building codes and local regulations.

6.2.8.1.2 Roof

The contractor shall incorporate in his design all elements that support the roof of the building. Fireproof and fire-resistant materials shall be preferred. Substation roof design shall prefer sloping roofs to prevent accumulation of water. The roof design shall compliment the overall building layout, ensuring adequate draining and sufficient space for maintenance and access too equipment. The roof shall be able to support any equipment that may be installed on top, including antennas and radios. Choice of materials shall comply with the local climate conditions.
The Contractor shall submit manufacturer and fabricator profiles to the Project Manager for review for all materials, accessories and fixings prior to procurement. The Project Manager may conduct due diligence and may require samples of the materials for inspection and testing, these costs shall be borne by the contractor. The Contractor shall provide the methodology on roof assembly before construction.

Roof structure

The Contractor shall design roof trusses, purlins and accessories in steel. The design shall incorporate all loads guided by the location of the site and shall be weatherproof. The design shall consider worst case maximum load with regard to regional weather data. The design shall comply to BS 5950 and installation shall be carried out as per Structural steelworks guidelines in this document. The trusses shall be weatherproofed accordingly.

Insulation
Insulation sheeting will be laid before installation of roofing sheets. The Contractor shall submit manufacturer technical data sheets and specifications for approval by the Project Manager, and a minimum thickness of 10mm shall be preferred.

Roof Structure
Structural steelwork shall be shop-fabricated from structural shapes of steel in lengths suitable for easy transport and erection. The Project Manager shall prefer bolts for joinery on site. Welding on site shall be minimized and cold galvanized.
All workmanship and fabrication shall be in accordance with the best practice and shall comply with the requirements of B.S. 5950. The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc. All steelwork shall be transported, handled, stored on Site and erected so that members are not damaged or subjected to excessive stresses. Fabrication and erection shall comply with B.S.5950 Part 2. Steel structures

shall be designed to anchor in reinforced concrete. The design for anchor bolts shall incorporate pull out strengths.

Roof sheets
Roof sheeting shall be hot dip galvanised troughed mild steel sheeting of IT5 profile or similar approved by the Project Manager. They shall be of minimum thickness 0.5 mm. The sheeting shall have approved plastic coating on face side. Type and brand of such sheeting shall be proposed by the Contractor and supported by the technical data sheets and manufacturer specifications.

The Project Manager shall prefer that the sheets shall be laid with a minimum 200mm end laps and double corrugation side laps away from the prevailing wind. The sheets shall be fixed to purlins with galvanised coach screws and seating washers.

Holes for screws shall be carefully drilled in the ridges of the corrugations and J-bolts used. Great care shall be exercised to avoid damage and disfiguration to the surface coating of the sheets. At eaves and exposed edges, the corrugations shall be closed with purposely made corrugation closers.

The contractor shall provide eaves of minimum 1m on all four sides of the building, otherwise provide canopies above doors and windows on gable sides.

Switchgear building - ceiling
The Contractor shall design for the provision of ceilings consisting of fore-manufactured sheets, mounted on steel grids jointed to roof structures. The ceiling shall be designed to be fireproof. If gypsum, the boards shall be of minimum 12mm thickness and shall have cornices.

The ceiling shall have an escape hatch in the office and in the washrooms. The contractor shall provide a ladder for maintenance within the Control Building. The external soffit shall be finished with T1G, light gauge steel or aluminum or any alternative material that shall guarantee service through the design life of the substation.

6.2.8.1.3 SUPERSTRUCTURE

6.2.8.1.3.1 Setting out Walling

The Contractor shall provide proper setting out rods and set out all work on the same for courses, openings, heights, etc. and shall build the walls and piers, etc. to the widths, depths and heights indicated on the drawings and as directed and approved by the Project Manager.

6.2.8.1.3.2 Materials

a) Cement
Cement shall be as described in concrete works in this document
b) Fine Aggregates
Fine aggregates for concrete blocks shall be as described for fine aggregate in Concrete Works.
c) Coarse Aggregate
Coarse aggregate for concrete blocks shall be good, hard, clean aggregates from an approved quarry. It shall be free from all de-composted materials and shall be graded up to 7 mm, and all as described for coarse aggregate, Concrete Works.
d) Machine cut stone
This shall be to BS 5628.
This shall be to approval of project manager and meet minimum required specifications. Minimum requirement is compressive strength of 7N/mm^2.

e) Natural Dressed Stone This shall be to BS 5628.

f) Concrete Blocks

Concrete blocks for walling shall be provided by the Contractor complying with B.S. 6073, and made in approved block manufacturing machines. Minimum thickness of blocks in external walls shall be 150 mm, and in internal walls the thickness shall be minimum 100 mm.

Blocks in external walls shall be hollow type. The volume of the cavities shall be not more than 50 % of the gross volume, and the dimensions of the cavities arranged so that each cavity is vertically continuous when the blocks are bonded. Blocks in internal walls shall be of the solid type. Samples of the proposed block types shall be approved by the Project Manager before any walling work is commenced.

Blocks shall be cast under sheds in suitable block manufacturing machines either power driven or hand operated. The form shall be of steel, and accurately made to size to give the required shape and squareness of block. The concrete shall be vibrated during casting to achieve a dense and uniform concrete. The material shall contain only sufficient water to obtain full chemical reaction of the cement and to give proper workability of the constituents.

The ratio of combined aggregate to cement shall not exceed 3:1. The Contractor shall present his proposal for mix recipe supported by test results for the Project Manager's approval. Concrete shall have minimum 28 days strength of 20N/mm2 in accordance with B.S. 1881. Mixing shall take place in mechanical mixers so as to thoroughly mix the constituents to a uniform consistency before casting.

On removal from the machine the blocks shall be carefully deposited on edge on boarding or a clean concrete floor under sheds so as to prevent drying out by the sun for 3 days. During this time blocks shall be kept constantly damp. The blocks may then be laid on edge in the open and kept damp by spraying or covering with wet hessian or by other means for a further 5 days. The blocks may then be stacked if required, but not more than one meter high, and in such a way as to prevent damage to the edges and corners.

No blocks may be used in building or be transported to site before having reached required 28 days strength criterion. All concrete blocks shall be of even texture and properly mixed ingredients and all portions of the block shall be properly set and hardened concrete.

Blocks shall be free from cracks or blemishes and shall be true to shape and size with clean sharp edges and corners and with corners truly square. Damaged blocks shall immediately be removed from the site. No dimension of a block shall deviate individually by more than 3 mm from the correct size. The average length, width and height of a sample of 15 blocks should neither be longer nor less than 2 mm than the correct size.

Dressed natural stone blocks at least 200mm width may be used as alternative to the concrete blocks.

6.2.8.1.3.3 Mortar

The cement mortar is to be mixed in the proportions of1 Cement: 4 Sand, and thoroughly incorporated with a sufficiency of water. Any cement mortar which has been left for more than one hour shall not be used in the Works.

6.2.8.1.3.4 Walling

All block work shall be laid in raking stretcher bond solidly bedded, jointed and flushed up in mortar. Where wall faces are to be plastered the joints shall be raked out to form a key. The blocks shall be thoroughly wetted for at least 24 hour before laying. Walls shall be carried up evenly course by course. During laying an open joint not less than 15 mm wide shall be left between the ends of all concrete lintels, whether pre-cast or cast in-situ and the blocks adjacent to these ends. These open joints shall be left as long as possible during construction and not filled until plastering or other works render such filling necessary. All such joints shall be properly filled in before the completion of the work. External walls shall be reinforced with two 8 mm high yield steel bars in every third horizontal mortar joint. The building shall be designed as a framed structure.

Block work which is not to be rendered or plastered shall be finished with a fair face and the blocks shall be selected for even texture and unmarked faces, regular shape and square unbroken arrases. The block work shall be pointed as the work proceeds with a neat joint. Where block work is to be rendered or plastered the joint shall be raked out 10 mm deep as the work proceeds to form an adequate key.

Galvanized steel ties with fishtailed end cast into the concrete spaced at alternate courses and extending not less than 150 mm into the block joints. All mortar joints are not to exceed 15 mm or less than 12 mm.

6.2.8.1.3.5 Lintels

Concrete lintels shall be used for all openings and shall be reinforced with two 12 mm high yield steel bars. Lintels shall have a minimum bearing of 500 mm at the ends.

6.2.8.1.3.6 Doors

General

Metal doors shall be supplied by approved manufacturers.
All doors shall be painted as specified under Painting and Decorating. All locks shall be master-keyed with three master keys supplied in addition to three regular keys for each door or gate.
Doors shall be measured by the number of doors of specified dimensions. The Contractor’s rate shall include all supplies, site works, painting and hardware.

Doors

Placement of doors shall be in accordance with the approved building drawing. The contractor shall submit manufacturer profile for approval by the Project Manager before procurement.

Door frames shall be pressed steel frames made from minimum 2 mm thick steel sheeting and reinforced where door closers are fixed. The main door shall have a latch provision to accommodate the Project Manager’s Standard Padlock. Thresholds shall be made from rolled steel sheeting approximately 100 mm wide and 12 mm high.

Door shall be filled with mineral wool acoustic insulation and lined both sides with steel sheeting minimum 1.25 mm thick. Total thickness of door shall be minimum 45-55 mm. Door frames are to be complete with 100 mm, loose pin steel hinges welded in position and adjustable striking plate.

Internal door frames shall be built to walls truly vertical and square with six-ties per frame. External door frames shall be built in to walls truly vertical and square with eight/ten ties per frame.

Frames shall generally be built-in during construction of the walls and securely fixed. A gap shall be left between the top of the frame and the soffit of the lintel during construction. Frames shall be adequately strutted to prevent distortion and shall be protected from damage during other work.

Door frames and similar components shall be fixed with countersunk screws or bolts with heads set into the frames. Walls shall be built as close as possible to the frames and the gap filled solid with mortar at each course. Render shall be neatly brought up to the frame and well tamped into any remaining cavities. The junctions between window frames or external door frames and external finish or block work shall be caulked tight with approved mastic or mortar wherever required, and neatly pointed. Mastic so used shall have long-term resistance against weather, insects and ultra-violet light.

Doors wider than 800 mm shall have three 100 mm hinges. Other doors may have two hinges except where specified or detailed otherwise. Door stops shall be fitted by screwed fixings where necessary. All doors shall have fire rating Class A30.

Entryways

Entry to rooms with panels and equipment shall be via ramps. These ramps and steps where necessary, shall be of reinforced concrete.

6.2.8.1.3.7 Windows

Placing of windows in accordance with Switchgear building drawings.

Unless otherwise indicated windows shall consist of aluminium sub-frame with clear glass of approved thickness. Windows shall be from an approved supplier and the details thereof shall be approved by the Project Manager. Windows shall be operable and provided with corrosion resistant metal insect screens or as directed by the Project Manager.

Frames shall generally be built-in during construction of the walls and securely fixed. Widows are to be built in to walls truly vertical square with six-ties per frame.

All aluminium or steel windows are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue. The aluminium window frames shall be KPLC blue and of minimum 2.5mm thickness. Window panes shall be of minimum thickness 6mm thickness which is shatterproof.

Windows are to be fitted complete with casement fastening, stays etc. All windows shall have approved burglar bars, and approved means of opening/locking.

6.2.8.1.3.8 Door and Window Furniture

Ironmongery shall be strongly made, well finished, good quality "stock pattern" articles. Ironmongery for windows and doors shall be galvanised or other approved manufacture for external use. Samples of all items shall be submitted to the Project Manager for approval before they are used for the Works.

All doors except emergency doors shall be lockable. External doors shall have approved security locks in the Employer’s standards. ironmongery shall be cleaned, oiled, adjusted and left in perfect working order.
Emergency doors shall be provided accordingly as per the safety requirements, complete with approved panic lock.

All ironmongery shall be of the best respective types required and no alternative articles will be accepted unless approved. Articles described as brass must be solid brass and not brass finish. Chromium plated articles must be plated satin finish on solid brass or other approved metal.

Where items for ironmongery are required to be fitted to steel door frames, etc., the Contractor must ensure that the Manufacture makes provisions for the correct fitting or lock striking plates, hinges, cleat holes, bolt keeps, etc.

Locks and Keys
Locks are to be two levers unless otherwise described. All locks are to be provided with three keys which must be handed over to the Owner on completion of the Works with identification labels attached.

Steel
Steelwork for general building construction is to be of approved manufacture complying generally with the appropriate British Standards and free from all defects, oil, dirt, loose rust, scale or other deleterious matter.

6.2.8.1.3.9 MV Switchgear Room

Openings for pressure release: In the MV switch-gear room it is necessary to arrange for openings for pressure release in case of explosion in one of the switch-gears. To avoid damage in the room/building any pressure shall be released through the openings as described.

Location of these openings must be beneath the ceiling on both longitudinal walls in the switch-gear room. The Contractor must calculate number and size of this pressure openings, and submit his proposal for approval.

Sufficient number of MV cable ducts through MV switch gear room wall joining the switchyard MV cable trenches shall be provided. The size of these ducts shall be big enough to accommodate Single core 630mmsqr MV cables. The position and number of the ducts shall be discussed and approved by the project manager. Spare duct shall be sealed to prevent entry by vermin.

6.2.8.1.3.10 Finishes

6.2.8.1.3.10.1 Schedule of Finishes

Room	Floor	Walls	Ceiling	Remarks/Notes
All Rooms	Terrazzo	Plaster and Painting, Tiles for wet areas	Sheet/plate-fire resistant	Sheets for ceilings = Prefabricated/ manufactured colour and type in accordion with approval of the employer. Switchgear building: External/internal colour in accordance with approval of the employer

6.2.8.1.3.10.2 Plaster and Floor Covering

Materials
Cement and water to be as before described. The sand to be screened through a sieve of 10 to 15 and meshes to 1 cm and to be washed if directed.

Mixing
All materials for mixing are to be used in proper gauge boxes and they are to be strike measured and not tamped down in boxes. Proper non-absorbent stages are to be used for mixing and storing mortar. No foreign matter must be mixed with the mortar.

The materials are to be mixed dry before adding water through a fine hose spray. No cement mortar which has taken its initial set will be allowed to be used.

Plaster Thickness
Unless otherwise specified all wall plasters should not be less than 13 mm thick and not more than 19 mm thick.

Cement Plaster

Cement plaster for external use to be composed of one part cement to four parts sand and for internal use to be one part cement to five parts sand.

Form Key

Rake out joints and roughen if necessary to form key for plaster.

For concrete surfaces, hack and apply 1:1 cement sand slush to form key. Continuously wet for 7 days and then apply plaster.

All brickwork and concrete works should be brushed down to remove dust and any other loose material.

Wetting

All internal and external brick or concrete surfaces are to be wetted well before plastering. All

cement plaster must be kept wet for at least 7 days.

Repairing Defects

All defective plaster, cracks, hollows, etc., are to be cut out to a rectangular shape, the edges undercut to form a dovetail key and to be made good to finish flush with the edge of the surrounding plasterwork.

All patches will be to the approval of the Project Manager and if the defects cannot be made good satisfactorily then the whole surface is to be removed and re-plastered at the Contractor's expense.

6.2.8.1.3.10.3 Glazing and Painting

Glass

All glass is to be of approved manufacture, free from bubbles, waviness, scratches or other imperfections and is to be well bedded, puttied and back puttied and secured with glazing pins or clips in steel sashes or with sprigs in wood sashes.

All glass shall be carefully cut to the required sizes so that all panes of figured or textured glass are uniform in appearance with the pattern parallel to the edges and wired glass shall be so cut that the wires are parallel to the edges.
The window glass for switchgear room shall be shatterproof type.

Putty

Putty for glazing to steel sashes is to be of approved proprietary brand. Rebates are to be thoroughly back puttied before glazing and all putty is to be carefully trimmed and cleaned off so that back putty finishes level with the top of sections internally, external putty covers sight lines exactly and finished straight and true. Rough surfaces to putty will not be allowed and any defective putty will be cut out and replaced at the Contractor's expense.

Rebates of wood sashes are to be given one coat of priming immediately before glazing.

Mirrors

Glass mirrors are to be of the thickness specified, of selected quality glass, silvered on back, with protective sealing coat and erased edges, unless otherwise described.

Generally

Allow for removing and replacing all cracked, broken or defective glass and leave thoroughly clean and perfect at completion.

Materials for Decoration

All paints, primers, varnishes, emulsions, stopping, etc., to be of approved manufacture. The contractor is to use proprietary ready mixed paints obtained from an approved supplier.
When a coat of proprietary paint is applied, the manufacturer's priming and previous coats suitable for the particular type are to be used.

All materials must be brought on to the site in unopened tins, and no dilution or adulteration will be permitted, unless approved by the Project Manager.

Emulsion Paint

Emulsion paint shall be PVA (Polyvinyl Acetate) alkali-resisting formulated with high washability and capable of resisting 8000 scrub test. The first coat to be specially formulated base coat for direct application to the specified surface.

Fillers

Higher grade cellulose fillers are to be used internally and premixed filler to be used externally.

High Gloss Paints

Primers for application to bare metal to be red oxide primer for iron and steel. For galvanised metal to be an approved zinc chromate or galvanised iron primer. For application on wood or plaster etc., to be an approved alkali primer.

Finish enamels

Finish enamels to be synthetic enamel high capacity paint with high coverage and high gloss finish unless otherwise described.

Workmanship

All surfaces are to be free from moisture, dust, grease and dirt and rubbed down smooth according to approved practice.

All plaster to be free from efflorescence and treated with one coat of petrifying liquid, approved sealer or alkali primer if required. Hard wall plaster to be glass papered before decorating.

Rectifying defects to decorated surfaces due to dampness, efflorescence, chemical reaction, etc., will be to the Contractor's account, as these surfaces must be checked and the appropriate precautions taken before applying the decoration.

Metalwork must be scraped free of rust, primed as described and finished as later specified.

Galvanised sheet iron, pipes, etc., are to be cleaned down to remove manufacturer's ammoniated dichromate protective covering, primed as described and finished as later specified.

Coated pipes are to be cleaned down, stopped and primed with one coat of aluminium primer and finished as later specified.

All knots in woodwork to be treated to prevent bleeding. Large or loose knots to be cut out and be replaced with sound wood, or cut back and filled. Small knots to be treated with two thin coats of Shellac in methylated spirits. Woodwork to be glass papered to a smooth surface with all sharp arrises, removed, all cracks, crevices, holes, etc., to be scraped out, primed as described and stopped with hard stopping, faced up and rubbed down to an even surface and finished as later specified.
All metal and woodwork to have the specified number of coats in addition to the priming coat.
Every coat of paint must be a good covering coat and must dry hard and be well rubbed down to a smooth surface before the next coat is applied, otherwise the Contractor will be required to apply extra coats at his own expense.

Each coat of paint to be of a distinctive colour: sample colours are to be prepared for the final coat which is to be an approved colour scheme and must not be applied without the permission of the Project Manager. After undercoats are on, the painter shall check all work and grain fill as necessary with filler as described.

Note

a) *All paints specified are to be obtained from an approved manufacturer by project manager and used in strict accordance to manufacturer instructions.*
b) *Their representative will check the paints being used and the method of application and will advise accordingly.*
c) *This section of the work to be carried out by an approved firm of decorators who must allow for the very best finish possible and of the highest quality obtainable.*
d) *The prices must allow for the removal and refitting of all beads, fittings, fastenings, ironmongery, etc., removed for decoration purposes to be carried out by skilled tradesmen of the appropriate trade*

6.2.8.1.4. Structural Design

The Contractor shall provide a detailed structural design for the Control Building and the Guardhouse. They shall apply the same principles as the Foundation designs in this section of the document.

6.2.8.1.5. Furniture

The Contractor shall provide furniture in the Office room of the Control building, as well as the guardhouse to Project Manager's Approval. Provision shall be made for storage of PPEs in the guardhouse leigh

6.2.8.1.6. Mechanical System- Plumbing and HVAC

Washrooms

The contractor shall include in his designs, two gender separated washrooms. These shall have a water closet each, a wash hand basin and a showerhead. They shall be supplied from the high-level water storage. Extractor fans shall also support proper ventilation. These shall be accessed from outside.

Kitchen

The contractor shall design for a kitchen area with countertops for microwave and utensil drying rack, as well as storage cabinets.

AC Installation

The Contractor shall supply and install minimum six (6) number AC units including wiring and insulator for the unit. The design for these AC units shall be done by the contractor and calculations approved by the Project Manager. The design shall take special consideration for projects in coastal or high humidity areas. The external AC unit drain ducts shall be directed to main drain and should not drain to the building apron. Wall mounted extractor fans shall be provided in the battery and washrooms.

6.2.8.1.7. Electrical System

This section of the specification relates to the supply, installation, testing and commissioning of the complete electrical services within the switchgear building, including:

The Employer reserves the right to reject any of the contractor suppliers if he feels the product does not meet the contract specification. All electrical fittings and plumbing materials are subject to Project manager approval.

Electrical Services General Description

The complete electrical installation shall comply with all local standards and codes. Should there be any conflict between local standards and what has been specified the sub-contractor should draw it to the attention of the Project Manager.

Lighting

Luminaries shall be fluorescent lamps except for the toilets and outdoor lighting (except switchyard and perimeter lighting) where GLS lamps can be utilized. In switchgear room: 250 lux is required. In offices 500 lux is required.

a. All luminaries shall be supplied, installed and tested by the electrical sub-contractor.
b. All metal work on the luminaries shall be connected to an insulated earth protective conductor.
c. Lighting Control Switches
d. Outdoor lighting shall be controlled from an automatic timer control system.
e. Lighting control switches shall be flush pattern with white finished plates.
f. Grid switches shall have 5 or 10 amp rating, generally where fluorescent discharge luminaries are controlled switches have 10Amp rating whereas with low energy PL lamp, 5 amp switches shall be installed.
g. Provide emergency lights both inside and outside the building on each side on DC supply.
h. Provide security lights with solar backup system.

Socket Outlets and Accessories

Reference should be made to the Standards given above for details on the socket outlets and accessories. Socket outlets to be mounted at 300 mm above floor level.conduit cast into the building structure shall be of the heavy duty PVC type. PVC conduits shall not be fixed to the surface of the structure

6.2.8.2. Battery Bank room

The room shall have an independent door opening to the switch yard, and shall have no inter connecting alley between this room and rest of the switchgear/control room. It shall also be installed with 2no. Exhaust fans for blowing battery fumes out of the room, one working and one on standby. They shall be composed of a non-sparking wheel construction and motor shall be explosion-proof type. Fans shall be wall mounted axial type with back draught dampers. The room's doors shall have applicable fire and security rating. Walls shall be protected against electrolyte splashing by applying an approved light-colored and resistant enamel paint. OSHA 1925.4.03 (A) General Requirements shall apply.
The battery room shall be provided with a tap and sink with cold water supply. Heavy duty PVC pipes shall be used instead of cable trench and they must not be on flush level with the floor (minimum 50mm off and above the floor).
Appropriate signage shall be provided outside the battery room. Appropriate PPEs for maintenance and handling of the batteries shall be provided. Racks and trays shall be designed for and provided. These shall be treated for resistance to electrolyte.

Floor finish shall be an approved acid-resistant epoxy coating applied as per approved manufacturer's specifications.
Lighting luminaries, sockets and switches within the battery room shall be explosion-proof and subject to approval by the PM The design shall consider that all possible sources of ignition including arcing sparks excessive surface temperature can be controlled and the probability of explosion reduced to acceptable low levels.

6.2.8.3. FIRE PROTECTION

6.2.8.3.1. External Fire Protection

A minimum of 2no. 25kg Dry powder Fire extinguishers with trolleys shall be provided with proximity to the Transformer in the yard. The contractor shall provide 6no. sand buckets.

All instructions and labels shall be in English. Fire extinguishers shall be provided in the guardhouse. One fire extinguisher (foam) shall also be provided at the control building on the side facing the switchyard.
In the cable trenches, fire retardant approved by the Project Manager shall be used at junctions of cable trenches and sprayed on the cables. Reinforced Concrete firewall shall be provided between equipment and the control building and/or transformers that breach the relevant clearance allowed. Design for the firewall to be done to BS 8110 with special consideration for fire rating.

6.2.8.3.2. Building Fire Protection system

Fire Detection and suppression
The building shall be fitted with addressable fire and smoke detection system. The contractor to train the local staff on use of the installed system. The system shall be integrated with station SCADA system for regional Control Centers remote monitoring.

Fire Suppression system at substation level
Portable fire extinguishers shall be provided under this Contract. Portable, wall mounted, hand held extinguishers shall be 9.5kg pressurized control discharge BCF units. The number of units within the Substation shall be a minimum of 6 Number. The body of the extinguisher shall be seamless, welded and brazed as appropriate. The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin.
Extinguishers shall be capable of controlled partial discharge. The type shall be of that recharge unit that is locally available. The extinguishers shall be walls mounted, attached, and located in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the instructions for operation face outwards.

Fire Evacuation Plan

The station layout shall have areas designated for assembly of people in the event of a fire alarm. A fire evacuation plan shall be designed and displayed at all entry points and approved by the Project Manager. Adequate signages shall also be placed within the substation to guide movement during evacuation

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

OVERHEAD LINES

TABLE OF CONTENTS

7 PARTCULAR TECHNICAL SPECIFICATIONS FOR DISTRIBUTION LINES 171
7.1 Distribution and sub transmission Lines 171
7.1.1 Nature and extend of Work 171
7.1.2 Design 171
7.1.3 Factor of Safety 172
7.1.4 Working Conditions 172
7.1.5 Clearances and Spans 182
7.1.5.1 Medium overhead lines minimum clearances at operating temperatures: 173
7.1.5.2 Additional Clearances 173
7.1.5.3 Special Clearances 182
7.1.6 Environmental Requirements 174
7.1.6.1 Wayleaves 174
7.1.7 Standards 175
7.1.8 Units of Measurements 176
7.1.9 Materials 176
7.1.10 Line Supports and Foundations 176
7.1.10.1 Physical and mechanical properties of Wood poles 177
7.1.10.2 Strength and Species 177
7.1.10.3 Pole Caps 177
7.1.10.4 Safety 177
7.1.10.5 Excavation 177
7.1.10.6 Erection 178
7.1.10.7 Pole Dressing 178
7.1.10.8 Back Filling 178
7.1.10.9 Physical and Mechanical Properties of Concrete Poles 178
7.1.11 Design, materials and construction of concrete poles 179
7.1.12 Insulators and Fittings 180
7.1.12.1 Insulator Fittings 180
7.1.12.2 Pin Insulators 181
5.1.11.4 Tension and Suspension Insulators 181
7.1.11.5 Post Insulators 181
7.1.13 Cross Arms 182
7.1.13.1 Steel Cross Arms 182
7.1.13.2 Materials 182
7.1.13.3 Welding 182
7.1.13.4 Galvanizing 183
7.1.13.5 Standard Sizes 183
7.1.13.6 Markings 183
7.1.14 Saty and Stay Blocks 184
7.1.14.1 Stay 184
7.1.14.2 Stay Insulator 184
7.1.14.3 Stay Block 184
7.1.15 Conductor 184
7.1.15.1 Conductor Characteristics 184
7.1.15.2 Joints, Clamps and Connectors 185
7.1.15.3 Drums 187
7.1.15.4 Markings of Drums 187
7.1.15.5 Conductor stringing 187
7.1.16 Safety 188
7.1.17 Operation Devices and Protection Systems 188
7.1.17.1 Isolation 188
7.2 Transmission line Particular Technical Specifications 189
7.2.1 Design philosophy 189
7.2.2 Drawings 190

7.2.3 Materials supply and installation manual....191
7.2.4 Maintenance manual ...191
7.2.5 Sample and models...192
7.2.6 Photographs...192
7.2.7 Transport, Access and Servitude...193
7.2.8 Crossing of Obstacles and Facilities ...194
7.2.9 Damages...197
7.2.10 Route clearance...197
7.2.11 Survey and geotechnical Investigations...198
7.2.11.1 Route selection...198
7.2.11.2 Contractor's Survey...198
7.2.11.3 Geotechnical Investigation...200
7.2.12 Conductors and fittings...202
7.2.13 Line insulators...205
7.2.14 Line Transmission towers ...209
7.2.14.1 Types of towers...209
7.2.14.2 Line design general arrangement...209
7.2.14.3 Tower Height design...210
7.2.14.4 Line design span...210
7.2.14.5 Tower design loads...210
7.2.14.6 Design conditions...211
7.2.14.7 Tower design...212
7.2.14.8 Materials fabrication...212
7.2.14.9 Tower Accessories ...213
7.2.14.10 Tower steel structure Materials...214
7.2.15 Transmission line Civil works...216
7.2.15.1 Tower Foundations...216
7.2.15.2 Foundation work...219
7.2.15.3 Tower erection...222
7.2.15.4 Tower grounding ...223
7.2.15.5 Conductor stringing...223
7.2.15.6 Transmission line site tests...225
7.3 Optical Fibre ground Earth wire...227
7.3.1 Technical descriptions...227
7.3.2 Optic fibres...227
7.3.3 OPGW Fittings and accessories...227
7.3.4 Quality control...230
7.3.5 Factory acceptance tests...233

7 PARTICULAR TECHNICAL SPECIFICATIONS FOR LINES

7.1 Distribution and Sub transmission lines

The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents.

Special attention shall be paid to Technical Specifications, in which the general technical requirements are specified. The drawings enclosed in are for bidding purposes only.

If the Specifications and/or Drawings do not contain particulars of materials or goods that are necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials shall be deemed to be included in the supply.

In the event of any conflict between the Drawings and the Specifications, the latter shall prevail. In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.

Should the Bidder find discrepancies in or omissions from these Specifications or from the other Documents, or should he be in doubt as to their meaning, he should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting his Bid. Such action shall, however, in no case be considered as a cause for altering the closing date of the Bid.

The scope of work covers supply of equipment, engineering and design, manufacture, testing before shipment and packing sea worthy or otherwise as required, delivery of all equipment to site (DDP), construction, installation and commissioning.
Where the new line share the route with existing lines, the scope of work shall include all the necessary works/modifications that will be required to accommodate the lines along the same route. The hardware/fittings and conductors of the existing lines shall be re-used.

The term "transfer" in this scope of works shall mean supply of new hardware/fittings, new concrete poles, stays, conductor, insulators as well as construction work in existing line routes. It also includes moving all equipment, such as distribution transformers, Autoreclosers, switches and links, capacitor banks etc., mounted on the present poles over to the new poles. In addition, all existing poles, conductors and hardware/fittings shall be recovered and handed over to the KPLC stores at locations nearest to the installation sites.

Cross arms:
Steel cross-arms shall be used in all cases including transfer (where applicable). Steel cross arms shall meet international accepted standards in addition to KPLC specifications for steel structures and line fittings.

Concrete Poles:
Concrete poles shall be used in all 66kV, 33kV and 11kV overhead line construction. All poles shall meet design class of 50SC (10m, 11m and 12m) poles and 75SC (14m and 15m) poles and KPLC Pre-stressed concrete poles particular specifications

Lattice and Monopoles Towers
Lattice or monopole towers shall be used for construction of 132 kV lines. The towers shall meet BS 8100, BS EN 50341 and BS EN 10163 and other internationally acceptable standards.

Optical Ground Earth Wire (OPGW)
OPGW (Optical Ground Earth Wire) shall be used in all 33kV lines and above. Standard size for

KPLC is 48 cores single mode Optic fibre. Where Overhead line transitions to Underground cable, an Underground Fibre Optic cable will be laid together in the trace of the power cable. OPGW earthing shall be done after every fourth pole.

Line conductor
The 11kV and 33kV Overhead line conductors shall be 150mm2 ACSR.
The 66 kV overhead conductor shall be 300 mm2 AAAC.
The 132 kV overhead conductor shall be 175mm2 Lynx or any other conductor specified in definite scope of work

Conductor Joints and terminations
All joints and terminations shall be of compression type for conductors of 150mm2 and above.

7.1.1 Nature and Extent of Work

The work covered by this Specification forms part of the KPLC's Distribution capacity enhancement Project and is for design, survey, supply, installation and commissioning of new Overhead Lines as specified herein and in the Attachments. The overhead lines will form part of KPLC's transmission and distribution network system.

The new lines may run in parallel with existing overhead lines, but due to constraints in wayleave in some areas/section of the lines, the existing lines shall be transferred to the new line. Where existing line is on wooden poles the wooden poles shall be replaced with Concrete poles.

The works to be carried out by the Contractor in accordance with the Specification and Condition of Contract and shall comprise and not limited to the following:

(a) Three-phase overhead lines having the particulars set out in the Scope of Works, Technical Schedules and Drawings attached to the Specification,
(b) the lines being complete with the survey, line conductors, insulators and fittings, poles and cross arms, Earthing (where required) and connections, and all other fittings necessary to have a complete distribution line.

7.1.2 Design

The following drawings shall be submitted by the Contractor according to the time schedule for approval:

- Detailed route maps
- Longitudinal profiles
- Tables showing the capacity of the poles and towers related to wind and weight span for the actual conductor sizes
- Sag tables for the actual conductor types for stringing conditions and included compensation for creep
- Erection drawings for each pole and tower line formation showing, insulator sets, fittings, cross arms etc.
- Pole and/or Tower foundation.

7.1.3 Factor of Safety

The minimum factor of safety at assumed maximum simultaneous working loading shall be as follows:

i) Line conductors based on ultimate strength

Max tension	3.0
Everyday stress	5.0

ii) Insulator and fittings, based upon electro-mechanical test and minimum failing load

Insulators and insulator fittings	2.5
Dead-end clamps and conductor fittings	2.5

iii) Steel structures, bolts and other steel pole members based on elastic limit of tension members and on crippling loads of compression members:

Steel Structures (Including steel cross arm)	2.5
Bolts, nuts and washers	2.5

iv) Supports, stays and cross arms subjected to the longitudinal transverse and vertical loads resulting in the lading conditions stated above:

Wood supports and cross arms	3.5
Concrete structures	2.5
Steel supports and cross arms	2.5
Stay assembly and fittings	2.5
Foundation – Concrete	2.5

7.1.4 Working Conditions

The maximum assumed working conditions shall be as follows: -

i) Minimum temperature of line:	5ºC
ii) Ambient temperature of line conductor:	35ºC
iii) Maximum temperature of line conductors:	80ºC
iv) Wind pressure on the whole projected area of conductors	400N/m2
v) Wind pressure on projected are of insulator:	400N/m2
vi) Wind pressure on projected are of support:	400N/m2

vii) Altitude: 0 – 2200 meters above sea level.

7.1.5 Clearances and Spans

7.1.5.1 Medium overhead lines minimum clearances at operating temperatures: -

i) Lines not exceeding 11kV across or along road:	5.8m (19ft)
ii) Lines not exceeding 11kV over private land:	5.2m (17ft)
iii) Lines not exceeding 33 kV over private land:	5.8 m
iv) Lines not exceeding 66kV over private land:	6.2m (20ft)
v) Lines not exceeding 132kV over private land:	7.0m

7.1.5.2 Additional Clearances

i) 11 kV line conductor to any part of the building:	2.7m (9ftinch).
ii) 33 kV line conductor to any part of the building:	5.0m
iii) 66 kV line conductor to any part of the building:	7.5 m
iv) 132kV line conductor to any part of the building:	10m

7.1.5.3 Special Clearances

a) Railway crossing clearances

i) All types of line including guard nets – 8.1m (30ft)

ii) The minimum clearance of any pole or structure from the center of a track shall be the height of the pole above ground plus 2.1m (7ft).

iii) Where the tract is in a cutting, no such pole shall be closer to the edge of the cutting than a distance equal to the height of the pole.

iv) Angles of crossing

Medium voltage, not less than 60°

b) Telecommunications Installation Clearances

i) Guard net – 1.3m (4ft)
Up to 66kV conductors using cradle guard–1.8m (6ft)

ii) Angles of crossing
Medium voltage, not less than 60°

c) Installation near Airport Clearances

i) Guard net – 1.3m (4ft)
Up to 66kV conductors using cradle guard–1.8m (6ft)

ii) Angles of crossing
Medium voltage, not less than 60°

d) Kenya pipelines

i) Guard net – 1.3m (4ft)
Up to 132kV conductors using cradle guard - 2.1m (7ft)

ii) Angles of crossing
Medium voltage, not less than 60°

7.1.6 Environmental Requirements

The Contractor shall undertake to complete all works in accordance with statutory requirements including those of:

i) The Kenya Wildlife (Management and Conservation Act) Applicable for all works inside National Parks.

ii) The Kenya Agricultural Act - Concerning protection against soil erosion.

iii) Public Health Act – Concerning with noise, water and air quality as they relate to human health.

iv) Chief Authority Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.

v) The County Government Act – Section 145 for preservation or protection of wildlife and Section 163 regarding noise disturbance controls.

vi) Kenya Forestry Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.

The Contractor shall take reasonable precautions to avoid damage to land, property, crops, etc. and shall ensure that the work is adequately supervised so that damage is reduced to the minimum. All surplus material shall be removed after erection and site shall be left in a clean and tidy condition, to the satisfaction of the Purchaser.

Where the Contractor considers that damage cannot be avoided if the work is to proceed normally, he shall notify the Employer accordingly. The Employer will coordinate and facilitate assistance with the landowner concerned during negotiations for compensation. The Contractor will be responsible for compensation in respect of damage and the Contractor shall proceed with the work within the limits indicated by the Purchaser.

Where temporary removal of bound, wall or similar obstacles is necessary for the purpose of foundation installation or support erection, the cost of removal and subsequent reinstatement shall be deemed included in the Contract rates for foundation and support erection.

Where it is necessary to provide scaffolding over roads, railways or telecommunication lines in order not to interfere with the passage of traffic, this shall be carried out by the Contractor at such times as may be convenient to the Authority concerned. Flagman and approved types of danger and warning notices shall be provided by the Contractor to ensure safety of the public.

7.1.6.1 Wayleaves

Wayleaves shall be provided by the employer to enable the Contractor to carry out the Works. In order to provide wayleave, the employer has to obtain approvals from the Government and other statutory authorities and consents from owners and occupiers of property which will be affected by the lines.

The procedure for obtaining approvals and consents is dependent on preliminary profile survey, as described below:

a) Representatives of the Employer will accompany Contractors staff during preliminary survey. The Employer’s representatives will issue notices to and liaise with landowners and occupiers in order to establish rights of entry for survey and agreement to limited cutting of vegetation as specified.

b) Upon approval by the Employer of preliminary survey, the Employer will initiate procedures for obtaining wayleave, and when necessary, approvals and consents have been granted the Employer will arrange for trees etc. to be cleared from the line route as specified.
c) Upon approval by the Employer of the position of support center pegs the Contractor shall submit access maps as specified, and the Employer will obtain the necessary rights of construction access for the Contractor.
d) Wayleaves procedures as described above will take place concurrently with profile survey, approval of center pegs, etc. The Contractor shall allow in his program for a period of up to two months from approval of preliminary lines to the grant of right of access for its construction.

e) Any conditions for the wayleave should be made known to the Contractor.
f) The wayleave procedures shall lead the construction programme for each section of the Contract.

7.1.7 Standards

Unless another standard is mentioned in this Specification, all materials used and provided under this contract and all services performed must be in accordance with the latest amendments of the Standards of the International Electro-technical Commission (IEC) or British Standards (BS), applicable Kenyan Standards and the attached Material Specifications.

Manufacturers who do not normally manufacture to IEC or BSI Standards may offer equipment in accordance with other recognized national Standards provided that they draw attention to any essential differences between their Standards and IEC/BSI Standards and Subject to the satisfaction of the Employer that the quality, finish and performance of the equipment complying with such standards shall be comparable to that complying with IEC or BS.

7.1.8 Units of Measurements

SI units (System International) shall be used in all the technical schedules and drawings.

7.1.9 Materials

Each of the several parts of the line shall be of such construction and design as to give long and continuous service with high economy and low maintenance costs.

All material used and equipment provided under this contract shall be new and of the best quality and workmanship and shall be of the highest class throughout with the designs and dimensions of all parts such that mechanical and electro-mechanical stresses which they are subjected shall not render them liable to distortion or damage under most severe conditions encountered in service. Repair of any defective parts shall not be permitted without the sanction in writing of the Project Manager.

The detailed design shall be carried out in manner to facilitate inspection, repairs and simplicity of operations and maintenance. All materials shall ensure satisfactory operations under the atmospheric conditions prevailing in the area where the lines are to be built, irrespective of season and under such variations of load and voltage as may occur under working conditions of the system. Line supports, conductors, insulators and fittings shall be such as to minimize the risk of damage due to deterioration, or damage in service of any part of the line. The design shall incorporate any reasonable precaution and provision for the safety for those concerned in the maintenance of the Contract Works and all associated works supplied and executed under other contracts.

All corresponding parts shall be made to gauge, shall be inter-changeable wherever possible throughout the Contract Works and are to be such as will facilitate the fitting of replacement.

7.1.10 Line Supports and Foundations where wood poles are used

The network shall be supported on wood poles, however alternative supports such as concrete and steel structures may be considered. The wood poles shall meet specifications set in Kenya Power and Lighting Co Ltd: Specification for Wood Pole and Kenya Standard KSO2-516: Poles for power and telecommunications lines. The concrete poles shall meet the specifications set in Kenya Power and Lighting Co. Ltd; Specifications for Concrete Pole Kenya Standard DKS 1933.

The poles can be of single pole type or H-pole type, with or without stay wires, with insulator chains or pin or post insulators, depending on the actual conditions and the approved design.

7.1.10.1 Physical and Mechanical Properties of Wood poles

The wood poles (Eucalyptus Salina) used shall have the following properties: -

Nominal length	10	11	11	12	12	14	14
Category	Medium	Medium	Stout	Medium	Stout	Medium	Stout
H(mm)	1.8	1.8	1.8	1.8	1.8	2.0	2.0
D_c(mm)	220	230	295	240	305	248	310
D_m(mm)	150	160	200	160	200	160	200
D_g(mm)	220	230	295	240	305	270	335
D_e(mm)	175.9	185.6	234.8	189	238.1	199.4	248.4
F(kN)	5.90	4.94	13.05	4.03	10.37	3.45	8.23
Ultimate load (kN)	8.64	8.73	18.42	8.89	18.24	10.46	20.02
Crippling load (kN)	59.4	58.6	149.8	51.2	128.9	45.9	110.3

H Ground position from butt

d_c Critical diameter

d_g Minimum groundline diameter (mm)

d_m Minimum top diameter (mm)

d_e Effective diameter

fLoad per mm of deflection at point of application ofload

Note that the mechanical properties used in the mechanical calculations are those stated in the Kenya Standard KSO2-516.

7.1.10.2 Strength and Species

Wood poles shall be of eucalyptus timber and shall belong to the strength groups Light, Medium or Stout as specified. The treatment shall be creosoting pressure-treated wood, or Chromated copper arsenate (CCA).

7.1.10.3 Pole Caps

Pole caps of approved type shall be used.

7.1.10.4 Safety

All poles shall have a DANGER/HATARI warning plate, placed at a visible point in the pole at a height of 1.7m and legible from a distance of at least 2m.

7.1.10.5 Excavation

The hole for the pole shall be excavated to a minimum of 1.8m for the 11m pole. If the base of the hole is not firm ground, the hole shall be excavated until firm ground is reached, otherwise the pole has to be placed on a flat rock block, min. 40 x 40 cm or a timber raft, min 80 x 80cm. depending on the conditions.

The minimum hole depth for wood poles shall be defined in the table: -

Pole Height H (m)	Size	Hole Depth Minimum (m)
10	Medium	1.6
11	Medium	1.8
11	Stout	1.8
12	Medium	2.0
12	Stout	2.0
14	Medium	2.2
14	Stout	2.2
15	Stout	2.4
17	Stout	2.6

The hole shall be dug to the required depth. Any holes left overnight must be covered in such a way that they do not pose any danger to persons or animals. A suitable method of warning shall be used to identify positions of the holes.

7.1.10.6 Erection

The butt of the pole is laid over the hole with the length in the direction of the line. A skid board is placed against the hole to facilitate the entry of the butt when the pole is raised and prevent earth breaking into the hole during the process of erection.

Erection of the poles shall be done using any of the following methods:

i) Erection ladders

ii) Truck mounted hydraulic lifts

iii) Guy ropes shall be used to prevent accident and to hold pole in a true vertical position. The pole is gradually raised to the vertical position and the butt guided in to the hole.

7.1.10.7 Pole Dressing

Partial dressing can be done while the poles are lying on the ground; in this case care must be taken during erection to avoid the fittings being damaged. The fitting of the insulator shall be done after the pole has been erected.

7.1.10.8 Back Filling

After erecting the pole and positioned it vertically, the pole shall be secured in this position by help of stones blocks placed in 2 or 3 layers, one layer at the bottom of the hole, and one to two layers at the top. The stones shall fill out the area between the pole and the wall and will secure that the pole remains vertical during the pole’s lifetime.

Between the layers of stone and above the top layer, the excavated soil can be used as backfill material if the original soil is appropriate for tamping.

The soil should be wet and backfilled slowly and each layer thoroughly tamped until the tamp makes a solid sound as the earth is stuck. Each tamping layer should not exceed 150 mm. If small stones or gravel are readily available, these should be mixed with the soil used in backfilling.

In areas where the ground is unsuitable for firm erection of poles i.e. swampy areas with black cotton soil etc. the pole has to be placed on a flat rock block or on timber raft as described under Excavation on previous page. It may also be necessary to change out the soil material around the pole.

7.1.11 Design, Materials and Construction of Concrete Poles

The concrete poles shall be designed and manufactured in accordance with Kenya Standard DKS 1933.

The poles shall be round, Prestressed or Reinforced Concrete Poles as per DKS 1933.

The materials used shall be in conformity with the design standard (DKS 1933) and shall be selected to suit the intended application.

The pole should be so designed that its strength in transverse direction shall be sufficient to take the load due to wind on conductors, fittings and the pole.

In accordance with Annex A of DKS 1933, the aggregate used in the manufacturer of the pole shall be free from veins and adherent coating and free from injurious number of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky and elongated pieces shall be avoided.

The surface of all reinforcement shall be free from loose scale, oil, grease, clay or other material that may have deleterious effect on the bond between the reinforcement and concrete.

The mix design, mixing and compaction of the concrete shall be such that the necessary strength in the pole is obtained after curing in accordance with DKS 1933.

Concrete shall be compacted by vibration, centrifugation or other efficient means. Hand compaction shall not be permitted.

The finished pole shall have a smooth external surface that is free from honeycombing.

A quarter (¼) of the poles supplied for each consignment shall incorporate an integral Earthing system comprising a non-stressed internal Earthing copper conductor (at least 70mm² stranded conductor) running the length of the pole and the ends of the conductor shall be left projecting from the pole to a length of 100mm at 200mm from top and 150mm below ground level. Manufacturer may offer alternative suitably designed Earthing termination for consideration

7.1.11.1 Physical and Mechanical Properties of Concrete Poles

The concrete poles shall conform to the following standard sizes:

Nominal Length (m)	Top Diameter (mm)	Working Load (kN)	Ultimate Load (kN)	Strength Class (as per DKS 1933)	Minimum Depth in Ground (m)
10	190	2.5	5	50	1.8
11	190	2.5	5	50	1.8
12	190	3.0	6	50	1.8
14	190	3.0	6	75	2.0
15	190	3.0	6	75	2.1

The required safety factor is 2.5 and pole taper for the Pre-stressed Concrete Pole shall be at least 13mm per meter.

Poles shall be supplied complete with suitably designed fittings for conductor and stay wire characteristics.

7.1.11.2 Marking

Each concrete pole shall be marked permanently by impressing on the pole (or by use of a permanently secured plate) at a position 1.5m above the pole Ground line with the following details:

- Manufacturer's name
- Date of manufacture (mm/yy)
- Length of pole (meters) and Tip dimensions (mm)
- Ultimate/Working load/Strength Class
- Type of pole
- Weight of pole
- Standard to which the pole complies
- The words "PROPERTY OF KPLC"

Ground line reference mark shall be conspicuous on the pole.

Where a plate is used it shall be made of stainless steel, securely affixed to the pole. In all cases the lettering shall be not less than 5mm high legibly impressed.

7.1.11.3 Bolts Nuts and Washers

All bolts and nuts shall confirm to BS 4190 and shall preferably have screwed threads of I.S.O. form. Nuts and heads of all bolts shall be of the hexagonal type. All bolts and screw rods shall be galvanized including the threaded portion. All nuts shall be galvanized with the exception of the threads, which shall be oiled.

7.1.12 Insulators and Fittings

7.1.12.1 Insulators

Insulation between conductors and support shall be polymeric for tension, suspension, pin and post insulators, and shall comply in all respects with IEC 305, 383 and 120, 1109 and 815 or such other standard as may be approved and with the requirements set out in this Specification and in the Technical Schedules.

Insulators polymeric type from approved manufacturers who shall have had at least ten years' experience of supplying complete insulator units to international purchasers. Technical particulars and service histories must be submitted for the type of insulator offered. Insulator units shall where possible be interchangeable with units already in use on the Employer's system.

All insulators shall be designed with a view to service in a tropical climate in an area subject to lighting storms, at an altitude of about 2200 m above sea level.

Glass Insulator strings, where specified in scope of work, shall consist of minimum quantity of 12 units for 132kV, 6 units for 66kV, 3 units for 33kV and 2 units for 11kV at 146 mm Centre distance between each disc.

The actual numbers and types of discs shall be selected to suit the requirements set out in the technical schedules.

Locking devices for the insulator units themselves and for associated ball and socket and fittings shall be of stainless steel and shall comply with IEC 372. The assembly shall be such as to allow easy removal for replacing of insulator units or fittings without the necessity to remove the insulator string from the crossarms.

All ball and socket joints on insulator sets shall be lightly coated with approved grease before erecting.

Each insulator shall be marked with the name or trademark of the manufacturer and the year of manufacture in accordance with IEC Publication 60383. In addition, each insulator shall be marked with the specified electromechanical or mechanical failing load in conformity with IEC Publication 60383.

7.1.12.2 Insulator Fittings

Fittings shall comply with BS.3288: Part 1 or such other standard as may be approved and shall be so designed that replacement of string insulator units and the arcing protection system can easily be performed during maintenance or repair under outage or live-line conditions.

All clamps shall be as light as possible and shall be designed to avoid any possibility of deforming the stranded conductors and separating the individual strands.

Bolts and nuts shall be in accordance with an approved specification. Bolt threads shall be coated with approved grease immediately before packing. Split pins for securing attachment of fittings of insulator sets shall be of stainless steel and shall be packed by washers of approved size and gauge.

All insulator strings shall be attached to crossarms by means of shackles or swivels. Hooks shall not be used.

7.1.12.3 Pin Insulators

Polymeric pin insulator shall be used for intermediate line poles and for small angles up to 20°.

On pin insulators, the conductor shall be bound in on top of the groove, using two suitable stirrups in each case. The bind shall be formed of a single layer of closely wound wire, extending at least 25 mm beyond the stirrups. The bind shall be wound on opposite directions, on each side of the insulator.

With Aluminium conductor, the bind shall be formed of two stirrups, with 2.5mm diameter aluminium binding wire. In addition, aluminium amour tape shall be used, wrapped in a direction opposite to that of the conductor lay. The amour tape shall cover the portion of the conductor that is in contact with the insulator, and extend at least 40 mm under the bind.

7.1.12.4 Tension and suspension Insulators

These Polymeric Insulators shall be used where increased tensile strength in the conductors is envisaged i.e. flying angles, section and terminal poles.

The table below gives creepage distance requirement in relation to pollution

Type of pollution	Creepage distance
Low	18-22 mm/kV
Medium	25-31 mm/kV
Extreme (Coastal/industrial area)	> 35 mm/kV

Where there is severe lightning activity, high insulation and creepage values are necessary.

7.1.12.5 Post Insulators

In high pollution areas, 33kV line shall use polymeric 66 kV line Post insulators and 11kV lines shall use 33kV line post insulators.

7.1.13 Cross Arms

The following types of cross-arms shall be used depending on the limiting factor

7.1.13.1 Steel Cross Arms

Steel crossarms shall be used in all cases as required.

Steel Crossarms shall be used extensively in the line making different formations. The choice of the formation will be determined based on the following:

i) Environmental conditions
ii) Landscape
iii) Available space

7.1.13.2 Materials

Structural steel used, shall be grade 43A as specified in the BS 4360: "Specification for weld able structural steel".

The tensile strength of the steel shall be not less than 430 N/sq. mm and yield stress shall be not less than 255 N/sq. mm .

Angle sections shall be as per BS 4848 Channel sections shall be as per BS4

7.1.13.3 Welding

Welding where specified shall be by metal-arc welding and shall be as per BS 5135. After welding and before galvanizing, welds shall be thoroughly cleared to remove slag and spatter, preferably by sand blasting.

All materials before and after fabrication shall be straight and free from twists. The material shall be free from blisters, scale and other defects.

All dimensions specified shall be subject to the following tolerances, unless otherwise stated.

i) Dimensions up to and including 50 mm: ±1 mm
ii) Dimensions greater than 50 mm: ±2 mm

Erection clearance for cleated ends of members connecting steel to steel shall not be greater than 2mm at each end.

Bolt holes shall not be more than 2mm greater than the diameter of the bolt for bolts up to 24mm diameter.

Cutting may be by shearing, cropping, sawing or machine flare cutting. Sheared or cropped edge shall be dressed to a neat finish and be free from distortion where parts are to be in metal contact.

All holes shall be drilled in one operation and burrs shall be removed. Holes shall not be formed by a gas cutting process. All matching holes for bolts shall register with each other so that a gauge 2mm less in diameter than the diameter of the bolt shall pass freely through the assembled members in a direction at right angle to such members.

7.1.13.4 Galvanizing

All materials to be galvanized shall be of the full dimensions shown or specified and all punching, cutting, and the removal of burrs shall be completed before the galvanizing process commences.

All galvanizing 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 729.

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

Galvanized steel structures shall be treated after galvanizing with Sodium Dichromate Solution.

Galvanizing	Steel Structures for inland installations
Minimum Average Coating Weight	610 g/m²

Bending of flat straps shall be carried out cold.

7.1.13.5 Standard Sizes

The standard sizes of the different cross arms shall be as shown on the table below:

Application	**Standard Length (mm)**	**Cross Section**		
		Height(mm)	Width (mm)	Thickness
11kV inter pole. Up to 150mm^2 conductor.	1625	70	70	9.5
11kV Section/Angle/Terminal up to 60^o, 150mm^2 conductor.	2290	125	70	9.5
33kV Inter pole	2400	100	75	9.5
33kV Section/Angle pole/ Terminal	2400	125	75	9.5

7.1.13.6 Markings

The cross arms shall be marked legibly and indelibly with the words “Property of KPLC”.

7.1.13.7 Line Formation

The following is a recommendation for the use of the different common line formations:

i) Line poles for deviations 0°-10°, Steel cross arm will be used for horizontal and delta formations.

ii) Line poles for deviation 20^o-60^o, double cross-arms or vertical flying angle shall be used.

iii) Line poles for deviations greater than 60^o, vertical sections shall be used.

7.1.14 Stay, Stay Insulators and Stay Block

7.1.14 .1 Stay

Stay wires shall be in conformity with the attached specification for stay wires and Guy Grips.
The dimension of stay wires used shall be in accordance with the actual load taking into consideration the Safety Factor given.
The stay wires shall with first-class workmanship be fastened to the pole to assure that they are keeping the pole in a vertical position during the pole's lifetime.

7.1.14.2 Stay Insulator

A sling type strain insulator shall be inserted, at a minimum, in each stay 1.6m from the top.

7.1.14.3 Stay Block

A reinforced concrete stay block buried to the depth of not less than1.6m shall be used as the stay anchor.

7.1.15 Conductor

Phase conductor to be used shall be Aluminium Conductor Steel Reinforced (ACSR) or All Aluminium Alloy Conductors (AAAC) and shall consist of steel strands together with aluminium strands or aluminium strands only. The specific conductor to be used shall be described in the definite scope of work

The outermost layers of the conductors shall be stranded with right hand lay. There shall be no joints in the individual wires of the outer layers of the aluminium wire.

The requirements for the conductors are specified in the attached Specification for Aluminium Alloy Conductors and Specification for Aluminium Conductor Steel Reinforced.

7.1.15.1 Conductor Characteristics

The conductors shall conform to the following:

15a Physical characteristics

Nominal Al. area (mm^2	Code Name	Steel No./mm^2	Alum. No/mm^2	Over all dia. (mm)	Calculated Al. equ. area (mm^2)	Total cond. Area (mm^2)	Weight Kg/Km	Copper Equiv. Area (sq.in)
150ACSR	Wolf	7/2.59	30/2.59	18.1	154.3	195.0	727	0.15
175 ACSR	Lynx	7/2.59	30/2.79	19.53	183.4	226.2	842	0.19
300AAA	Upas		37/3.53	24.71		362.1	997	0.3

15b Electrical characteristics

Nominal Al. area (mm^2)	Tensile Strength (kgs)	Resistance at 20 ºC (Ohm/Km)	Current Rating (Amp)	Inductive reactance ohm/km Spacing	
				30cm	50cm
150	6880	0.1844	430	0.235	0.266
175	7880	0.1576	470	-	-
300	10600	0.09155	610	-	-

The current ratings are based on the following operating conditions:

- Ambient temperature 35°C
- Maximum conductor temperature: 80°C
- Intensity of solar radiation: 0.089 w/cm^2

7.1.15.2 Joints, Clamps and Connectors

Conductor fittings shall be designed in accordance with BS. 3288. The electrical conductivity and current capacity of each joint or clamp shall be not less than those of the equivalent length of conductor.

Dead end clamps and tension joints shall be of the wedge clamp type and shall be so as not to permit slipping off or cause damage to or failure of the complete conductor at a load less than 85 per cent of the ultimate strength of the conductor. (Refer to the safety factors: 3.0 for conductors, 2.5 for clamps/fittings)

The design of joints and any tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly. All external nuts shall be locked in an approved manner. There shall be no relative movement within the clamp between individual layers of the conductor itself.

Mid span joints shall comply with the mechanical requirements of the Specification for line conductor joints and clamps. Compression dies shall be of a common size and dimensions for each fitting for a given size of conductor. Not more than one mid span joint will be allowed in one section in one phase conductor.

Parallel Groove (PG) clamp can be applied to joint conductors where there is no mechanical load.

7.1.15.2.1 Conductor terminations.

Ball ended hook, Socket clevis and Socket tongue shall be suitable for use on Aluminium conductor steel-reinforced (ACSR) of outer diameter between 7.00 mm and 25 mm (25 sq. mm and 300 sq. mm) and standard disc insulator of ball and socket type with the ball pin diameter of 16 mm.

<u>Ball ended hook, socket clevis and socket tongue</u> shall be of malleable iron or ductile iron, hot dip galvanized to BS 729.

<u>Tension clamps</u> shall be bolted type and shall be suitable for use on aluminium conductor steel-reinforced (ACSR) of outer diameter between 7.00 mm and 25 mm (25 sq. mm and 300 sq. mm).

The clamp body and keeper piece shall be of high strength and heat-treated cast aluminium alloy.

The clamp cotter bolts, and U-bolts shall be galvanized steel and the pin shall be stainless steel.

The clamp shall have slip strength of not less than 85% of the rated ultimate strength of conductor it is intended for use with.

7.1.15.2.2 Joints (non-tension)

<u>Parallel groove clamp (PG Clamp)</u> shall be suitable for use on aluminium conductor steel-reinforced and all aluminium conductors of outer diameter in the range of 7.00 mm to 18.2 mm for ACSR conductors and 25 mm for AAAC conductors (300 sq. mm).

(a) The groove of the PG clamp shall correctly fit the conductor it is intended for use with. It shall have adequate cross sectional area and length.

(b) The PG clamp shall be of electrolytic, high strength, corrosion resistant aluminium alloy.

7.1.15.2.3 Suspension Clamps

Suspension clamps shall be suitable for use on aluminium conductor steel-reinforced (ACSR) of up to 18.2 mm diameter (150 sq. mm) and All Aluminium Alloy Conductor (AAAC) of up to 25mm diameter (300sqmm) shall be of the following types.

(a) Clevis ended hook type and pivoted type (similarly known as envelope type and trunnion type respectively).
(i) The clamp body and keeper piece shall be of high strength, heat-treated cast aluminium alloy.
(ii) The clamp cotter bolts, hangers, brackets and U-bolts shall be of galvanized steel and the cotter pin shall be of stainless steel.
(b) Angle suspension clamp type (similarly known as side opening type).
(i) The clamp shall be suitable for use on turning angles from 10 to 120 degrees.
(ii) The clamp body and keeper shall be of malleable iron or ductile iron; hot dip galvanised to BS 729.
(iii) The clamp cotter bolts and bolt shall be galvanised steel and the cotter pin shall be stainless steel.

7.1.15.2.4 Connectors

The connectors shall be suitable for use on stranded bare conductors and shall correctly fit the conductor it is intended for use.

The connector shall have adequate cross-sectional area and dimensions and shall have current carrying capacity at least equal to the capacity of the conductor it is intended for.

(a) Aluminium connectors
(i) Aluminium connectors (line taps) shall be suitable for connecting stranded aluminium conductors
(ii) The connector shall be manufactured from electrolytic, high strength aluminium.
(b) Copper connectors
Copper connectors shall be suitable for connecting stranded copper conductors.
(c) Bi-metal connectors
(i) Bi-metal connectors shall be suitable for connecting stranded aluminium conductors to stranded copper conductors.
(ii) The bi-metal connector shall be designed to provide an effective corrosion barrier between the dissimilar metals (aluminium and copper).

7.1.15.3 Drums

Drums for conductors shall be stoutly constructed of good quality timber or steel and clearly marked with length and type of conductor in a manner not easily removable. Drums shall be securely battened around the perimeter and shall be lined with approved impervious material to prevent contact between the contents and both the drum itself and any chemicals with which the drum has been treated.

All timber drums and battens shall be protected from deterioration on site by termite or fungus attack by an approved impregnation treatment at the works before dispatch. Such substance shall not be harmful to the conductor.

All drums shall have spindle holes of adequate diameter and be stoutly reinforced with steel plate.

The cut ends of the conductor shall be properly secured to the flange of the drum and shall be treated in an approved manner to prevent the ingress of moisture during transit or storage.

The Contractor shall deliver all empty drums to the employer's store. All drums are non-returnable and shall remain the property of the Employer.

7.1.15.4 Markings of Drums

The following particulars will be indelibly stenciled on both flanges of every drum:

i. Contract title and reference number
ii. Manufacturer's name
iii. Direction of rolling
iv. Lifting instructions and limitations
v. The words "Property of KPLC"

An aluminium nameplate shall be fixed to each drum clearly showing the following:-

a) Conductor materials and stranding
b) Length of conductor
c) Net weight
d) Gross weight
e) Manufacturers batch number
f) Manufacturers drum number
g) Winding date
h) Approximate measurements

7.1.15.5 Conductor Stringing

All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

Every precaution is to be taken to prevent damage to the conductor. Clamps and other devices used for handling the conductor during stringing shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor. Conductor grooves in sheaves and tensioner shall be lined with neoprene or rubber.

Conductors shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

Conductor drums shall be closely examined before conductor pulling commences and all nails and other things that could damage the conductor shall be removed.

7.1.15.6 Re-conductoring

Where applicable, before the re-conductoring commence, the Contractor shall inspect the line and check that the clearances to ground, trees, houses, roads etc. meet the requirements. The contractor shall also check that:

- The capacity of poles, cross arms and stay wires is sufficient for the new conductor
- The quality of poles, cross arms and stay wires is satisfactory
- The pole heights are sufficient for the new conductor
- The poles are in vertical position

Where the existing installation does not meet the above requirements, change out of material or aligning work of poles must be carried out.

When re-conductoring, the Contractor must handle all tilted poles with utmost care. Before loosening the existing conductors, the poles have to be secured with stay wires. Climbing the poles has to be done by use of ladders placed against the tilted direction.

All tilted poles shall be corrected to a vertical position before the stringing work of the new conductors starts. Poles that do not meet capacity- or quality-wise meet the new requirements have to be changed out.

After aligning the poles, the top of the pole shall not be out of the vertical axis by more than the top pole diameter.

All clamps, fittings and details not suiting the new conductors or quality-wise not meet the requirements, shall be changed out.

7.1.16 Safety

Personnel shall be required to use necessary protective gear, which conform to applicable codes.

Personnel working near high voltage areas shall be required to use non-slip foot wear, gloves, safety glasses, helmets, etc. They shall also be required to observe stipulated safety clearances.

Fire prevention and safety program shall also be observed.

7.1.17 Operation Devices and Protection Systems

Operation devices consisting of single and three pole disconnectors shall be installed at locations specified by the designer. The disconnectors shall be easily accessible during normal conditions. They will be fixed in such a way that they cannot be closed by the action of gravity. Their characteristics shall be capable of meeting the maximum rated current of the circuit.

7.1.17.1 Isolation

7.1.17.1.2 Air break Switches

Air break switches shall be used to interrupt small currents (up to 10% of rating of (ABS).

7.1.17.1.3 Protection against over Voltages

Protection against overvoltage will consist of surge diverters at locations specified by the designer.

7.1.17.1.4 Protection against Overcurrent

The network comprises main line and spurs.

Circuit breakers shall be installed at the beginning of the main line at the primary substation.

Short circuit fuses shall be installed at the beginning of the primary spur. Autorecloser and Sectionaliser shall be located as specified by the designer.

7.2 PARTICULAR TECHNICAL SPECIFICATIONS FOR TRANSMISSION LINES

7.2.1 DESIGN REQUIREMENTS

7.2.1.1 Philosophy of Design

The philosophy of design contained within this specification is based upon deterministic principles whereby the applied loading multiplied by the appropriate safety factor must be less than the ultimate strength of the component.
In tendering the Contractor will be deemed to have concurred as a practical manufacturer with the design and layout of the works as being sufficient to ensure reliability and safety in operation freedom from undue stresses and satisfactorily performance in all other essentials as a working plant.

The transmission lines shall be designed with high reliability and low cost of maintenance as the primary consideration in accordance with the relevant sections of the specification.
The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the erection and subsequent maintenance of the contract works.

7.2.1.2 Units of measurement

In all correspondence, technical schedules design calculations and drawings the metric (SI) units of measurement shall be used. Angular measurements shall be degrees with 90^0 comprising a right angle.

7.2.1.3 Design Calculations

All sets of calculation shall be complete, bound titled and given a unique drawing number
The binding shall be such as to allow the easy introduction of subsequent pages if necessary.

Bound into each set shall be fully detailed index. Following this shall be a design information sheets which incorporates the following details: -

a) The design concept shall be summarized
b) Full details of manual design papers or other aids referred to in the text shall be given with photocopies of relevant sheets if appropriate.
c) Full loadings shall be reiterated with their deviations if appropriate
d) Design stresses shall be reiterated
e) Code or standard references should be quoted and equation written out in full for initial calculation

Should the Contractor be required to re-submit amended calculations or additional sheets the following annotation shall be adopted:-

f) Amended sheets should retain the same sheet number but have a lower case revision letter suffix i.e. sheet 14 when amended becomes 14a then 14b.
g) Additional sheets that needed to be inserted shall be given the sheet number they are added to plus an upper case letter prefix i.e. additional sheets to page 60 become A60, B60 and if subsequently amended A60a etc.

Where a computer program is used for design calculations a full explanation in the English language shall be provided to assist the Employers approval of the calculations for each and every program used. Details must include name of program author source, comprehensive description of theoretical basis including all references to relevant documentation, checks undertaken on program and list of projects on which the program has been used.

7.2.2 DRAWINGS

7.2.2.1 General Requirements

Drawings shall be to scale fully detailed and all dimensions shall be in Metric Units. General arrangements drawings submitted shall be to scale of not less than1 to 50 and all detail drawings not less than 1 to 20. Profile drawings shall normally be drawn to a vertical scale of 1 to 200 and a horizontal scale of 1 to 2,000.

Drawings sheets shall conform in size to BS 3429, mainly A0, A1, A2, A3, and A4. A3 drawings shall be used as much as possible for construction drawings.

The sheet size is to be stated on the drawing within or adjacent to the title block.

Drawings shall conform to BS 308 or equivalent.

The scale used shall be stated on the drawing as a ratio together with linear scale at a convenient position along the margin of the original drawing sheet.

The physical draughting requirement in respect of line density, strength, contrast, contrast, spacing and character legibility shall be met to ensure drawings are suitable for microfilming in accordance with BS 5536 and the specification for micro-copying of drawings to BS 4210.

All drawings shall bear in English, serial number of the project, drawing number, which shall be unique to this project and scale. The system of numbering and layout of the title block will be to the approval of the Employer. The title block shall include the name and address of the Employer. The revision notes shall detail the nature of each revision. The revision shall be enclosed in a cloud with the revision letter indicated.

7.2.2.2 Computer Generated Drawings

The submissions generated drawings by electronic transmission or any other electronic form shall be subject to agreement by the Employer.

7.2.2.3 Contract Drawings List

At defined interval the Contractor shall submit the requisite number of copies of the contract drawing list.

The list shall contain the following information:

a. Drawing number,
b. Drawing title
c. Revision status
d. Approval status

All changes since the previous issue shall be clearly indicated and when agreed only the front (index) revised sheets need to be submitted.

7.2.2.4 Contract Record Drawings

The Contractor shall submit to the Employer:

a) A final issue of the contract drawing list indicating which of the drawings design calculations, methods statements etc that they propose to issue as final contract drawings. These drawings shall be updated to incorporate all modifications made during erection and commissioning.
b) Requisite number of prints of each schedule, including where appropriate the supply and installation material manual.
c) Requisite number of drawings including design calculations schedules including the supply and installation material manual in diskette format in either WPG or DXF format.
d) Requisite number of polyester/transparency film copy of each drawing, including design calculations, profile and route maps.

The distribution of the contract record drawings will be advised by the Employer.

7.2.2.5 ROUTE MAPS

During the progress of the work the Contractor shall record on profiles, supply and install material manuals (SIMMs) and on a set Survey Maps of approved scale such particulars as will allow an accurate reference to be made afterwards in case of any faults or projected modifications to the line.

The map and/or profile sheet shall show the exact position of every support with approved reference marks. The maps shall be supplemented or profiles marked by sketches where necessary to delineate boundary position of support which cannot be clearly indicated on the maps.

The date included on the maps profile sketches and SIMMS shall be submitted to the employer to whom facilities shall be given for examining such records during the progress of the work.

7.2.2.6 SAG TEMPLATES

The Contractor shall supply the specified sets of templates in strong stable colourless plastic or similar material not less than 3mm thick. Engraving shall be on the back face of the templates. The templates shall be for the specified equivalent spans.
Each template shall be accurately shaped to provide the sag curve; the same curve shall be engraved on the template at a distance below representing the minimum allowable vertical clearance to normal ground. A further sag curve in still air at minimum temperature shall also be shown. Each template shall be clearly endorsed with the sagging basis, conductor particulars equivalent span and unless otherwise specified to a scale of 1:200 vertical and 1:2000 horizontal.

Templates shall be supplied to the Employer before the submission of the profiles. Failure to do so may result in delay which will be responsibility of the Contractor.

7.2.3 MATERIALS SUPPLY AND INSTALATION MANUAL

As soon as final support positions are approved, the Contractor shall provide the requisite copies of the A4 size Supply Install Material Manual (SIMM).
Each support position shall be represented by one of the manuals with the following information recorded:

a. Provisional and final support numbers.
b. Profile and record map reference drawing numbers.
c. Span
d. Wind span
e. Weight Span
f. Angle of deviation
g. Support type, leg and body extensions and General Arrangement (G.A.) drawing reference numbers
h. Foundation type and G.A. drawing reference number
i. Earthing details and G.A. drawing reference number
j. Insulator set details and G.A. drawing reference number
k. Sag adjustment setting and linkage requirements – (where appropriate)
l. Phase conductor jumper details including spacer and general arrangements drawing reference number – (where appropriate)
m. Earth wire set details and G.A. drawing reference number
n. Earth wire vibration damper G.A. drawing reference number
o. Aircraft navigator (obstruction aids) drawing reference number – (where appropriate)
p. Fibre optic junction boxes and cabling G.A. drawing reference number – (where appropriate)

In addition, the following schedules shall be included: -

i. Phase conductor and OPGW sags and tension (erection and final)
ii. Suspension insulator sets off-sets
iii. Location and spacing of all phase conductor spacers dampers – (where appropriate)
iv. Location of all phase conductor and earth wire tension and non-tension joints
v. Location and spacing of all aircraft warning spheres (where appropriate)
vi. Location of all fibre optic joint boxes – (where appropriate)

The appropriate reference drawing numbers shall also be included. Preliminary copies of SIMMs shall be available prior to any site work commencing, together with materials summaries. This is Hold Point.

7.2.4 MAINTENANCE MANUAL

The Contractor shall provide at the specified period before the end of the construction period of the contract, a maintenance manual covering the following information: -

a) Type, code numbers and description of all plant erected, together with names and addresses of manufacturers
b) Methods of assembly of all fittings
c) Method of replacing any part of the plant including the use of maintenance holes provided on the support access provisions and where appropriate the application of “live - line’ maintenance techniques.
d) Recommendations of preventive maintenance including frequency of inspection.
e) List of recommended maintenance equipment with a description of its use and limitations
f) Type and application of temporary Earthing equipment.
g) Personal safety equipment requirement and any risk assessment required.

The above information must be specified to this contract and entirely in the English language. Drawings and diagrams shall be used where necessary to enable the Employer/Purchaser to properly maintain the whole of the works.
The manual shall be suitably bound within a hard cover and all materials used shall be reasonably hard wearing.

The manual shall be submitted to the Employer. This is Hold Point.

7.2.5 SAMPLES AND MODELS

If the nature of the works makes it desirable the Contractor/ supplier may be asked to submit or prepare for the Employer such samples, patterns and models as the Employer may reasonably require for the purpose of design approval at the expense of the Contractor/supplier.

7.2.6 PHOTOGRAPHS

The Contractor shall make all arrangements to provide progress photographs of all tests and such sections of the work in progress as directed by the Employer. Each photograph shall be suitably entitled, in digital format. The photographs shall be the property of the Employer and no copies of the photographs shall be released without the authority of the Employer.

The Contractor will normally be required to provide every month at his own cost the specified number of sets of un-mounted progress photographs suitably inscribed of potions of the work in progress throughout the period of construction. Any variation to these quantities will only be with the permission of the Employer.

7.2.7 TRANSPORT, ACCESS AND SERVITUDE

7.2.7.1 WAYLEAVES

7.2.7.2 General

Way leaves and access facilities, subject to the requirement of landowners and occupiers, will be provided by the Employer to enable the Contractor to carry out the erection of the contract works. Such facilities will not necessarily include facilities for storing materials nor necessarily include access for wheeled vehicles.
The Contractor shall satisfy themselves that the necessary rights of entry and access have been obtained before

The contractor shall indicate to the employer such pipes or other obstructions telephone telegraph and power lines which infringe the clearance specified or otherwise fail to satisfy the requirement of the specification.
The necessary agreement for the removal of obstruction such as trees and for the permanent removal or guarding of pipes telegraph telephone and power lines, will be obtained by the Employer.

7.2.7.3 Way leaves Schedule

Before the Contractor commences work on any property, he shall obtain the way leaves schedule from the Employer, including details of any special requirement of the occupiers concerned. This is a hold Point.

7.2.7.4 Access to Site, Notice of Entry

7.2.7.4.1 Access Routes – General

The Employer may indicate to the Contractor the general route for access to each or any position as agreed by the Employer, otherwise the Contractor shall make all necessary arrangements (other than questions of way leaves) with the occupier.

Subject to the provisions of the preceding paragraph before commencing work, the Contractor shall at his own expenses do what is necessary to make the access suitable for his use and shall take all reasonable precautions to avoid damage, including if required erection of temporary fences or gates where permanent fences, hedges or gates have been removed. The Contractor shall not be entitled to any additional payment in the event of a particular access being difficult.

The Contractor shall be responsible for maintaining agreed access routes in a usable condition without undue widening for the duration of the contract. The occupier shall not be put to any inconvenience in gaining access to his land or buildings. No unauthorized access routes shall be taken by the Contractor.

7.2.7.5 Commencement of work

Before beginning on any property, the Contractor shall be responsible for obtaining confirmation from the Employer that way leaves are in order and any agreed accesses have not been altered and for giving not less than 48 hours' notice to the occupier that work is to begin. Work shall proceed on any land within the requisite period of such notice being given to the occupier.

7.2.7.6 Suspension of work

Where work is to be suspended without the expectation of it being resumed within the specified period, the Contractor must notify the occupier of such intention and shall similarly give the occupier prior notification of the resumption of work. The purpose of this Clause is to assist in maintaining good relations between the occupier, the Contractor and the Employer and to keep the occupier informed of what is going to happen on or across his land.

7.2.7.7 Compliance with occupier's requirements

At all times during the execution of the works, the Contractor shall ensure compliance with all such reasonable requirements of the occupier as are brought to the Contractor's notice by the Employer. The Contractor shall not be entitled to any additional payment in respect of his compliance with the reasonable requirements of the occupier.

7.2.7.8 Notice to Authorities

Before the Contractor carries out the stringing of conductors along or across power or telecommunication circuits, public roads, etc, he shall give the requisite notice to the appropriate Authorities of the time and date when he proposes to perform the work and shall send a duplicate copy of each notice to the Employer.

7.2.7.9 Route Clearance

For details of the clearance requirements for survey, access routes, line route, support locations and conductor stringing, reference shall be made to paragraph 7.2.10 on route selection and clearance

7.2.7.10 Access Roads

For details of the access road requirements reference shall be made to paragraph 7.2.10 on route selection and clearance

7.2.8 CROSSING OF OBSTACLES

7.2.8.1 General

The Contractor shall, at his own expense, make any necessary arrangements and take the necessary precautions where the route crosses buildings, telecommunication, power or pipe lines, orchards, gardens, railways, antiquities or other obstructions or ground over or across which erection cannot be carried out in the normal manner or has to be avoided. These arrangements must be submitted to the Employer. This is a Hold Point.

Where a support is set across a fence, hedge, bank or wall, the Contractor shall remove and reinstate the fence, hedge, bank or wall at his own expense and he shall be responsible at his own expense for making good to the satisfaction of the Employer, owners and tenants concerned, all land, property, roads, drains, fences, walls hedges, gates and the like which he has damaged or disturbed during the execution of the contrast works and shall remove all surplus material after erection. The Contractor shall take proper precautions to prevent the straying of and damage to livestock until after the backfilling of excavations and permanent reinstatement of fences, walls, hedges, gates and the like are completed.

7.2.8.2 Public Utilities

The Contractor shall ensure that the erection of the contract works does not cause damage to or interference with existing telecommunication, power or pipe lines.

Where appropriate Authorities affected deem it necessary for the protection of their employees, property, or the public, or for the assistance of traffic, to provide flagmen and watchmen, the cost of such provision shall be borne by the Contractor. Where required by the appropriate Authorities work shall be carried on outside normal hours and at the Contractor's own expense.

The Contractor shall also be liable to make good at least to the original condition or compensate the owners, operators and users or any public undertaking in respect of any damage however caused to their property, lands or roads arising out of or in consequence of the execution of the works.

7.2.8.3 Scaffolding

The Contractor shall provide all necessary scaffolding and the like for the crossing of telecommunications or power lines, roads, railways building or other obstacles. The Contractor shall advise the Employer in each instance of the scaffolding he proposes to use. Drawings of the proposed scaffolding shall be submitted to the Employer, and the appropriate regulatory authorities. This is Hold Point.

7.2.8.3.1 Live Line Scaffolds

The scaffolding which is used to cross specified low, medium and high voltage power lines shall be of such dimensions and allow such clearances that the power lines being crossed may remain in commission during construction of the new transmission line. It may only be possible to have shut-downs on the lines to be crossed for sufficient periods of time to top out and net the scaffolds. Such restrictions in building and use of the scaffolds will not be grounds for claiming additional costs. Design and construction of the live scaffold shall not be inferior to the minimum standards outline in the following clause.

7.2.8.3.2 Live Line Scaffold-Construction

The scaffold shall be designed to withstand the maximum design wind speed, except that a reduced return period will be accepted. Consideration shall also be given due to impact loading, due to dropping of the upper phase conductor.

The scaffold shall, unless otherwise approved by the Employer, consist of 3m wide 300mm squire mesh nylon nets attached to steel wire ropes running perpendicular to the lower line route, carried by metal scaffolding at 3m intervals. The nets shall be attached to the catenary wires by means that do not require the presence of any persons on the net or the catenary wires whilst the lower line is alive. An additional movable 3m by 50 mm mesh walk net laid over the 300 mesh nets may be used whilst the lower line is dead.
Normally, steel or aluminium tubular scaffolding to BS 1139 and BS 6323 should be used. The use of pre-formed units or frames shall be subject to the Employer's approval.

The mechanical construction shall be in accordance with BS 5950. Reference shall also be made where appropriate to BS 5973.
The design of the scaffold shall have due regard to the requirements of safety with particular respect to accidental contact with live conductors during construction, use and removal.

The scaffold, including foundations, shall be designed and constructed to ensure stability during the process of erection and removal, and also at times when work has caused for any reason including adverse weather conditions. The foundations shall be suitable for the ground concerned.

The base width of any tubular steel supporting structure shall not be less than 25 percent of its height. Lighter materials (e.g. Aluminium) shall be used with caution. Adequate diagonal bracing shall be provided.
The scaffold shall extend at least 5m either side of the outermost conductors of the upper line. A maximum of 2m of this distance may be provided by means of catchers.

Catchers shall be provided at each end of each scaffold support. The catcher may be vertical or inclined to a maximum angle of 45^0 from the vertical. They shall be capable of withstanding the specified impact loads without excessive distortion that would permit a falling conductor to approach or touch a live-line.

The upper parts of the scaffold shall be provided with soft wood rubbing boards or otherwise protected in an approved manner to prevent damage to the conductors resting on or being drawn over the guard. Soft wood poles may be used for this purpose. The height of these boards shall be sufficient to prevent the conductor damaging the nylon net. To avoid damaging the conductors no object other than non-metallic lashing or the catchers shall protrude above the rubbing boards.

Sufficient endless or double ended lead lines for hauling over pilot wires shall be placed over the scaffold prior to re-energization of the lower line.

The side supports shall have working platforms to facilitate the required running of conductors and prior wires. Working platforms shall be provided with hand rails, toe boards and notices warning of the danger of live conductors. The heights of hand rails shall be 1m and the toe boards 230 mm. Each working platform shall have a notice plate indicating the “Safe Climbing Height”.

The scaffold shall be fitted with danger plates at intervals of not more than 6m along the anti-climbing device with at least one plate on each face of the structure.

The scaffold shall be constructed to prevent unauthorized access or climbing by the use of barbed wire anti-climbing devices, fences or other means approved by the Employer.

The scaffolding shall be lit with red warning lamps from ½ hour before sunset to ½ hour after sunrise if erected within 2m from a highway or footpath without an intervening fence. The scaffold the Contractor shall provide or arrange for the supply and maintenance of these lamps (e.g. with the line Contractor).

If the scaffolding is constructed adjacent to a roadway, a guard constructed from steel drums filled with soil or a soil bund shall be provided and suitably lit.

Where possible the resistance to earth of the scaffold shall be less than 10 Ohms. Special consideration by the Employer and the lower line operator shall be given in cases where this is not attainable with a reasonable number of driven earth rods.

Bonding the scaffold to the earthing systems of either the live-line, or the line under construction is not normally acceptance. In the former case a nearby line fault could cause the scaffold to become live. In the latter case a fault between the live-line and the scaffold could cause components of the line under construction to become alive, particularly as its earthing system may not be complete.

The earth rods should normally be driven into the ground around the outside and approximately 1 m from the scaffold structure. The rods should be securely connected electrically and mechanically to the scaffold structure by flexible copper or aluminium leads with minimum across-sectional areas of 64 mm^2 or 100 mm^2 respectively.

Drawings of the scaffold complete with details of the clearance plates and earthing arrangement, together with supporting calculations shall be submitted to the Employer and appropriate regulatory authorities. This is a Hold Point.

7.2.9 DAMAGE

7.2.9.1 General

The Contractor shall take all reasonable precautions to avoid damage to land, property, roads, crops, fields drains, fences walls, hedges, gates, trees and the like and shall ensure that the work is adequately supervised so that any damage is reduced to the minimum. Save as otherwise provided, the Contractor will be liable for all damage arising by or in consequence of the works except unavoidable damage to crops and shall pay compensation or make good at the option of the Employer.

7.2.9.2 Contractor's Responsibility

The Contractor's liability for loss or damage shall extend to any such loss or damage resulting from the employment of a Subcontractor. This does not relieve the Contractor of his liability for all actions of his Subcontractor.

7.2.9.3 Livestock

Adequate provision shall be made by the Contractor to prevent the straying of or injury to livestock during the execution of the work and until the permanent reinstatement of fences, wall, hedges, gates and the like is completed.

The Contractors shall be liable for any injury to or loss of livestock due to failure to comply with the above requirements.

7.2.10 ROUTE CLEARANCE

Where clearing is required, the following requirements shall be observed:

a) Tree and tall scrub shall be cleared to a distance of 15m on either side of the centre line of the route. Trees and bushes shall be cut down to a height of not more than 1.25m above ground level. In addition, tall trees outside the cleared area, of such height that could fall within 3m of the conductors, shall be trimmed by the Contractor. No tree may be felled without the express permission of the Employer. This is a Hold Point.

b) Felled trees and scrub shall be removed from a path 2.5m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and roots from this track and leave a graded way for negotiation by Land Cruiser or similar four-wheeled drive light vehicle for patrolling and maintenance by the Employer.

c) The Contractor shall clear a 4 m wide agreed construction track from public roads, of all trees, stumps, scrub and vegetation to tower positions as required by the Employer. Such tracks need not be surfaced but shall be graded and shall include culverts to prevent wash-way.

d) All felled trees and tree trimmings shall remain the property of the landowner.

7.2.11 SURVEY AND GEOTECHNICAL INVESTIGATIONS

7.2.11.1 ROUTE SELECTION

The Employer will indicate to the Contractor either on maps or during visits to the sites the proposed route of the transmission line, with approximately positions of the angle and terminal support and the position of such intermediate supports as it may have been desirable to determine during preliminary way leaves negotiations. The Contractor shall give the Employer the requisite period of notice prior to commencing the survey. This is Hold Point.

7.2.11.2 CONTRACTOR SURVEY

7.2.11.2.1 Access for Survey

The Contractor's surveyors shall in all cases announce himself to the occupier/landowner immediately before entering any private property for the purpose of survey.

7.2.11.2.2 Accuracy

Profiles shall be produced as a result of a precision ground or aerial survey, the accuracy of which shall be such that the vertical tolerance between levels forming the profile and actual ground level shall not exceed 300 mm, and the measured to an accuracy of not less than 0.2 percent. All levels shall be related to the specified national datum.

7.2.11.2.3 Profile Drawings – Size & Scales

Computer plotted profiles on plain plastics drawings sheets will be accepted by the Employer.

The profile shall either be drawn on a mixture of a melinex type material or as otherwise approved with printed grid lines of increasing thickness in 1, 5, 10 and 50 mm squares and shall be drawn on the reverse side of the melinex to the grid lines.

However the format of the profile shall not differ from the details specified in the following clauses.

Unless specified to the contrary the scale of the profile shall be:

- 1:2000 horizontally and
- 1:200 vertically

The profile shall be plotted with the direction of the line route left to right on profile sheet. In general, individual profile sheet shall commence and finish at tension supports but where this is not practicable and continuation sheets are found to be necessary the ground line is to be drawn so that there is an overlap of at least 300 mm between adjacent sheets. The chainage of each section between tensions structures shall start at zero, be on 50mm printed grid line and not less than 150mm from the left-hand margin. Each section shall normally be started on a new sheet. The date of survey of each section shall be added.

If more than one section is drawn on one sheet a gap shall be left in the ground line of not less than 150mm.

7.2.11.2.4 Profile Drawings – Details

The following details and information are to be included on the profile drawings:

a. At each angle position "tie– in" sketch shall be provided on the profile sheet. This sketch shall show clearly the location of the support using as reference where possible points which can be located on the ground and on the 1:5,000 or closest available scale of survey map. The direction of the line and angle of deviation are to be shown stating also whether the deviation is left or right. Where reliable maps of reasonable scale and accuracy are not available for locating and plotting support positions survey methods acceptable to the Employer shall be employed to establish grid co-ordinates supports and ground features shall be related to these.

b. Where ground slope across the line route exceeds 1 in 25 the level of ground left and right of the centre line shall be recorded at specified horizontal offset distances where the side slope is uniform. Where the slope breaks upwards beyond this distance levels will be recoded up to a specified horizontal offset distance. The offset levels shall indicate on the profile as broken and/or chain lines and the distance off-line started.

c. The profile shall show all changes of level of 300 mm or more along the route centre line and along the off-set lines. All features such as hedges, fences, graves, ditches, roads, railways, rivers, buildings, canals, telephone and railway lines and all power lines shall be shown. Route numbers or name of roads shall be stated or, if unclassified the destination. Railways are to be given the destination, number of tracks, whether or not electrified and the level at the top of rail stated.

d. The chainage is to be shown at each 300 m and at every geographic feature or obstruction. Chainage shall also be given to all pegs.

e. The specified Datum shall be the basis for all levels and the levels above the specified Datum shall be shown at 10 m vertical interval at the beginning and end of each profile sheet. Levels shall be shown at each peg on line and at every obstruction or geographical feature.

f. The visual nature of the ground shall be noted whether cultivated, woodland, etc, with special reference to marsh soft ground or rock and other relevant information such as soil instability.

g. All buildings or high obstruction within 30 m of the centre line shall be shown dotted at their measured height with the distance left or right of line indicated.

h. Where the ground contour rises to a point which would be less than 100 mm from the top of the profile sheet, the ground line shall be terminated and continued on a new sheet with an overlap of 300 m of line route.

i. The following detail shall be shown for crossing of power lines: -
   - Voltage and type of construction
   - Ground levels at point of crossing and support structures;
   - Height of top conductor and earth wire at point of crossing and at point of support;
   - Distance from crossing point to support structures along route of line to be crossed;
   - Angle of crossing;
   - Temperature at time levels were taken (state date and time);
   - Support structures members.

j. Along the bottom of the profile sheet a route map shall be drawn, to the same scale as the horizontal scale of the profile, showing all relevant details, within a distance of 30m each side of the route centre line. All items covered by sub-paragraphs (a) and (i) above as appropriate shall be included

k. On tower spot locations, local profile for each tower shall be provided. Stub length and foundation depth design shall refer local profiles as much as possible.

7.2.11.2.5 Support Location on Profiles

The Contractor shall submit to the Employer the requisite copies of the profile drawings upon which shall be indicated the proposed location and type of each support, spans, section lengths, (i.e. distances between tension supports), equivalent spans, wind and weight span, phase conductor swing angles, difference in level between adjacent phase conductor attachment points and the sag templates used. This is a Hold Point.
In addition, the relevant position of the bottom or lowest phase conductor at the specified maximum conductor temperature, together with another line parallel to the phase conductor at the minimum statutory ground clearance, shall be shown on the profile.

7.2.11.2.6 Check Survey

The Contractor shall carry out a check survey. Profile drawings/preliminary profile will be made available to the Contractor, who will be required to check the profile survey and survey and design final route for approval.

The Contractor is required to check thereon the proposed support positions and submit the profile to the Employer. Profile details and support locations shall be in accordance with the preceding clauses. Check survey shall include Contractor notes on final route selected and shall be approved by Employer; approved centre shall be the transmission line approved design centre. Design and construction set out will be based on this without changes, and any deviation shall be reported immediately to the Employer with the proposal for restoring design centre.

7.2.11.3 GEOTECHNICAL INVESTIGATION

7.2.11.3.1 General

Geotechnical investigations shall be undertaken in accordance with the technical requirements detailed in the following clauses.
Where required by the Employer, the Contractor or his appointed geotechnical consultant shall undertake the specified slope stability analysis and design. The Contractor shall give the Employer the requisite period of notice prior to commencing the geotechnical investigation. This is a Hold Point.

7.2.11.3.2 Level 1

Level 1 geotechnical investigations shall be based on a visual-tactile examination or disturbed soil samples for the determination of both soil classification and strength.

7.2.11.3.3 Level 2

Level 2 geotechnical investigations shall be based on in-situ testing for the determination of the soil strength and visual tactile examination of disturbed samples for the determination of soil classification

7.2.11.3.4 Level 3

Level 3 geotechnical investigations shall be based on in-situ testing (as level 2) for the determination of the soil strength and the recovery of disturbed soil samples for the subsequent laboratory testing. Laboratory soil classification tests for non-cohesive soils shall be article size distribution, moisture content and relative density, whilst those for cohesive soils shall be moisture content and Atterberg limits.

7.2.11.3.5 Level 4

Level 4 geotechnical investigations shall be based on a combination of in-situ testing (as level 2) and the recovery of disturbed/undisturbed soil samples for the subsequent laboratory testing.

7.2.11.3.6 Soil and Ground Water Samples

Where specified, soil and ground water samples shall be obtained for determination of the chemical content i.e. organic matter, sulphate, pH and chloride content.

7.2.11.3.7 Geotechnical Investigation Criteria

Geotechnical investigation shall be undertaken to the following criteria:

a) Geotechnical investigation shall be undertaken as near as possible to the tower site. For test foundations the investigation shall be undertaken as near as possible to the test site, and shall take account of the theoretical failure surface of the foundation.

b) Time lapses between the investigation and foundation installation shall take into account any noticeable effect on the geotechnical properties due to rainfall or seasonal variations in the groundwater level;

c) Depth of investigation shall be:

   i. For trial pits 2m; or
   ii. the foundation depth plus 1.5 times the maximum base width dimension for concrete pad and chimney or steel grillage foundations; or
   iii. 3m or 5 times shaft diameters (whichever is greater) below the foundation depth for drilled shaft, piled foundations; or
   iv. at least 2m into rock or hard dense stratum ($N_{SPT} > 50$) if this occurs before the recommended depth; or
   v. for uplift or lateral foundation tests not less than 1m below the base of the test foundation.

d) SPTs (standard penetration tests) should be undertaken at the top of each stratum and then at 1m intervals in soil or weak rock;
e) PMTs (Pressure meter tests) should be undertaken in each stratum or as required;
f) CPTs (Cone Penetration Tests) should be taken continuously over depth of investigation
g) VSTs (Vane Shear Tests) should be undertaken at top of each stratum and then at 1m intervals;
h) Soil/rock description should be based on disturbed samples taken in each stratum and thereafter at 1m intervals.
i) Highest ground water level and variation in water level

APPENDIX 6.A.1

GEOTECHNICAL INVESTIGATION

Geotechnical Investigation Level	**Frequency**
Level 1	Every tower site
Level 2	Every tower site
Level 3	Every tension and terminal tower

Ground water samples shall be taken at every tension tower position for chemical analysis.

7.2.12 CONDUCTORS AND FITTINGS

7.2.12.1 POWER CONDUCTOR

The power conductor shall be Aluminium Conductor Steel Reinforced (ACSR)-175 mm^2 codename "Lynx" and shall comply with IEC 60889. The outermost layer of the conductors shall be right-handed lay (z-lay). The Aluminium shall be of the highest purity commercially obtainable and shall not be less than 99.5%. The Contractor shall submit certificates of analysis giving the percentage and nature of impurities in the metal from which the wires were made. There shall be no joints in the individual wire of the outer layers of aluminium wires. All steel core wires unless specified to the contrary shall be hot-dipped galvanized to comply with the requirements of IEC 60888.

Unless specified to the contrary all conductors shall be uniformly covered with neutral grease as per IEC 61089. The minimum fill factor of grease shall not be less than 70 percent. Each layer of wire except the outer layer shall have, both lengthwise and peripherally, an even and continuous coating of grease. Wax thickened greases shall be applied at a temperature above the dropping point and shall be substantially free from contaminants.

The grease shall protect the conductors from corrosion in service, not corrode the steel or aluminium, be compatible with any wire drawing lubricant that might be applied on the conductor, not flow nor exude from the conductor during storage, transport, erection or service at temperatures of up to 100 degrees celsius. In addition, the grease should have adequate resistance to oxidation and conform to relevant current health and safety requirements.

7.2.12.2 TECHNICAL DETAILS OF LYNX ACSR CONDUCTOR

Nominal section	:	175 mm^2
Conductor strand	:	30/7 (2.79 mm)
Tolerance of diameter: Aluminium	:	$\pm$ 1.0%
Steel	:	$\pm$ 2.0%
Minimum tensile strength after stranding : Aluminium	:	17.2 kg/mm^2
Steel	:	128.5 kg/mm^2
Minimum coating weight of zinc	:	240g/m^2
Calculated section : Aluminium	:	183.40 mm^2
Steel	:	42.80 mm^2
Total	:	226.20 mm^2
Outside diameter	:	19.53mm
Unit weight of conductor	:	0.842kg/m
Ultimate tensile strength (UTS)	:	8,140kg
DC resistance at 20 deg. C	:	0.1576 Ohm/km
Approximate current carrying capacity	:	480 A

7.2.12.3 CONDUCTOR SAG DESIGN

Sags shall be computed under the following conditions:

Most severe design conditions :	Max. Wind pressure under min temperature
Max. wind pressure on conductor	385 N/m^2
Max air temperature	36^0 C
Min. air temperature	10^0 C.
Min. conductor temperature	0^0 C
Max. conductor temperature (continuous loading)	35^0 C
Max. conductor temperature (fault conditions)	200^0 C
Average conductor temperature	36^0 C
Factor of safety	
- Max. Working tension to UTS	more than 2.5
- Everyday stress to UTS	more than 5.0
Young's modulus of aluminium	6,300kg/mm^2
Young's modulus of steel	21,000kg/mm^2
Linear expansion coefficient	17.8X $10^{-6}/^0$C

7.2.12.4 DRUMS

The conductors shall be supplied on impregnated drums of approved materials constructed so as to enable the conductors and OPGW to run smoothly and those as spare materials shall be supplied on steel drums of approved materials for storage for long duration.
Length of conductors on one drum shall not be less than 2,000m.

7.2.12.5 JOINTS AND REPAIR SLEEVES

Tension joints of the conductors shall be of compression type and shall be free from slipping off, causing damage to or failure of the complete conductors, OPGW or any parts thereof at loads less than 95 per cent of the ultimate breaking strength of the conductors and OPGW.
Electrical conductivity and current carrying capacity of the tension joints for the power conductors shall not be less than those of equivalent length of the conductors.
The cut ends of steel wires and steel component inside the joint shall be protected from the weather in an effective and permanent manner.

Aluminium sleeves shall have plugholes for injecting compound.

All tension joints shall be supplied with aluminium fool-proof gauges or anti-displacement pins for correct positioning, adequate quantity of filling compound in injectors and aluminium collars for gap filling.
Full details of the joints including an illustration of practices for filling the air gap between sleeves, method of correct positioning of steel sleeves, gauges for ascertaining the compressed size, etc. shall be submitted with the tender.
Repair sleeves for the power conductors shall be of the compression type and the conditions stated above for the tension joints shall apply to the repair sleeves where applicable.

7.2.12.6 ACCESSORIES FOR POWER CONDUCTORS AND OPGW

In order to prevent fatigue of power conductors and earth wires due to repeated vibrations caused by breeze, the following countermeasures shall be applied.

a) Trunnion type suspension clamps
b) Vibration dampers
c) Armour rods.

7.2.12.6.1 Trunnion type suspension clamps

Suspension clamps shall be of trunnion type, made of aluminium alloy and as light as possible. They shall be designed to avoid any possibility of deforming the stranded conductors and earth wires and of separating the individual strands and shall be free to pivot in the vertical plane containing the conductors and earth wires.

Suspension clamps except jumper suspension sets shall have a suitable dimension for clamping the conductor with preformed armour rods; and shall not permit the complete conductor with armour rods to split at load less than 2,250kg for ACSR. Particular attention shall be paid to the elimination of corona emission from all parts of the suspension clamp.

7.2.12.6.2 Vibration Dampers

Vibration dampers shall be of Stockbridge type for both conductors and OPGW. The dampers shall be applied in all conductors and OPGW in every span except slack spans into the substations. The dampers shall be designed to be attached to the conductors and OPGW in a manner, which will prevent damage thereto and free drop of the weight in service. Clamping bolts shall be provided with domed self-locking nuts designed to prevent corrosion to the thread.

The nominal weight of damper shall be 12 pounds (5.44kg) for the conductors and 4 pounds (1.81kg) for the OPGW. The numbers of the dampers to be installed per span shall be:

a) 2 pieces per conductor or OPGW for spans up to 600 m and,
b) 4 pieces for the spans longer than 600 m.

First and second dampers will be positioned at 1.1m and 2.2m for power conductors and 0.6m and 1.2 m for OPGW respectively from the centre of suspension clamps or from the mouth of tension clamps.

7.2.12.6.3 Armour Rods

Preformed armour rods shall be applied to all suspension points of the power conductors except jumper suspension points.

Suspension clamps for those conductors protected by armour rods shall be suitable for the enlarged conductors.

7.2.12.6.4 Corona and Radio Interference

The design of all line conductor fittings, vibration dampers, etc., shall avoid **sharp corners** or **projections** which would produce high electrical stress in normal working. The design of adjacent metal parts and matching surfaces should be such as to maintain good electrical contact under service conditions. Particular care shall be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

7.2.13 LINE INSULATION

The transmission line for the project is aligned on an elevation level of 1500-2500m above sea level. The area has high humidity levels, tropical sunshine and prone to medium pollution by agricultural activities.

Silicon-rubber long-rod type Composite Insulators of the approved type shall be used to support the power conductors of the Transmission line. All insulator units will be composed of top and bottom arcing rings to equalize the voltage distribution over the insulator. The top shed of the insulators shall also have a larger diameter to prevent waste from birds and animals tracking down along the insulator.

7.2.13.1 Insulators Design

The insulator units shall be designed to withstand the design service voltages including lightning, switching and power frequency, the mechanical loads relevant to the installation-service-maintenance conditions, the service temperature and environmental effects. Internal stresses due to expansion and contraction of any part of the insulator unit shall not lead to deterioration.
The insulators should withstand wind pressures of up to a maximum of 385N/ m2.

The design of insulator units shall be with end over mould or such as to avoid local corona formation and no significant radio interferences shall be exhibited. The long rod Insulator units shall comply with the requirements of IEC 61109.

7.2.13.2 Fittings

All fittings to make each composite insulator set complete for beneficiary use shall be supplied and included in the rate for each insulator unit. Such bolts, nuts, washers, cotter pins and retaining pins with necessary spares as may be necessary for the use for erection shall be deemed to be included in the appropriate items.

Ball and socket couplings shall be in accordance with the requirements of IEC 60120/16. Sockets shall have “R” type security clips in accordance with the requirements of IEC 60372.

Clevis tongue couplings shall be in accordance with the requirements of IEC 60471.

All ferrous fittings shall be made of steel, ductile iron or malleable iron hot dip galvanized, and shall have sufficient strength for abrasion and weariness produced by repeated vibration. Cotter pins shall be made of non-ferrous metal or stainless steel and designed as the self-locking type.

The arcing ring shall be provided for the top and bottom of each insulator string and shall be of such design and shape that it reduces the voltage across the part of the insulator adjacent to the conductor for each insulator string, to a value which prevents visual corona formation on the metal caps and pins of the insulators and shall minimize the Radio / Video interference voltage from complete insulator and hardware assemblies when operated at the voltage up to 420 KV.
The arcing rings shall be of such design that when added to suspension and tension assemblies, the resulting flash-over values of the complete insulator string shall not be reduced below the percentage indicated hereunder, of corresponding flash over values with the rings omitted.

The percentages are:
a) Wet 50 Hz: 100%
b) 1.2 / 50 Impulse: 96%

The rings shall be of hot dip galvanized steel or Aluminium tube having outside diameter as required for corona control and minimum thickness of 2.5mm. Both inner and outer surfaces shall be galvanized to the required specifications (BS 729). The details of the rings, brackets and methods of mounting shall be of such design that the rings may be readily replaced under 'hotline' maintenance.

The horizontal distance between corona rings at suspension rings at suspension insulator strings shall be kept as small as practicable to accomplish the required reduction in Radio/ Video Interference (RVI).

All the accessories and the fitting offered against this specification shall be subjected to corona test. The corona shall not take place and shall extinguish at the voltages specified i.e. when a voltage of the specified value applied (Phase to Neutral i.e. RMS) the corona shall appear and shall disappear again at the specified value of voltage.

7.2.13.3 Pollution

The design of insulator units should take into account the principles contained in the IEC 60815 for medium pollution environment. For this project the minimum creepage value of 25mm/kV shall be applied (Creepage distance of 3700 mm).

7.2.13.4 Zinc Collars

The insulator unit cap and pin shall be fitted with zinc-collared pins to prevent cracking due to pin corrosion caused by the effects of pollution and high humidity in the project area.

7.2.13.5 Insulator Protective Device

The design of insulator fittings including corona shields shall comply with the following requirements:

a) Shall effectively protect the insulator unit and fittings from damage caused by power arcs.
b) Shall effectively improve the voltage distribution along the insulator unit;
c) Shall effectively improve the corona performance of the insulator unit.
d) Shall be designed in such a way as not to subject to breakage fatigue due to wind induced vibration;
e) Shall withstand the specified mechanical load
f) Shall be suitable for live line maintenance

7.2.13.6 Materials

The silicon rubber composite insulator shall comply with requirements of IEC 61109. The tension bearing material shall be E-CR Fibre Glass and the housing and sheds made of HTV silicone rubber.
Insulator caps and pin bases of malleable cast iron shall be manufactured from a suitable grade of MCI complying with the requirement of BS EN 1563 for spheroidal graphite or BS EN 1562 for white heart and peralitic.

Insulator end fitting of forged or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS 1472 or BS 1490 and/or BS EN 1676 respectively.
Security 'R" clips shall be of phosphor-bronze composition in accordance with the requirements of BS 2870 and supplied in the half-hard condition with a minimum harness of 155 VPN

Zinc collars shall have a total impurity not greater than 0.05 percent and shall comply with the requirement of BS EN 1179.

All insulator caps, bases and pins shall either be inherently resistant to atmospheric corrosion or a suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in the appropriate grade of stainless steel, shall be protected by hot-dipped galvanising to comply with the requirements of BS 729.

7.2.13.7 Tests

Type, sample and routine tests shall be undertaken on the insulator units in accordance with the IEC 61109.

7.2.13.8 MINIMUM CLEARANCES

Minimum Clearance of Live Parts to towers shall be as per Appendix 9.A.2

APPENDIX 9.A.1
Specifications for the Composite Insulators

No	Specifications	Suspension	Tension
1	Maximum System Voltage (kV)	145	145
2	Pollution Category	Medium Category -II	Medium Category -II
3	Dielectric	Silicon rubber	Silicon rubber
4	One-minute power frequency withstand voltage, 50 Hz, wet. (kV)	275	275
5	Lighting impulse withstand voltage, 1,2/50 pos. (kV)	650	650
6	Power arc current	25 kA, 0.5 sec	
7	Minimum creepage distance (mm)	3700	3700
8	Specified mechanical load, tension (KN)	70	100
9	Minimum Arc Gap (mm)	1250	1250
10	Material fittings	Steel h.d.g	Steel h.d.g
11	Material of rod	E- CR Glass	E- CR Glass
12	Material of housing and sheds	HTV- Silicone	HTV Silicone
13	Socket	IEC 60120/16	IEC 60120/16
14	Ball	IEC 60120/16	IEC 60120/16
15	Arcing Rings material	Steel h.d.g	Steel h.d.g
16	Arcing rings	IEC 61284	IEC 61284

APPENDIX 9.A.2

Minimum Clearances of live parts to towers

The minimum electrical clearances of live parts to earthed structures (Tower) shall be as follows:

Minimum clearances		
a) In still air (vertical position)	:	1350 mm
b) Under 20^0 swing of suspension insulator set or jumper conductors	:	1350 mm
c) Under 40^0 swing of suspension insulator set or jumper conductors	:	1140 mm
d) Under 60^0 swing of suspension insulator set or jumper conductors	:	830 mm

APPENDIX 10.A.2

Minimum Ground clearances of lowest conductor on tower

Above general terrain	7.1m
Above main roads	7.5m
Above other Power lines	3.2m
Above other Telephone lines	3.2m
Above railways	8.5m

7.2.14 TRANSMISSION LINE TOWERS

7.2.14.1 Type of Tower

Towers shall be self-supporting and broad base galvanised steel lattice type with body and hillside extensions. The hillside extensions shall be applied for tower legs on the slope so that legs are suited to the original slope of tower site and also that excessive land cutting around foundations and land collapse is prevented.

The following tower types shall be designed for the project in order to meet various tower positions and loadings economically.

(a) Type-S : Use at tangential positions or angle points up to 2 degrees of horizontal deviation, provided with suspension type insulator sets.

(b) Type-L : Use at positions of light angle up to 15 degrees of horizontal Angle deviation with tension type insulator sets.

(c) Type-M : Use at positions of medium angle up to 30 degrees of horizontal angle deviation with tension insulator sets.

(d) Type-H : Use at positions of heavy angle up to 60 degrees of horizontal angle deviation with tension insulator sets.

(e) Type-HS : Use at positions of specifically heavy angle up to 75 degrees of horizontal angle deviation with tension type insulator sets.

(f) Type-T : Use at positions of line termination or 60 degrees of horizontal angle deviation with tension type insulator sets.

7.2.14.2 Tower design general arrangement

Towers shall have the general arrangements and configurations shown in the drawings included with the specification. They shall be designed to resist the specified ultimate system loading. Clearances between live parts and supporting steelwork and between the phase conductors and ground or other obstacles shall be as specified.

All tower designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

The design shall be such that the number of different parts shall be as few as possible to facilitate transport, erection and inspection. The maximum weight of the heaviest single member should be limited to that within the normal lifting capability of the proposed erection equipment.
Main leg members of lattice steel towers shall be formed of the maximum single lengths appropriate to the body or leg extensions and shall not without the Employer’s approval incorporate additional spliced sections.

For lattice steel towers a fully triangulated system of bracings shall preferably be adopted. If full triangulation is not adopted, the overall stability and secondary bending stresses must be considered in the design.

Where fabrication processes employed adversely affect the material properties, or introduce zones of high stress concentration the overall design of the structures shall take such factors into account.

Cross-arms shall be so arranged that they can be disconnected in the plane of the longitudinal face of the support without disturbing any members forming part of the support body.

The cross-arms should be designed to take and be compatible with the AB CHANCE Live Line maintenance tools and equipment.

Appropriate bird guard protective devises shall be installed to keep away birds from roosting directly over the insulator units.

7.2.14.3 Height of Towers

Height of towers shall be determined in the under-mentioned way:

H = Gc + Sg + Li + Hc + Hg

Where,

H	=	total height of tower
Gc	=	Necessary ground clearance of power conductors above ground or other objectives.
Sg	=	Maximum conductor sag
Li	=	Length of a suspension insulator set, but nil for a tension type towers.
Hc	=	Vertical spacing of upper conductor cross -arm spacing
Hg	=	Vertical spacing between upper conductor cross-arm and overhead OPGW.

Towers shall be provided with body extensions in a 3m step to a standard height for maintaining necessary conductor ground clearance mentioned in *Appendix 10.A.2* on various ground profiles. In addition, in the body extensions, each leg will have hillside extensions in a 1m step to suit for the original ground slope.

7.2.14.4 Design Span

The design of all towers shall provide for the following basic, wind and weight spans:

Type of Tower	S	L	M	H	HS	T
Basic span (m)	350	350	350	300	500	250
Wind span (m)	350	350	350	250	450	250
Weight span (m)	500	450	400	300	300	300
Uplift Weight (KN/Phase)	25	50	60	110	150	250

The term basic span means the horizontal distance between centres of adjacent supports on the level ground which the height of standard towers is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term wind span means half the sum of adjacent horizontal span lengths supported on any one tower.

The term uplift weight means the weights of conductors and overhead OPGW supported upwards at any one tower for reinforcing strength of cross arms.

7.2.14.5 Design Loads

Structural loading shall refer, ASCE Manual and Report on Engineering Practice No. 74 “guidelines for electrical transmission line structural loading”.

The following loads shall be applied in the design of towers:

(a) Wind Loads

- On power conductors and overhead OPGW : 385N/m^2 (on the projected area of conductor or wire)
- On tower structures :690N/ m^2 (on the projected area of structure members)
- On insulator sets : 385N/ m^2

(b) Maximum working Tensions of Conductor and OPGW

- Power conductor Lynx : 22,500 N
- Overhead ground wire OPGW : 14,100 N

(c) Vertical Loads

- Tower structures : actual weights of tower structures including accessories
- Power conductors : Weight of conductors of specified weight span with accessories
- Overhead earth wire : weight of specified weight span with accessories
- Erection Loads : such loads as workers' weights on tower members, reaction of temporarily backstays during stringing operation, etc

(d) Horizontal Angle Effect

-Power conductors and overhead OPGW : horizontal component of maximum working tension of conductors and OPGW due to the specified horizontal angle deviation.

The towers shall be designed for the following wind and weight spars.

Type of tower	S	L	M	H	HS	T
Wind Span [m]						
- Normal working condition [m]	350	350	300	250	450	250
- Broken wire condition [m]	200	150	150	100	300	250
Weight Span [m]						
- Normal working condition [m]	350	400	400	300	550	250
-Broken wire condition [m]	250	200	200	150	300	250
Uplift weight for cross arms (KN)	20	35	50	100	140	250

7.2.14.6 Design Conditions

(a) Assumed Normal Loading Condition:
The assumed maximum simultaneous working loading on towers shall be as follows:

(i) Vertical loads : as above-mentioned.
(ii) Transverse loads : wind loads horizontal angle deviation effects
(iii) Longitudinal loads : wind loads and erection loads but together with maximum working tensions of power conductors and overhead earth wire for their termination for Type-T tower.

(b) Assumed Broken- : Wire Condition

Under the condition, any one power conductor or an earth wire is assumed to be broken at their maximum working tensions in addition to the loads under the normal condition. In the case of Type-S tower, the pull will be assumed to be reduced to 70% of the specified maximum working tensions.

(c) Factor of Safety:

The following factors of safety for tower structures shall be applied in the design.

(i) More than 2.5 for the synthetic maximum load under the normal loading condition.
(ii) More than 1.25 for the synthetic maximum load under the broken-wire condition.

Those factors of safety shall be proved under tower loading tests on the proto-type towers in the manufacturer's testing station, and there should be no failure or permanent distortion during the tests.

7.2.14.7 Design of Towers.

Latticed steel structures shall be designed with geometric configurations based on structural strength, electrical, economic, and safety requirements. Member forces caused by the design factored loads shall be determined by established principles of structural analysis.

Each type of towers shall be designed so that no failure or permanent distortion shall occur when tested with applied force equivalent to 2.5 times the maximum simultaneous working loadings specified in the Clause 10.2.4 [Normal Working Loading] and also equivalent to 1.25 times the maximum simultaneous working loadings resulting from the assumed broken wire condition. Design loads shall consider:

a) Minimum legislated levels
b) Client specifications including factors of safety,
c) Expected climatic conditions,
d) Line security provisions,
e) Design life of not less than 50 years,
f) Construction and maintenance operations.

The ultimate design stress, obtained from the working stress multiplied by the factor of safety of 2.5 under the normal condition and 1.25 under the broken wire condition, in tension members shall not exceed the yield point of materials. The ultimate design stress, obtained from the working stress multiplied by the above mentioned factor of safety, in compression members shall not exceed a figure obtained from an approved formula to be entered in Tender based on the yield point of materials. Alternately, formulas in the American Society of Civil Engineers standard for the design of self-supporting latticed steel transmission structures ASCE 10- 97. Structural loading shall refer, ASCE Manual and Report on Engineering Practice No. 74 guidelines for electrical transmission line structural loading.

Tower design report shall consist of full structural analysis report showing correctness of dimensional detail calculations, tower profile/layout drawings, shop detail drawings, erection drawings and bills of materials. Shop detail drawings shall be approved by the producing utility Engineer of Record (EOR) regarding compliance with the purchaser's specifications and the strength requirements of the design.

Designed tower full size prototype proof test shall be conducted and approved before tower materials shop production and delivery to site.

7.2.14.8 Materials and Fabrication.

The towers shall be fabricated with mild and/or high tensile steel of the finest quality or other approved materials, of which mechanical properties shall comply with Grade Fe 430 and Fe 510 specified in ISO 630-1980 or equivalent.

No member of the tower shall be less than 6mm in thickness and 50mm in width of flange for leg members of towers and main members of the cross-arm, and 5mm and 45mm for the web and nominal members respectively.

The slenderness ratio shall not exceed 150 for the leg and arm members, 200 for the web members and 250 for the nominal members as compression member and 350 for tension only member.

All the connection shall be made by mild and/or high tensile steel bolts and nuts. No bolt shall be less than 12mm in diameter. All bolts and nuts shall be provided with approved spring washers. Antitheft bolts shall be used from ground level to the tower anti-climb level.

Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding diameter of bolts. Holes shall be drilled for the members not less than 13 mm in thickness. For the members having thickness below 13 mm, holes may be drilled or punched, but the former is preferred.

All the steel members should have clearly identifiable part numbers which enable quick identification of similar parts. The letters 'KPLC' should also be inscribed on each bracing- by punching or any other suitable method, with more than one inscription for parts of length greater than 0.5m.

All burs shall be removed completely by reaming and smoothing before hot-deep galvanising.

7.2.14.9 Tower Accessories

The following accessories shall be provided for every tower.

(i) **Anti-climbing device and climbing steps**: All towers will be provided with the anti-climb device on each leg at the height of 3 m to 5 m above the highest ground level at all tower locations. The device installed on the step-bolted legs shall be provided on all towers. Gates shall be designed to open upwards only and shall be secured with galvanised bolts and nuts. No padlocks are required.

Each tower shall be provided with step-bolts of an approved type on diagonal sides of the tower at a spacing no more than 380mm, starting immediately above the anti-climbing device and continuing to the earth wires.

Holes for removal step-bolts below the anti-climbing guards shall be provided at not more than 380mm centres on the step legs.

(ii) **Danger, Number and Helicopter patrol plates**: Danger plate which shows warning sign for tower climbing of other people than maintenance crew will be provided on all towers.

Number plates which show tower number set serially from Narok to Bomet will also be installed on every tower.

On the top of every section tower, and every 10th tower, additional number plates will be provided to aid helicopter patrol over the transmission line. Lettering and size of plates shall be to the Employer's requirements, and should be both sides of the number plate for clear identification when patrolling from either end.

All plates shall be of anti-corrosive material. If enamelled iron plates are used, the whole surface of each plate including the back and edges shall be properly covered and resistant to corrosion. On all plates the colours shall be permanent and free from fading. With enamelled plates, washers or fibre or other approved material shall be provided back and front of the securing bolts.

(iii) **Tower Earthing**: No separate earth conductor from top to bottom of towers is required and earthing continuity will therefore depend on surface contact between bolted members. All structures shall be provided with means for connecting earthing devices at or around nominal ground level, on each leg and for connecting earthwire bonds to each top crossarm or earthwire peak.

Each leg of towers will have an earthing rod underneath its foundation to act as basic grounding required by good transmission line Engineering. Basic grounding shall be constructed in such a way that isolation from the tower and concrete foundation is possible to allow earthing survey if required during line service life.

Maximum earthing resistance of a tower is targeted on 10 Ohms, and in case of higher resistance than 10 ohms, additional horizontal counterpoise earthing system will be added in the ground longitudinally to the line route with more than 50 cm depth. The rate entered in the schedule of prices shall include for all necessary fittings and shall be adjusted at the variation rate for increased or reduced fittings.

(iv) **Aircraft Warning Devices**: Due to the activity of aircraft in the vicinity of certain parts of the transmission line, it shall be necessary to mount warning spheres on earth wires at some locations. Aircraft warning spheres shall be capable of being clamped securely to overhead earth wire. The sphere itself shall be of plastic or fibreglass construction of at least 0.5m in diameter and coloured orange or yellow as required by local regulations. The Contractor is to enter rates against appropriate item in the schedule of prices for the above and he will be advised early in the contract of actual requirements.

(v) **Bolts:** Where appropriate all metal parts hall be secured with bolts and nuts with single spring washers. When in position the bolts shall project through the corresponding nuts by at least three threads, but such projections shall not exceed 10mm. No screwed threads shall form part of a shearing plane between members.

In order to safeguard the tower members from theft; special anti-theft bolts shall be applied from ground level up to 1 metre above the anti-climbing device. The bolts shall be approved by the Employer. The bolts are of the type that shears once the full torque has been applied.

The nuts of all bolts attaching phase conductor insulator set, earth wire sets, maintenance brackets/plates shall be locked in an approved manner preferably by locknuts.

The bolts of any one diameter in a tower shall be one grade of steel. Leg members shall be joined in such a way that electrical continuity is maintained to ground.

(vi) Rectangular and Auxiliary Cross Arm

The type H, HS and T towers may be provided with rectangular arms where horizontal angle exceeds 45 degrees.
The prices of the rectangular arm set shall be included in the prices for the towers.

(vii) Spare Towers

Three sets of spare suspension tower shall be provided, and one set each for section and angle towers used in the line. Spare web bracings shall also be provided, sufficient for five (5) standard towers up to the anti-climbing device level.

7.2.14.10 Materials

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate, unless otherwise specified and shall be suitable for all the usual fabrication processes, including hot and cold working within the specified ranges.
The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, laminations, segregations and other defects. There shall be no rolling laps at toes of angles or rolled-in mill scale.

Unless specified to the contrary the following grades of steel shall be applicable for tower design:

a) Mild steel shall be either grade S235JRG2 or S275JR.

b) High tensile steel shall be grade S355JR for sections less than 20 mm thick and S355JO for sections greater or equal to 20 mm thick, except for plates which shall be greater or equal to 40 mm thick.

7.2.14.11 Workmanship

All steel lattice members shall be cut to jig and all holes in steelwork shall be drilled or punched to jig. All steel parts shall be carefully cut and holes located so that when the members are in position the holes will be opposite each other before being bolted up. The drilling, cutting, punching 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 structures on site. High tensile steel members shall be bent hot. Care shall be taken not to punch holes too close to the edge of members.

Means shall be provided to enable the Employer to carry out such checking of members, as he may consider necessary. Built-up sections, when finished, shall be true and free from all kinks, twists and open joints and the materials shall not be 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 or crossarm shall be selected at random and assembled to form complete latticed supports or cross-arms in the presence of the Employer representative at the manufacturer's works.

7.2.15 CIVIL WORKS FOR TRANSMISSION LINE

7.2.15.1 FOUNDATIONS

7.2.15.1.1 General

Concrete pad and chimney type foundations will be applied to most of the towers, the design of the concrete foundations of the towers shall be performed based on the requirements and assumptions set out below, and the details of the design and drawings for each type of foundations shall be submitted with the Tender.

Such design of foundations for the towers are subject to modifications to suit the site conditions as indicated in writing by the Engineer during execution of the Contract without any price adjustment of the items of the foundation stubs.

7.2.15.1.2 Concrete Block Foundation

The types of the concrete foundations and natures of earth to be considered shall be as follows:-

Types of concrete foundation Assumed natures of earth yield bearing capacity		L	M	H
- Vertical	[ton/m^2]	60	40	20
- Lateral	[ton/m^2]	30	20	10
Mass	[kg/m^3]	1,600	1,500	1,400
Angle of frustum	[degree]	30	20	10

All Structural Concrete shall be reinforced with steel bars to structural design details. Deformed steel bars are preferable for the reinforcement.

The abbreviations L, M and H of the concrete foundation types shall mean as follows: -

L : Light concrete foundation
M : Medium concrete foundation
H : Heavy concrete foundation

The angle of frustum of earth shall mean the angle vertical of earth frustum to resist the uplift force.

Natures of concrete to be considered shall be as follows: -

<u>Assumed natures of concrete</u>

Allowable strength:		
-Compressive	[kg/m^2]	60
-Tensile	[kg/m^2]	6.0
-Shearing	[kg/m^2]	6.0
Mass:		
-Concrete without reinforcement	[kg/m^3]	2,300
-Concrete with reinforcement	[kg/m^3]	2,400
Allowable strength on:		
-Galvanized steel action	[kg/m^2]	3.6
-Round reinforcing bars	[kg/m^2]	7.2
-Deformed reinforcing bars	[kg/m^2]	12.0

Each type of foundation shall be designed based on the following formula:

[1] Against compression load

$$\frac{q}{F} \geq \frac{C+G+Ws}{A}$$

Where:	q	:	Yield bearing capacity of earth [ton/m^2]
	F	:	Factor of safety
	C	:	Compressive load [ton]
	G	:	Weight of concrete [ton]
	Ws	:	Weight of earth above foundation pad [ton]
	A	:	Area of foundation pad [m^2]

[2] Against uplift load

$$G + \frac{Ws'}{F} \geq T$$

Where,	T	:	Uplift load [ton]
	Ws'	:	Weight of earth in frustum [ton]
	F	:	Factor of safety

[3] Against lateral load

$$\frac{q' \times A'}{F} \geq Q$$

Where,	Q	:	Horizontal load [t]
	q'	:	Yield lateral bearing capacity of earth [ton/m^2]
	A'	:	Projected area of foundation chimney and pad [m^2]

The factor of safety shall not less than 2.5 under the normal working conditions and 1.25 under the broken wire conditions.
The upper surfaces of the foundation pads shall be reinforced and sloped within 45 degrees to the horizontal. The minimum thickness of the edges of base pad shall be not less than 300mm.
The frustum shall be assumed to start from the top edges of the pad. Where frustums overlap each other, allowance shall be made for loss of uplift resistance.

Concrete shall cover any part of the top steelwork by at least 100 mm and shall extend above the ground for the minimum height of 350 mm. Additional 500 mm minimum chimney extension shall be provided to foots on lower side in sloping areas. The upper surface of chimney shall be sloped to ensure drainage of water.
The cleats shall be attached by bolting at the base of each stub to assist in transfer of leg load to the foundation pad. Minimum portion of stub loads in the design of cleats shall be assumed as 50 per cent.

7.2.15.1.3 Special Foundations

Besides the above mentioned concrete foundations, special foundations such as raft type foundation, rock anchor, piled foundation or others may be required. Final type of foundation to be applied for each tower shall be determined in accordance with results of soil investigation performed by the Contractor during route survey and soil investigation.

For the purpose of tendering, basic designs shall be submitted with the tender under the following assumptions, and prices for the special foundations shall be quoted based on the design.

[a] Raft type foundation

The foundation shall be designed with the following specifications: ultimate bearing capacity of 10ton/m^2, soil weight of 1.4 ton/m^3 and no angle of frustum of soil. Weights of reinforced concrete and soil shall be taken as entirely submerged. Other design conditions specified in this subsection will be applied.

[b] Piled foundation

Piles used for the foundation shall be either pre-casted concrete pile with circular or square cross section or in-situ concrete pile.

[i] Pile data

Pile diameter or dimension

- Circular cross section	-	Φ300 mm.
- Square cross section	-	300 x 300 mm
-Pile depth below ground level	-	12 m
-Ratio or ultimate bearing/uplift capacity of pile	-	2.5: 1

[ii] Uplift

The mass density of concrete below ground level shall be assumed as 1,600 kg/m^3 to allow for hydrostatic effects and similarly soil as 960 kg/m^3. Additional weight of concrete shall be included as necessary to provide the specified resistance to uplifting under any condition. Where bored or driven piles are proposed having no specially made bulb or enlarged concrete foot to provide positive uplift resistance but relying on skin friction alone, at least 75% of the networking uplift force, and 50% of the net broken wire uplift force shall be provided in dead weight of concrete, whichever is the greater. The cost of such concrete shall be included in the piled foundation rate.

[iii] Compression

Mass density of concrete shall be assumed as 2,300 kg/m^3 on their technical acceptability and cast.
Contractors must justify assumptions of equal performance of their piling system with that proposed. No extra payment shall be made for access tracks necessary for heavy piling rigs.

Piles shall be embedded in a reinforced concrete cap of adequate dimensions and the caps tied with nominal reinforced concrete beams of a minimum size of 460 mm deep by 300 mm wide with at least eight 19 mm diameter main reinforcing bars per beam.

Piling shall be carried out using an approved procedure throughout. The actual length and numbers of piles required at any given location shall be approved by the Engineer on the basis of the final agreed design data.

[c] Other Foundations

Where special ground conditions exist which do not allow for any of the above designs in an original or modified, special types of foundations may be employed. They will be paid for on basis of submitted rates schedule for concrete, steel and excavations applying throughout, irrespective of special conditions.

Tower prices shall cover for all costs not covered by special scheduled rates where admissible including the provision of access tracks and standings for piling equipment or building of bund for the Contractor's convenience in paddy fields or other flooded areas.

7.2.15.2 Foundation Works

7.2.15.2.1 Soil Investigation

The Contractor shall make tests of subsoil conditions at every tower site by means of an approved simple hand-operated borer [sampling] and sounding tool, and indicate results on the approved soil test sheets together with ground water levels and proposed foundation type to be applied at the tower position.

The Contractor shall obtain the Engineer's approval for the foundation type in advance of the foundation works at each tower site. Particular note is to be made where any poor ground is encountered likely to require special foundations. The test results shall show firm evidences to prove reasons why the proposed type of foundation is selected from the specified foundation types. The cost of the sub-soil tests is deemed included in the rate for foundation work.

The Engineer may request the Contractor additional sub-soil tests at the bottom of excavated pits, if the Engineer judges its necessity for further confirmation on the proposed foundation types. The sub-soil tests shall be done at the earliest stage of the filed works to the urgency of having tower stubs and templates on site in order that foundation works can proceed with a minimum of delay. BS5930, soil investigation code will apply as a technical guide for reference.

7.2.15.2.2 Excavation and Backfilling

Where angle towers are fitted with unequal length cross arms at each side of the tower, the tower center shall be offset to ensure that conductors are located as near as possible equidistant either side of the route centerline in adjacent spans.

The Contractor shall ensure that excavations are made to the correct depth and width. If excavations are taken deeper that the designed dimension the excess depth shall be backfilled with concrete at the Contractor's expense. If excavations are made wider than the designed dimension, such modifications to the design as the Engineer may require shall be made at the Contractor's expense.

For uplift foundations, undercutting or other approved method shall be applied as far as possible for allowing upward bearing of the foundation pad against undisturbed soil for a minimum width of 250mm all around. Alternatively the concrete pad shall be cast to the edge of the excavation for a minimum height of 250 mm in order to gain assistance by adhesion to the original ground. In cases where the concrete block is cast in undercutting, the earth frustum assumed to resist uplift shall be considered to start from the bottom of the vertical edges of the block. Otherwise, the frustum shall be assumed to start from the upper top of the block edges.

The backfill of all types of foundations shall be thoroughly rammed with mechanical rammers, and the ramming shall be carried out at intervals of not greater than 300 mm to ensure thorough consolidation of the backfill as the Engineer requires.

Foundation Concrete faces shall be painted with an approved bituminous paint to separate backfill from concrete before backfilling.

In no circumstances shall peat, black Cotton soil or equivalent materials be used as backfill for foundations. Where excavations are made in peat ground, backfilling to be foundations shall be made with a suitable soil or hardcore from an approved source at the Contractor's expense. Backfill shall be finished in such that the original ground contours are restored as nearly as possible, any subsidence of backfill shall be made good before the issue of the Taking-Over Certificate.

7.2.15.2.3 Stub Setting

Stubs for tower foundations shall only be installed with the use of templates or by use of the lower sections of the tower with the suitable temporary bracings to ensure correct spacing. The stub setting templates shall be of approved type with sufficient rigidity to ensure correct setting of the stubs. The method selected shall be such that all four stubs are supported and interconnected by a rigid steel framework. The main members of the templates must be in the position by the template while the concrete is placed. The templates are not to be removed until at 48 hours after the foundations have been completed and backfilled.

The templates shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross-section, and shall be equipped with central alignment notches or holes, corner braces, riser-braces, and stub angle bolting legs to permit the accurate setting of stubs in respect of the following requirements:

a) Longitudinal centreline
b) Tower lateral centreline
c) Stub elevations [with reference to datum]
d) Stub levelling
e) Inclinations of stubs
f) Stub hip bevels
g) Spacing between stubs

No concrete shall be started before the stubs are confirmed to be in the design positions.

7.2.15.2.4 Concrete Works

[a] Concrete for concrete foundation and pile shall have the minimum required breaking strengths as specified in the technical schedules. BS 5328 will refer when specifying concrete and BS 8110 in reference to structural use of concrete

[b] Cement used shall be Portland with minimum strength of 42.5 KN/m^2 or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS-12.

[c] Aggregates shall be clean and free from dust, earthy or organic matter or salt. Coarse aggregate shall be approved grading to be retained on a mesh not less than 5mm square, and of a maximum size to pass a mesh not more than 40 mm square. Where specially approved in writing by the Engineer, coarse aggregate of uniform size which will pass a 25mm mesh may be used throughout. Fine aggregate shall be river sand and shall be coarse, sharp, clean and fee from dust, salt, clay, vegetable matter or other impurity and shall be screened through a mesh not more than 5mm in the clear. It shall be well graded mixture of coarse and fine grains from 5mm gauge downwards. Aggregates shall conform in all ways to BS812 and KS 95:2003.

[d] Water shall be clean and free from all earth, vegetable or organic matter, salt, soil, oil, acid and alkaline substances either in solution or in suspensions. Quality shall be confirmed by lab test.

[e] At least four weeks before commencing any concreting work, the Contractor shall make trial mixes using samples of cement and fine and coarse aggregates.
The test specimens for the trial mixes shall be of cube type. Preliminary test specimens shall be taken from the proposed mixes as follows:
For each proposed mix a set of 6 specimens shall be made from each of 3 consecutive batches. Three from each set of six shall be tested at an age of seven [7] days and three [3]

at an age of 28 days. The test shall be carried out in an approved laboratory.
Neither the mix proportions nor the source of supply of materials shall be altered without the prior approval of the Engineer except that the Contactor shall adjust the proportions of the mix as required, to take account of permitted variations in the materials, such approval shall be subject to the execution, to the Engineer's satisfaction, of trial mix procedures set out herein.

[f] Where directed by the Engineer concrete cubes are to be taken and tested to verify the concrete strength during site concreting works. The Contractor shall provide the cube molds at site for the purposed, accordingly. The test specimens shall be 150 mm cubed and the mold shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mold shall be provided with the metal base having a smooth machined surface. The interior surfaces of the mold and base should be lightly oiled before concrete is placed in the mold.

[g] The cost of concrete testing shall be deemed to be included in the Contractor's general schedule rates. Testing Lab shall be approved

[h] Requirements for testing concrete samples during construction are set out in Clause 11.8.

[i] The concrete shall thoroughly wetted before backfilling commences. When shutters are to be struck, backfilling of excavation is not to take place immediately, and the concrete shall be kept continuously moist to avoid rapid drying.

[j] In the event that the Contractor proposes to use ready mixed concrete for foundation work, approval must first be obtained from the Engineer, who will inspect the batching plant and cement, sand and gravel used for concrete. No ready mixed concrete shall be used in foundation work if it has been mixed in the lorry during its journey for more than 45 minutes. At the discretion of the Engineer, ready mixed concrete may be used in foundations in excess of 45 minutes journey, if the cement is added to the drum at site and is thoroughly mixed prior to placing, or alternatively if the ready mixing lorry carried its own drum during the lorry's journey and not mixed for more than 45 minutes prior to placing. The Engineer's decision to reject any of the above methods of supplying ready mixed concrete shall be final.

[k] Throughout the line route, the Contractor shall at regular intervals and at the time of survey, obtain samples of subsoil and ground water, which he shall have analyzed to ascertain if any agents be present which may have an adverse effect on concrete made with normal Portland cement. The analyses shall be forwarded to the Engineer without delay together with any recommendations for the use of special cement. The Engineer's decision as to the type of cement to be used will be final. The cost of obtaining soil and ground water samples is deemed to be included in the Contract Price. The cost of any special cement used will be paid at an appropriate rate to be agreed with the Engineer.

[l] Concrete shall be placed immediately after mixing. All concrete shall be thoroughly compacted by vibration during the operation of placing, and shall be free from honeycombing and other defects. The upper surface of the concrete for all types of foundations shall be finished smooth and sloped in an approved manner to prevent accumulation of water. A concrete addictive of a type approved by the Engineer may be used.

7.2.15.2.5 Piling and Other Special Works

Pilling will be carried out using an approved procedure throughout. The actual length and numbers of piles required at any location will be approved by the Engineer on the basis of the final agreed design data and payment made for departures from the assumed tender design quantities on the basis of the difference of quantities times the Schedule variation rates. Piles shall be tested in accordance with Clause 11.8. Tender Prices shall include for all necessary casings, pumping, and depreciation of piling machines, materials, transportation, testing and others.

Where special ground conditions exist which do not allow for any of the designs in an original or modified form, special types of foundations may be employed which will be paid for on the basis of schedule rates submitted. To this extent the submitted schedule of rates for concrete, steel and excavations shall apply throughout irrespective of special conditions.

7.2.15.3 Erection of Towers

Where tower members arrive on site with slight distortions due to handling in transit, they shall be straightened by the Contractor using approved means and offered to the Engineer for inspection and acceptance or rejection before erection commences.

In general, towers shall be assembled and erected with bolts finger tight only. Final tightening of bolts shall only take place when all members are in place. As far as practical, bolts shall be inserted with the nuts facing outwards or downwards.

Whenever wire slings or ropes are liable to abrade tower members, the members shall be suitably protected by heavy Hessian bags or strips, or by some other approved means.

The Contractor shall make use of temporary struts on panels prior to lifting, if in the opinion of the Engineer, there is likelihood of damage occurring to that panel during lifting. Where derricks are used for lifting panel they shall be securely guyed and shall be supported only at approved locations on the legs.

All towers shall be vertical under the stress set up by the completed overhead line to the satisfaction of the Engineer. The maximum acceptable deviation form vertical shall normally be 1%.

Proper precautions shall be taken to ensure that no parts of the towers or supports are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.

Suitable ladders shall be used whenever necessary during erection, but such ladders and removal step bolts shall be removed when erection work is in progress.

Before assembly of members, joints shall be free of all earth, or any other substances which might prevent the correct alignment of members. After erection, all materials shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads. Approved equipment shall be used for tightening the shear bolts which will be used from ground level up to one metre above the anti-climbing devices. After erection, the rest of the bolts up to the bottom cross arm shall have the threads smashed in an approved manner to prevent unauthorized removal.
Damage to the galvanised surfaces of bolts, tower steelwork or smashed bolts shall be repaired using zinc rich paint or similar and the cost of such repair is deemed to be included in the appropriate rates.

The Contractor must ensure that tower erection, steel handling and operation of equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as the public.

Lower parts of towers erected in the submerged area during wet seasons shall be protected from corrosion with an approved paint as ordered by the Engineer. The cost for the paint shall be quoted in the Price Schedule.

7.2.15.4 Grounding of Towers

Before placing foundation concrete, basic grounding earthing rods specified in Clause 11.8 shall be erected to each foundation cleats. Installation shall ensure that earthing can be isolated from the tower and concrete foundation to allow earthing survey. Measurement of footing resistances of all towers shall be carried out with an approved instrument before stringing of an overhead OPGW. A target value of the resistance is less than **10 ohms**. The Contractor shall report the measured value in an approved form to the Engineer. The Engineer will instruct necessitate of installation of counterpoises to the Contractor who shall then provide the counterpoises as specified in the Clause 11.8 to the instructed towers and measure the resistances for reporting the Engineer. In case the resistance is still high, the Engineer may order the Contractor to install additional counterpoises.

7.2.15.5 Stringing of Conductor And OPGW

a) The fullest possible use shall be made of the maximum conductor lengths in order to reduce the number of joints to the minimum. The number and location of conductor and overhead OPGW tension joints shall be approved. Tension joints shall not be less than 15m from the nearest clamp.
b) Unless the Engineer agrees to the contrary, midspan joints shall not be not used-
   (i) at locations which would allow less than 3 clear spans between mid-span joints on a given conductor and wire
   (ii) in spans crossing power lines, telecommunications lines, public roads or buildings, and
   (iii) in single span sections.
c) Conductor repair sleeves shall not be used without the permission of the Engineer, which will be granted only in exceptional circumstances.
d) Conductor and OPGW stringing shall be carried out entirely by tension stringing methods and the Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment which he intends to use. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required to install all conductors and OPGW shall be continuously controlled.
e) The conductor and OPGW tension during stringing operation shall be kept as low as possible, consistent with keeping the conductor and OPGW clear of the ground whilst in motion. At no time will the tensions be allowed to exceed 75% of the final tension.
f) All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.
g) Conductor and OPGW drums shall be securely anchored during the stringing operation and drum jacks shall be of the self-braking type to prevent conductor over run.

h) Conductor an OPGW pulling shall be such as will ensure a continuously steady pull. Every precaution is to be taken to prevent damage to the conductor and OPGW. Clamps and other devices used for handling conductor and OPGW during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor and OPGW Grooves in sheaves and tensioners shall be lined with neoprene or rubber. Sheaves shall have an electrical conducting path between their suspension points and the conductor supported within them and shall run with minimum friction.
i) Conductor and OPGW shall be effectively earthed in an approved manner during running out and at all places where men are working on them.
j) At least three months before stringing commences, the Contractor shall give due to consideration to all the factors involved and submit to the Engineer for approval a fully detailed stringing schedule stating locations of conductor and OPGW drums, winch operation for stringing and the proposed positions of mid-span joints, together with temporary staying wires of towers and all other relevant information.
k) Conductor and OPGW drums shall be closely examined before conductor pulling commences and all nails and other things which could damage the conductors and OPGW shall be removed. During stringing, the conductor and OPGW drums are to be supervised at all times and the conductor and OPGW shall be inspected for defects while it is being pulled off the drums. Any damage caused to conductors or OPGW shall be reported to the Engineer whose decision to replace or repair will be final.

l) Conductors and OPGW shall be carefully regulated to the correct prestress and initial tensions by a measurement of sags. Ambient temperature shall be measured by a thermometer suspended on the tower at the sag measurement position. Making for and application of anchor clamps shall follow regulation to initial tension without delay. Immediately after regulation and clamping has been completed in a section, the sag of conductors and OPGW shall not depart from the correct value by more that $^{+}/_{-}1.5\%$. Suspension insulator sets shall be installed so that clamps are within 20mm of their correct position on the conductor.
m) The insulators strings shall be cleaned and inspected before assembly. Any defective insulator be shall be removed from site forthwith. Insulators have the security clip, cotter pins and other locking devices fully in place and shall be erected in a manner avoiding damage to the sheds, fibre-glass rod or locking devices.
n) Where required by the Engineer, the Contractor shall check prior to the issue of the Taking-Over Certificate that the sags of conductors and OPGW in selected spans are within the specified tolerance, and shall make any adjustment necessary to ensure compliance.
o) Joints, clamps, etc. shall be applied using the approved tools and in such a manner that no bird-caging, over-tensioning of individual wires or layers or other deformation or damage to the conductor and OPGW occurs. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands.
p) Compression fittings shall be applied only by linemen approved by the Engineer, using approved methods. The outer surfaces of conductors and OPGW and the interiors of compression sleeves shall be scratched-brushed immediately before assembly.

q) After conductors have been made off and landed, stringing sheaves shall be removed and suspension clamps and vibration dampers shall be fitted with minimum delay. Suspension clamps shall be fitted with due regard to offsets where appropriate, and the conductor and OPGW shall be cleaned before the clamp is assembled.

r) The Conductor shall keep a record of all sagging showing details of the section, the sagging and checking spans, ambient temperature, pre-stress, initial and final sags, the date of sagging and clipping-in offset, etc. This record shall form part of the final records for the line and shall be handed over to the Engineer prior to the issue of taking-Over Certificate. The records shall be available for inspection at any time.

7.2.15.6 Tests at site

[1] General

Following investigations and tests shall be carried out by the Contractor, when ordered by the Engineer.
Those investigations and tests as mentioned in the Price schedule will be paid for at the rates entered. Other investigations and tests not scheduled in the Price Schedule shall be deemed to be included in the prices of the relative items of the works.

[2] Ground Prove Tests

Tests by means of an approved type of penetrometer or other approved means shall be carried out during the check survey as provided for in Clause 11.4. Results of these tests shall be submitted to the Engineer on an approved form giving a preliminary indication of the ground bearing properties and water levels, etc. Bore penetration shall be at least 9m below ground level in poor ground.

[3] Laboratory Soil Tests

Where ordered by the Engineer, the Contractor shall obtain soil samples and submit these for tests to an approved laboratory to determine the necessary properties of the soils for the purpose of foundation designs. Such information shall be detailed in an approved manner and conclusions given as to the recommended bearing pressures to be adopted. Tests shall be carried out generally in the manner described in BS-1377

[4] Ground Bearing Test

Where ordered by the Engineer, the Contractor shall carry out ground bearing tests to determine the ground bearing capacity, by means of loading a 300 mm square plate in an approved manner. Tests shall be carried out generally in the manner described in BS-5930.

[5] Pile Bearing and Uplift Tests

Where ordered by the Engineer, the contract shall carry out pile bearing and uplift tests for all types of pile generally in accordance with the method given in the BS CP-2004. Such tests shall be carried out to determine the ultimate uplift and bearing values.

[6] Foundation Loading Tests

Where ordered by the Engineer, foundation loading tests shall be carried out in full scaled individual footings.

(7) Records of Site Investigation Tests

All records of site investigation tests shall be detailed in an approved manner. Sample log sheets, charts, etc. shall be submitted to the Engineer for approval before any investigation commences. All site investigation data, charts, etc. shall be handed over to the Engineer in triplicate upon satisfactory conclusion of the tests, and before the issue of Taking-Over Certificate.

Where the Contractor carried out other tests at his own expense, not ordered by the Engineer, and to the contrary, where the Employer had independent tests made along the route of the line, such information shall be made available to the Contractor.

[8] Concrete Tests

The Contractor shall carry out tests on sample of concrete from the foundation works, as required by the Engineer as specified in Clause 11.4. The test specimens shall be stored at the site at a place free from vibration under damp sacks for 24 hours. They shall be then removed from the moulds, marked and stored in water at a temperature between 10^0 C and 21^0 C until the testing date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in a damp sand, or other suitable damp materials, and shall be brought in the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the time of the test.
The results shall be handed in triplicate to the Engineer, as soon as possible after testing, and not later than seven days.

[9] Support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the stringing operation of overhead earthwire, as specific in Clause 11.6. The placing of tests electrodes shall normally be along the center line of the route in such direction as to ensure that the lowest resistance to earth is recorded, and a note shall be made of the direction in the time of the test.

[10] Additional Footing Resistance Test

If in the opinion of the Engineer, it is necessary to reduce the tower footing resistance by means of counterpoises, the Contractor shall make further measurement after the additional counterpoises have been carried out before the stringing operation of the overhead earth wire. Any further measurement shall be carried out as necessary without extra charge.

[11] Measurement of Galvanising Thickness

The Contractor shall have on site an instrument suitable for accurate checking of galvanizing thickness for the Engineer's use. The gauge shall be available from time of arrival of the first consignment of steel work until the issue of Taking-Over Certificate. The cost of the gauge and other operating expenses shall be deemed to be included in the contract price and the gauge shall remain the property of the Employer.

[12] Testing of Rock Anchors

Where rock anchor foundations are used in hard rock, as provided for by the Engineer's order, the Contractor shall test individual anchors by tensile test loading to failure for obtaining design data of the foundations. **The test shall be considered satisfactory if the steel bar fails by yielding at or above its ultimate strength**.

Anchor for the testing shall be installed away from permanent foundation anchors but in the same rock. The frequency of the test shall depend upon the different types of hard rock encountered and the number of tests performed shall be such as to give confidence in the employment of rock anchor foundations and experience of the type of rock suitable for their use. The frequency of test shall, in the case of dispute, be reasonably determined by the Engineer. Tests shall be carried out generally in the manner described in BS-8081 on ground anchorages.

The cost of tower test shall be included in the relevant schedule rates.

[13] **Test on Completion**

The line shall be energized at full working voltage before handing over, and the arrangement for this and such other test as the Employer/ Engineer shall desire to make on the completed line shall be assisted by the Contractor who shall provide such labour, transport and other assistance as required without extra charge.

7.3 OPTICAL FIBRE GROUND EARTH WIRE (OPGW)

7.3.1 TECHNICAL DESCRIPTION

The overhead earth wire shall be Fibre Optic Ground Wire (OPGW) with at least 48 (forty-eight) single mode fibre optic cores and a maximum of 96 cores

The fibre optic earth wire supplied shall be suitable for installation on transmission line and shall be supplied complete with all necessary fittings and optical joint boxes. The OPGW fittings and optical joint boxes shall be type approved.

The fibre optic earth wire shall comprise an optical sub-unit containing optical fibres over which shall be laid aluminium, aluminium alloy or aluminium coated steel strands.
The clad steel wire incorporated in fibre optic earth wire shall comply with the requirements of IEC 61232. Shaped aluminium or aluminium alloy wire sections shall conform to the requirements of the appropriate IEC standard.

The optical sub-unit shall withstand the temperature rise associated with the specified lightning fault current flowing in the earth wire without damage. The fibre optic earth wire (OPGW) shall be manufactured in continuous lengths of not less than 2,000 m.

The overall system design of the fibre optic system shall meet the following minimum requirements:

a) Single failure or degradation in any optical fibre not more than one year averaged over five years;
b) Failures or degradations affecting more than one optical fibre, not more than one in ten years;
c) Increase in optical system transmission attenuation due to accumulated ageing and other effects at the end of five years and not more than 0.05 dB/km.

7.3.2 Optical Fibres

Optical fibres shall be single mode fibre and shall conform to IEC 793-2-BI.

The fibre coating material shall be mechanically strippable. The optical fibres shall be capable of being jointed by fusion technique.
There shall be no measurable long term or short-term optical attenuation change due to the temperature rise associated with a fault current flowing in an earth wire, or a lightning strike on the earth wire.

7.3.3 OPGW Fittings and Accessories

The fibre optic earth wire shall be with approved conductor fittings and accessories. The application of these fittings and accessories shall not damage the earth wire or fibres, either mechanically or optically.
Contractors shall provide detailed specifications for all types of cable fittings and accessories (anchor and suspension spirals, vibration dampers, earth connections and clamps, etc.) used in the installation of the OPGW.

Optical ground wire suspension and tension assemblies shall be based on pre-formed spiral armatures according to the OPGW cable manufacturer's specification so as to assure the required minimum bending radius of the ground wire and to avoid concentrations of mechanical stresses applied to the cable.

The suspension assemblies (armor grip suspension) shall be based on helical rods made of high-tensile, corrosion-resistant aluminium alloy. For the tension assemblies the helical rods shall be of aluminium clad steel for the ACS type OPGW.

It is understood that all other small parts, for fixing the OPGW along the tower structure from the earth wire peak up to the OPGW joint box and cable accessories are supplied under the contract.
The manufacturer of the spiral armatures shall have experience of at least 5 years successful production of the offered type of fittings and accessories.

7.3.3.1 Optical Joint Boxes

Optical joint boxes shall be provided to protect the splice joint of optical fibres, either when individual lengths of the fibre optic OPGW, are jointed or between the fibre optic earth wire and the underground fibre optic cable.

The joint boxes shall consist of external steel or die cast aluminium housing providing protection to IEC 529 IP 44 and an internal die cast aluminium or high impact plastic ABS box to IEC 529 IP54

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.

7.3.3.2 Fixing Clamps

A bolted clamping system shall be used to attach the OPGW to the inside of the support, without drilling or modifications to the support steel work.

The attachment clamps shall be capable of being attached and detached from the support, without affecting the OPGW.

7.3.3.3 Non – Metallic Underground Fibre Optic Cable and ODF

The fibre optic cable shall be circular in cross section and shall be designed so that any cable strain is not directly imported on the optical fibres. The cable shall not include any metallic components to prevent high-induced voltages when used in switching or substation compounds.
The underground fibre optic cables to be provided and installed between the splice boxes at the substation gantries to the optical fibre distribution frame (ODF) installed inside the telecommunication room at the substation control buildings shall be suitable for laying indoors, outdoors (direct or indirect sunlight), in ducts, on trays, underground and in water. The cable sheaths shall be resistant to solar radiation, the effect of oil, bacterial action, insects and rodents. Cable entries shall be protected against insects and rodents.

The optic distribution frame (ODF) shall be equipped with low loss optical connectors (< 0.3 dB including the loss in the bulk head, loss in the connector splice & the loss in the pig tail) of the screw-on type. Auxiliary connectors shall be provided to facilitate testing and maintenance of the fibres/equipment. All spare fibres shall be properly terminated and spliced on connectors of the same type within the frame.

7.3.3.4 Materials

7.3.3.5 Fibre optic earth wire materials

External aluminium, aluminium alloy or aluminium coated steel strands.

7.3.3.6 Optical Joint boxes

Optical joint boxes shall be made from either a suitable grade of aluminium alloy complying with the requirements of BS 1490 and / or BS EN 1676 or steel complying with requirements of BS 3100

7.3.3.7 Fixing Clamps

Fixing clamps shall be made from a suitable grade of aluminium alloy complying with the requirements of BS 1490 and / or BS EN 1676. Bolts shall be made from mild steel grade S275JR to BS EN 10 025. Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall unless otherwise specified be threaded ISO Metric Coarse Pitch to BS 3643: Part 2, Tolerance Class 7h/8g.

7.3.3.8 Protective Treatment

7.3.3.9 Fibre optic earth wire

Where two layers of wire strands are provided over the optical sub-unit, the external surface of the optical sub-unit and the inner strand layer shall be greased, using approved conductor grease.

7.3.3.10 Ingress of Moisture

The cable shall be capped before shipment to prevent the ingress of water.

7.3.3.11 Optical Joint boxes

Optical joint boxes (steel exterior) shall be hot dipped galvanised after manufacture to meet the requirements of BS 729.

7.3.3.12 Installation

7.3.3.13 General

The supplier of the OPGW shall be responsible for the supervision of installation by the Contractor; to ensure that system reliability requirements are met.

7.3.3.14 Workmanship

The Contractor shall ensure that the fibre optic cable are not strained or damaged either mechanically or optically during stringing and/ or jointing.

7.3.3.15 Fibre Optic joints

Optical fibre joints in the OPGW, or between the OPGW and the non-metallic underground fibre optic cable, shall be housed in optical joint boxes. The joint boxes shall be located immediately above the anti-climbing device for convenient access by technical personnel. All joint boxes shall be earthed to the support steel work using approved multi-wire / multi-strand flexible aluminium earth bond.

7.3.3.16 Terminal Equipment

7.3.3.16.1 SDH Multiplexer for STM-1/4

The existing SDH STM-1/4 optical terminal Communication equipment in Substations where line bays are to be constructed shall be adapted to accommodate the telecommunication requirements for the new 33/ 66/132kV lines in the definite scope of work.

The existing SDH STM-1/4 equipment shall be equipped with all necessary hardware and software configurations for provisioning of line tele-protection, SCADA and Voice communication.

7.3.3.16.2 Remote Terminal Units.

Substation Control and Monitoring System (SCMS)/SCADA shall be installed at the Substations for purposes of Supervisory of the Substation as well as the Control of the substation Equipment (where SCMS exists either at Narok or Bomet or both stations, interfacing with the existing unit shall be done if spare capacity exists. If no spare capacity is available, a new unit shall be installed)

7.3.3.17 Scope of Work

The Contractor shall include detailed system design, manufacture, supply, installation, testing, commissioning, remedying of defects, maintaining the works during the defects liability period and any incidental work necessary for the proper completion of the work in accordance with this contract.

Detailed requirements are as follows: -

- System design – The system design and preparation of Contractor's drawings for approval of the Engineer
- Supply and installation of suitable lead in cables (includes but not limited to; fibre optic patch cords, Ethernet cables and tele-protection interfacing cables) to the equipment terminals
- Supply and installation of SFP modules and tele-protection interfacing cards on the existing SDH equipment in definite the definite scope of substation and Lines
- Supply and installation of supervisory management system (SCMS)/SCADA and cabling to the relevant distribution frame (s). Where SCADA exists at either or both stations, interfacing with the existing unit shall be done if spare capacity exists
- Multiplexed signals for permissive and direct inter-trips for 66 and 132 kV Lines.
- Testing and commissioning of the telecommunication and SCADA systems up to the terminal equipment and integrating stations

7.3.4 Quality Control

7.3.4.1 Types of Tests

Type, sample and routine tests shall be undertaken on the OPGW, their associated fittings, non-metallic underground fibre optic cable and optical fibres in accordance with the requirements of specification, CCITT G652, IEC 793 and IEC 794 as appropriate.

7.3.4.2 OPGW Tests

a) Fatigue

The Contractor shall submit documentary evidence to show the fatigue life of the OPGW including that of the optical sub-unit compared to that of a conventional conductor of similar characteristics. e.g. diameter, mass, stranding etc.

b) Stress-Strain

A sample of OPGW not less that 10m length, complete with the proposed end fittings shall be subject to a stress-strain test. The test shall be undertaken in accordance with IEC 1089 Annex B and the measuring techniques in accordance with IEC 794-1-E1.

c) Tensile performance

The test shall be undertaken in accordance with the load conditions specified in IEC 1089 Annex B and the measuring techniques in accordance with IEC 794-1-E1.

d) Crush and Impact

The test shall be undertaken in accordance with the recommendations of IEC 7941-1-E3 and IEC –794-1-E4.

The crush test shall be undertaken by applying a 10kN load for 1 minute to the OPGW via two 50mm x 50 mm flat plates.

The impact test shall be undertaken by dropping a 4 kg weight from a height of 150 mm onto the end of a 20mm diameter steel mandrel places on the OPGW. These should be done 20 times.

e) Temperature cycling

The optical performance under temperature cycling shall be tested in accordance with IEC 794-1-F1 with specified temperature ranges for a duration of 4 hours. The test should be undertaken twice.

f) Water Ingress

The optical sub-unit shall be tested for water ingress in accordance with IEC 794-1-F5

g) Fault Current

A sample of OPGW not less than 2 metres in length shall be subjected to a fault current pulse. The test shall be performed twice with an interval of 30 minutes between tests. After the second impulse the OPGW shall be dismantled and the optical cable examined throughout its length for any signs of deterioration.

h) Lightning Strike

Tests shall be carried out to verify the effectiveness of the OPGW to withstand the effects of a lightning strike. The test shall consider both an initial stroke and a follow through. The test shall be carried out on a sample of OPGW not less than 2 metres long. The acceptable criteria shall be that earth wires calculated residual strength is not less than 90 percent of the original stated ultimate strength.

7.3.4.3 Optical Fibres
Optical fibres shall be tested in accordance with the requirements of IEC 793.

7.3.4.4 Optical joint Boxes
Optical joint boxes shall be visually inspected to ensure they meet the specified requirements.

7.3.4.5 Non- metallic underground Fibre Optic cable
Non-metallic underground fibre optic cable and the optical fibres shall be tested in accordance with the requirements of IEC 793 and IEC 794 as appropriate.

7.3.4.6 Fibre Optic cable
All fibre optic cables shall be tested prior to dispatch using an OTDR on each fibre and other tests detailed in this document.

7.3.4.7 Test Certificates

Test records, covering type and sample tests shall be provided.

7.3.4.8 Test equipment
The following test equipment where required in the definite scope of work shall be supplied and shall remain the property of the Employer after the completion of the site installation. The equipment shall be delivered to the Employer's site depot complete with suitable packaging after completion of the installation tests.

a) One-Portable Optical Time Domain Reflectometer (OTDR) with 1300 and 1550 nm modules. Storage and printing capabilities of traces shall be provided;
b) Two- Portable Optical Power meters for 1300 and 1550nm;
c) Two- Portable High Stability Laser Sources for optical power measurements at 1300 and 1550 nm wavelengths:
d) An optical fibre fusion splicing machine which shall be of the automatic type, designed to carry out fibre core alignment, pre-cleaning and fusion splicing as a fully integrated and properly co-ordinated sequence of functions. It shall only be necessary for the operator to correctly prepare the fibre ends and carry out preliminary alignment prior to initiating the slicing sequence. Optical devices and light sources that are utilised in the fibre system shall form an integral part of the fusion splicing machine and the alignment process. Devices that rely on the use of remotely mounted light sources will not be acceptable. The fusion splicing machine shall be capable of producing splices with an average attenuation value of less than 0.05 dB.

7.3.5 Factory Acceptance Tests

The Contractor shall arrange for 2 participants from KPLC and the Project Manager to witness tests of major equipment listed below in the manufacturer's plant. All routine tests shall be carried out in the presence of the Employer's representatives. The Contractor shall arrange and meet the full cost of the air tickets, local transportation and training at manufactures factory and per diem costs at SRC rates.

The following major equipment shall be offered for inspection:

a) OPGW and ADSS

b) Fittings

FAT shall be carried out as prescribed in the particular technical specification.

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SWITCHGEARS AND AUXILIARY SUPPLIES

TABLE OF CONTENTS

8.0 PARTICULAR TECHNICAL SPECIFICATIONS SWITCHGEAR 236
8.1 General 236
8.2 Design Data 236
8.3 Breakers and Switches 236
8.3.1 Circuit Breakers and Switches 236
8.4 Measuring Transformers 237
8.4.1 Current transformers… 237
8.4.2 Voltage Transformers 238
8.5 SF_6 Gas… 239
8.5.1 Low Density Warning 239
8.5.2 Gas Refilling 239
8.6 High and Medium Voltage Outdoor Switchgear 239
8.6.1 General 239
8.6.2 Circuit Breakers 239
8.6.3 Disconnectors/Isolators and Earthing Switches 240
8.6.4 Measuring Transformer 240
8.6.5 Lightning Arresters 241
8.6.6 Line Traps 241
8.6.7 Coupling Capacitors 242
8.6.8 Line Matching Units 242
8.7 Conductors, Insulators, Accessories 242
8.7.1 Conductors 242
8.7.2 Tubular Conductors 243
8.7.3 Insulators 243
8.7.4 Accessories 244
8.7.5 Cable Ducts 244
8.7.6 Cable Marshalling Kiosks 244
8.7.7 Tests 244
8.7.8 Conductors, Insulators, Accessories 244
8.7.9 Tests on the Switchyard on Site 245
8.10 Auto reclosers 245
8.10.1 General 245
8.10.2 Modes of operation 245
8.10.3 Operating Mechanism 245
8.11 Power Supply 245
8.11.1 Control Cabinet 246
8.11.2 Control Requirements 246
8.11.3 Protection Requirements 246
8.11.4 Insulating and Interrupting Medium 247
8.11.5 Ratings 247
8.11.6 Bushing Current Transformers 247
8.11.7 Alternative Indoor 66 kV Switchgear 247
8.12 Medium Voltage Indoor Switchgear 248
8.12.1 General 248
8.12.2 Panels 248

8.12.3 Circuit Breakers and Disconnectors 249
8.12.4 Circuit Isolation and Interlocks 249
8.12.5 Switch-Disconnectors and Fuses 250
8.12.6 Shutter Mechanism 250
8.12.7 Earthing 250
8.12.8 Cable Connection 250
8.12.9 Measuring Transformers 251
8.12.10 Protection and Control 253
8.12.11 General 253
8.12.12 Arc Detection 253
8.12.13 Optional Equipment and Accessories 235
8.13 MV Cables and Accessories 253
8.13.1 General 253
8.13.2 Conductors 253
8.13.3 Cable 254
8.13.4 Cable Laying and Routing 254
8.13.5 Manufacturer’s Identification 255
8.13.6 Manufacturer’s Identification 255
8.13.7 Armour 255
8.13.8 Testing 255
8.13.9 Sealing and drumming 256
8.13.10 Terminations 256
8.13.11 Joint and termination material 256
8.14 Current carrying Capacity and Design Parameters 256
8.14.1 Termination 256
8.14.2 Jointing and termination materials 256
8.15 Auxiliary Supply and Substation Lighting 257
8.15.1 General 257
8.15.2 Switch board and Ac distribution panels 257
8.15.3 Circuit breakers and Fuses 258
8.15.4 Current transformers 259
8.15.5 Auxiliary supply 259
8.15.6 Auxiliary transformers 259
8.15.7 Distribution boards 259
8.15.8 Switch yard lighting 260
8.15.9 DC emergency lighting 260
8.16 DC Supply 261
8.16.1 General requirement 261
8.16.2 110 VDC and Charger system 261
8.16.3 110V Batteries 261
8.16.4 Charger (110V) 262
8.16.5 Battery conductor and fuses 263
8.16.6 48V Battery and Charger system 263
8.16.7 Alarms and Metering 264
8.16.8 Inspection and testing 265

8 Particular technical specifications for Switchgear

8.1 General

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

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

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

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

8.2 Design Data

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

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

8.3 General Clauses for HV and MV Switchgear

8.3.1 Breakers and Switches

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

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

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

A sufficient number of auxiliary contacts, with at least 10NO and 10NC contacts as spare, for 110 VDC shall be provided for control and interlock purposes.

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

8.3.2 Circuit Breakers

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

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

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

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

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

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

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

8.4 Measuring Transformers

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

- Power frequency test voltage on secondary windings, 1 min. 2.5 kV
- Overvoltage inter-turn test, 1 min. 3.5 kV

8.4.1 Current transformers

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

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

The core(s) for measuring:

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

The core(s) for energy metering:

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

The core(s) for protection:

▪ Accuracy for overcurrent and earth fault	class	5P20
▪ Transformer Differential protection	class	X or SP
▪ Line differential protection	class	X or SP
▪ Distance protection	class	X or SP
▪ Restricted earth fault	class	X or SP

- Accuracy limit factor equal to or greater than 20

Neutral Current transformer

Shall have at least three cores:	Earth fault	class	5P20 (two cores)
	Restricted earth fault	class	X or SP

- Accuracy limit factor equal to or greater than 20
- The Neutral current transformer shall have the same current ratio as Phase current transformers

The core(s) for bus bar protection:

- To be adapted to the protection scheme offered, shall be shall be class 5P20
- The Line current transformers shall have at least four (4) cores, whereas for the neutral shall have least Three (3)cores

The core characteristic shall be optimized to the selected scheme in sections where new bus bar protection shall be installed.

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

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

8.4.2 Voltage Transformers

The windings for measuring purposes shall be designed as follows:

The core(s) for measuring:

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

The core(s) for energy metering:

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

The core(s) for protection:

- Accuracy class 3P
- The Voltage transformer shall have three cores

The secondaries shall be provided with a single pole 2 or 4Ampere miniature circuit breakers with alarm contacts.

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

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

8.5 SF6 gas

8.5.1 Low Density Warning

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

8.5.2 Gas Refilling

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

8.6 High and Medium Voltage Outdoor Switchgear

8.6.1 General

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

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

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

All breakers and switches shall come ready for distribution automation.

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

8.6.2 Circuit Breakers

The three-phase circuit breakers shall be of the outdoor, single pressure SF_6 for 66Kv and above and Vacuum type for 33Kv and below. The breakers shall be mounted on steel structures.

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

A spring-operated mechanism is be employed. Pneumatic and Hydraulic operating mechanism are not accepted.

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

0-t-CO-t'-CO   t = 0.3 sec t' = 3 min and CO-t2-CO t2=15 sec

The total breaking time (opening time plus duration of the arc) of the breakers shall be as short as possible, but in no case is it to be longer than 50msec. whereas closing shall be less than 70msec.

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

8.6.3 Disconnectors and Earthing Switches

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

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

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

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

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

The disconnectors and earth switch shall have enough auxiliary contacts for signaling, commands and interlocking plus spares for automation use. Insertion of the operation handle (mechanical operation) shall automatically disable electrical operation.

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

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

8.6.4 Measuring Transformers

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

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

8.6.5 Lightning Arresters

The lightning arresters shall be of the metal oxide gapless type, complying with IEC 60099-1
For tendering purposes, the lightning arresters shall have the following characteristics (the Contractor shall check the values by calculations to be approved by the Project Manager):

System Voltage	132kV	66kV	33kV	11kV
(1) Continuous operating voltage (r.m.s.) (kV	96	59	28	9
(2) Rated discharge current (8/20 ms) (kA)	10	10	10	10
(3) Rated Voltage (kV)	108	54	27	9
(4) Creepage distance (mm)	4092	1800	900	500

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

The lightning arresters shall be fitted with a pressure relief device, Current indicating meter (optional) Operating counter. Surge counters shall be supplied for each single-phase arrester for 11Kv voltages and above

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

8.6.6 Line Traps where applicable

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

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

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

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

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

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

Every line trap shall be supplied with a line matching unit as per specifications in paragraph 8.6.8 below.

8.6.7 Coupling Capacitors

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

8.6.8 Line Matching Units

Where they are required, the Phase to phase coupling units complete with coupling filters and protection circuit, including hybrid transformer.

The high frequency coupling units shall be assembled in a sheet steel box or similar and be suitable for mounting on the pedestal support for the coupling capacitor. The filters are to be suitable for outdoor use in a hot dusty/humid climate and are to have weather proof door seals together with breather holes to avoid condensation. The units are to have an earthing switch which should preferably be interlocked with the box door/lid such that the latter cannot be opened unless the earth switch is closed to earth the device, and clear ON/OFF position of this switch should be indicated. The terminal of the filter, which shall be connected directly to the substation earth, shall be clearly designated. The device shall meet requirements of IEC 60481.
The device shall be fitted with a rating plate clearly defining but not limited to the following data:

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

Technical requirements:

Bypass filter:

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

Drain Coil:

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

Earthing Switch:

- Rated current 300A r.m.s
- Lightning Arrester:
- Rated voltage 660 V
- Max. 100% impulse spark over voltage 3300 V
- Rated discharge current 5kA

8.7 Conductors, Insulators, Accessories

8.7.1 Conductors

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

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

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

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

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

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

8.7.2 Tubular Conductors

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

Transformer bays (HV and LV) for 7.5MVA 33/11kV substation and above shall use aluminium-magnesium-silicon tubular Bus bars or 2 x $300mm^2$ AAA conductor.

8.7.3 Insulators

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

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

Minimum factors of safety shall be:

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

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

8.7.4 Accessories

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

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

8.7.5 Cable Ducts

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

8.7.6 Cable Marshalling Kiosks

For each switch bay a separate dust and waterproof, cable marshalling kiosk shall be provided, with a minimum IP 54. It shall be possible to securely fix the hinged front door in open position.

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

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

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

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

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

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

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

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

8.7.7 Tests

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

8.7.8 Conductors, Insulators and Accessories

Tests for physical and electrical properties on conductors shall be made in accordance with ASTM Standard B 398 and 399 (IEC Equivalent) or other equivalent and approved standard. These tests on wires shall be made on wires removed from the complete conductor. All wires making up the conductor sample shall be tested.

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

8.7.9 Tests on the Switchyard on Site

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

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

8.10 Auto reclosers

8.10.1 General requirements

Provided below are general requirements for 33/11kv Auto reclosers and where these requirements differ with those provided in *the attachment for KPLC Specification for Auto* reclosers, the data in the attachment ***KPLC specifications for Auto reclosers*** **shall prevail.**

Auto-reclosers are used on remote/semi urban 33 and 11kV lines outside the substations on lines instead of circuit breakers.

The Auto reclosers are not acceptable for line bay use inside the substation. The Auto-reclosers shall be designed for pole mounting with the following features:

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

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

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

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

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

8.10.2 Modes of operation

The Auto recloser operation modes shall meet the IEC standards.

8.10.3 Operating Mechanism

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

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

8.11 Power Supply

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

8.11.1 Control Cabinet

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

8.11.2 Control Requirements

A microprocessor based control unit for the recloser is required which also integrates the protection relays. The control unit shall have a socket for serial communication and downloading of information to a hand-held external unit from the memory.

The auto recloser shall have facilities for manual tripping and locking out by means of an external handle or similar.

The following control functions shall be provided on the front panel:

- Local/remote control selection
- closing/tripping
- Auto reclose in/out (one trip to lockout)
- Protection engaged/disengaged
- Earth fault in/out
- Sensitive earth fault in/out
- Relay status.
- Energy profiles;
- Demand registers

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

8.11.3 Protection requirements

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

Dead times and reclaim time shall be selectable in steps.

The protection system shall have facilities for:

- phase faults
- earth faults
- sensitive earth fault.

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

The sensitive earth fault relay shall be of the definite time type with instantaneous element, adjustable between 2 and 10A in steps. Time delay should be settable between 0 and 20 secs. in steps.

The relays shall be equipped with in rush restraint facilities. A counter is to be provided to keep record of the number of in/out operations.

8.11.4 Insulating and Interrupting Medium

The interrupting medium for 33 and 11kV shall be vacuum. The insulating medium shall be SF6 or solid insulation. The SF6 gas used shall comply with IEC publication 60376.

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

Where SF6 gas filled auto reclosers are offered, the supplier shall provide the user with necessary instructions for refilling the gas and maintaining its required quantity and quality. The auto recloser shall have facilities for lockout in case of low pressure with an associated indicator flag easily seen from the ground. A pressure gauge easily read from the ground shall also be provided.

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

8.11.5 Ratings

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

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

8.11.6 Bushing Current Transformers

The bushing current transformers for protection shall be single core and provided on all phases. They shall be rated as per design requirements if not specified.
All transformers above 2.5MVA shall be fitted with line and neutral bushing current transformers. The bushing transformers shall have a minimum of four (4) core, except for the neutral that shall have a minimum of three (3) cores.

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

8.11.7 Alternative Indoor 66kV Switchgear

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

8.12 Medium Voltage Indoor Switchgear

8.12.1 General

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

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

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

The medium Voltage Indoor switch bus bar conductor shall be high grade tinned copper. Aluminium bus bars shall not be accepted.

8.12.2 Panels

The boards shall be complete with bus bars, Withdrawable circuit breakers, cable connection points, earthing switches, measuring transformers, cable relays, instruments and other ancillary equipment, fully wired, but dismantled to individual panels/sections for delivery purposes.

The boards shall be suitable for indoor use and shall be of single bus bar three-phase configuration at a rated frequency of 50 Hz. If so indicated in Scope of Work, the bus bar shall be split by a Withdrawable sectionalizing circuit breaker. In any case shall it be possible to add new boards including such bus coupler at a later stage.
The cubicles shall be short circuit and arch type tested. The switchgear shall consist of cubicles of tropical design. The shall be metal-enclosed with separate compartments for bus bars, circuit breakers, cable termination and instruments, and shall be so designed that future extension can easily be made.

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

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

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

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

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

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

8.12.3 Circuit Breakers and Disconnectors

The three phase circuit breakers shall be of the vacuum type for 33 kV and 11 kV.

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

0-t-CO-t1-CO t = 0.3 sec t1 = 15 sec

The total breaking time (opening time plus duration of the arc) of the breakers shall be as short as possible, but in no case is it to be longer than 60 msec.
The circuit breakers shall be designed for switching of capacitor banks and shall be such that re-striking during breaking operation cannot occur.

A spring-operated mechanism shall be provided and the mechanism shall be equipped for electrical local (from switchgear) and remote control (from control Centre). If not otherwise stated in Scope of Works, the control voltage for closing and opening commands and for the operating mechanism motor(s) shall be:

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

A local position indicator shall be mounted in the front panel of the operating mechanism cubicle. The circuit breakers shall be mounted on manual operated trucks so that they can be moved into counter contacts of the switchgear (draw-out/jack up down type). All breakers of same rating shall be fully interchangeable.

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

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

The stored energy shall for all types of operating mechanisms be sufficient to allow a complete O-C-O cycle.
A sufficient number of auxiliary contacts for 110VDC shall be provided for control and interlock purposes.
Motors shall be designed in accordance with valid IEC publication and shall be effectively protected by miniature circuit breakers, with alarm contacts.
All wiring shall lead to terminals. 10% of the terminals shall be spare.

8.12.4 Circuit Isolation and Interlocks

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

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

8.12.5 Switch-Disconnectors and Fuses

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

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

8.12.6 Shutter Mechanism

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

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

8.12.7 Earthing

All cubicles shall be connected to earth via conductors with min. 50 mm^2 cross section area.

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

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

8.12.8 Cable Connection

The cable termination compartment for feeders shall have adequate space for housing of cable terminals up to, 2x3 single core 300mm^2 Al XLPE (two single core set) and shall be complete with cable terminations, bolts, nuts and cable glands.

The cable termination compartment for the connections to the 66/11kV transformers must allow for cables dimensioned for 23MVA.
For cable test purposes, it must be possible to loosen the connection between cables and the measurement transformers from the front of the switchboard, with energised bus bars without removing any apparatus. The Bidder shall demonstrate this in his Bid.

8.12.9 Measuring Transformers

8.12.9.1 Current Transformers

All current transformers shall have bar primaries and shall be Oil insulated, hermetically sealed type and complying with IEC 60044. Cast resin type from a reputable manufacturer and meeting IEC Standards is also acceptable. All current transformers shall have a maximum short-time current rating of 25kA for 3 seconds.

Feeder out bays shall be equipped with a current transformer on three phases with four cores:

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

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

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

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

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

Fourth core shall be class SP or PX, with Vk =350V, Ik =30mA.

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

Note: *For Busbar protection core as per the design*

Incomers shall be equipped with a current transformer on each Phase with four separate cores:

For differential protection, not less than 15VA, Class PX

33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-800-1200-1-1-1Amp

For Restricted earth fault, not less than 15VA, Class PX

33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-600-1200-1-1-1Amp

For over current and earth fault protection, not less than 15VA, Class 5P20

33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-600-1200-1-1-1Amp

For instruments, not less than 15 VA, Class 0.2:

33kV: Ratio adapted to transformer rating
11 kV: Ratio: 400-600-1200-1-1-1Amp

Loose Transformers for transformer Neutral

(a) Loose single-phase current transformers with three separate secondary cores for connection of Restricted Earth fault Protection and Neutral Overcurrent Protection. This shall apply where the transformer doesn't have bushing neutral current transformer. Ratio as per design.

8.12.9.2 Voltage Transformers

Three phase voltage transformers shall have the following characteristics

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

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

Accuracy class of 0.2 for the measuring winding and 3P for protection, capacity shall be between 100 to 200VA for the protection winding in accordance with IEC 60186.

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

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

The transformer shall be resin encapsulated of the electromagnetic type

8.12.10 Protection and Control

8.12.10.1 General

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

8.12.10.2 Arc Detection

The complete 11kV board shall be fitted with arc detection devices in the cubicles with a scheme that will instantaneously trip the necessary circuit breakers to effectively isolate the faulty part of the switchgear board. The arc detection devices shall be placed to cover all the HV compartments of each Switchgear panel i.e. Bus bar compartment, CB compartment and Cable compartment: and shall instantaneously trip the appropriate circuit breakers. The arc detection shall be insensitive to sunlight and flashlight. Rapid tripping scheme shall not influence the test requirements given above. The arc detection trip indications shall be available on the SCADA. The scheme is to be approved by the Project Manager.

8.12.10.3 Optional Equipment and Accessories

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

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

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

8.13 MV Cables and Accessories

8.13.1 General

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

All cables shall be suitable for operation:

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

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

8.13.2 Conducting material

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

8.13.3 Cable construction

The conductor shall be covered with:

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

8.13.4 Cable Laying and Routing

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

Cables shall be laid on corrosion resistant (aluminum or hot dipped galvanized) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15 % spare capacity. The distance between each tray shall at least be 300 mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

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

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

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

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

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

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

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

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

All cross section must be checked against max load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity.
The cables shall be marked with item designation in both ends as well as by entrances in enclosures.

The cable marking shall be fire proof.

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

The cable supplier's instructions regarding handling and bending radius shall be followed.

8.13.5 Laying-up and Fillers of Three Phase Cables

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

8.13.6 Manufacturer's Identification

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

8.13.7 Armour

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

8.13.8 Testing

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

8.13.9 Sealing and drumming

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

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

8.14 Current carrying Capacity and Design Parameters

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

8.14.1 Terminations

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

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

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

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland.

8.14.2 Joint and termination material

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

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

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

8.15 Auxiliary Supply and Substation Lighting

8.15.1 General

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

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

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

Domestic installations are part of the Civil Works.

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

8.15.2 Switchboards and AC distribution Panels

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

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

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

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

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

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

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

The main switchboard shall be designed so that additional panels can be added in the future (including possibilities for extending the bus bars).

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

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

8.15.3 Circuit Breakers ad Fuses

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

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

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

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

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

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

The breakers for DC shall be two-pole, and with thermal overload and magnetic short-circuit protection in both poles. All such circuit breakers, miniature circuit breakers, switches, contactors, fuses, etc., shall be of a type specifically designated for the use on DC, and the dynamic current and the making and breaking capacities shall be ample for the short-circuit power of the batteries.

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

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

8.15.4 Current Transformers

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

The cores for measuring purposes of current transformers shall have accuracy class 1 and instrument security factor less than or equal to 5. The cores for protection shall have accuracy class 5P and accuracy limit factor greater than or equal to 10.

Power frequency test voltages, 1minute:

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

8.14.4.1 Instruments and Relays

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

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

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

8.14.4.2 Tests

Tests shall be made in accordance with the applicable standards.

8.15.5 Auxiliary Supply (415/240Vac)

Three phase auxiliary supply is part of the scope and installation subject to approval by the employer

8.15.6 Auxiliary Transformers

Station transformers are part of the scope of supply and installation.

8.15.7 Distribution Boards

Current carrying capacity of main transformer circuit breaker and alternate supply shall not be less than 200A. The two sources shall be switched by a changeover system that will select between the sources and shall be arranged within the main board and incorporate a manual by-pass switch.

For 7.5MVA Substations and above the changeover system shall be Automatic with 240VAC controls circuits with auto and manual operation selection.

The board shall be equipped with instruments for measuring of current and voltage in all phases both on the incoming lines and bus bars. Also incorporated shall be phase failure relay, phase rotation relays and energy meters for recording of energy consumption. The Bus bars shall be copper with continuous current rating of the phases and neutral from the transformer and alternative source in the main switchboard be at least 200 A. The current rating of the feeders shall be ample for the actual load and have at least 50% reserve capacity compared to the actual load.

The figures given in these specifications are indicative only. Only a limited number of different makes, types and ratings shall be used, for the purpose of standardization and interchangeability.

8.15.8 Switchyard Lighting

The switchyard lighting shall be by means of floodlights with 400W for bay lighting and 70W for perimeter lighting. The lighting shall be constructed with high pressure sodium lamps. The housing shall be of high pressure die-cast aluminium with a non-corrosive finish. Refracting front covers of etched vandal-resistant polycarbonate shall be provided. The enclosure protection shall be min. IP65. The switch bay and transformer illumination level shall be 50 lux on 0.85m height in the switchyard and for the transformers. The perimeter illumination level shall be 5 lux. The perimeter lighting shall be controlled by photocells. All necessary supports, fixing material and cabling from the distribution board shall be included.

8.15.9 DC Emergency Lighting

Emergency lighting shall be provided for 23MVA substations and above or as specified under definite Scope of works.

8.15.10 Hand Lamps and Portable Hand Sets

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

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

8.15.11 Clock

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

8.16 DC SUPPLY

8.16.1 General

This section covers general technical requirements of the batteries and battery chargers, the main DC switchboards and the sub-distribution boards and panels for the DC auxiliary supply of the plants.

Where these technical requirements provided in the subsequent clauses are in conflict with those provided in the attachments for *KPLC specifications for Battery and chargers*, the data in the attachment ***KPLC specifications for battery and charger shall prevail***.

8.16.2 110 VDC Battery and Charger system

The DC bus bars shall have two poles. The bars and the connection conductors to the breakers shall be insulated. All boards shall have instruments for reading of voltage and current (two directions) and be equipped with relays giving alarm by high and low voltage and by earth leakage in all insulted poles. 110VDC shall be used for the main circuits of the control and protection and for DC motors, unless otherwise stated in Scope of Works.

For 23MVA Substations and above the 110VDC shall comprise of two independent systems i.e. double batteries and chargers allowing one system to carry all loads while the other system is out of services or when boost charging one battery. The two 110V batteries shall be located in separate rooms. Under normal operational conditions the two systems shall each carry 50% of the load. Trip 1 circuits and trip 2 circuits shall be connected to separate systems.

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

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

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

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

For 7.5MVA 33/11kV substation voltages and below the battery bank systems shall be 110Vdc/165Ah and 48Vdc/100Ah. Single battery and Charger system shall be installed to carry all the substations DC loads for at least 10 hours with the failure of AC system.

8.16.3 110V Batteries

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

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

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

The 110V batteries shall be loaded with the switchyard load. Alarms shall be provided for battery faults.

The batteries shall be of the Nickel Cadmium type, with a nominal cell voltage of 1.2V.

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

8.16.4 110V Charger

The rated current of the battery chargers shall be selected to allow for recharging a fully discharged battery in 5hours, in addition to simultaneously supplying the DC load.

In addition the chargers shall comply with the following technical data and requirements:

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

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

The chargers shall be completely equipped for a fully automatic and controlled charging and float charging of the batteries, and shall be of a constant voltage type with current-limiting device.

Each of the charges for the 110V or 48V batteries shall be rated to maintain normal charging and float-charging of both batteries.

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

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

- Breakers and protection on AC and DC side, with alarm contacts
- One V-meter for the DC voltage
- One A-meter for the DC current
- One lamp indicating that the charger is charging
- Alarms for "high volts", "low volts", "earth fault" and "fail"

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

8.16.5 Battery Conductors and Fuses

Conductors from the batteries to the fuse boxes shall be installed in short circuit and earth fault proof conduits. That is, the conductors shall be single pole insulated and in addition placed on insulators, separate for each pole. All conductors shall be placed at minimum 5cm distance from each other, even at crossings. The conductors shall lead through insulating pipes in the wall of the battery room to closed fuse boxes made of insulating material on the wall inside the battery room. For the 110V and 48VDC system there shall be separate fuse boxes. The wall-holes shall be tightened against gas intrusion.

8.16.6 48 V DC Battery and Charger System

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

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

The battery and charger sets shall be sized to adequately supply the loads to be connected to the battery. The rectifier output shall be k x S were.

k = 1.5
S = sum of the following:

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

The battery capacity shall be C = 1.5 x C_n, where C_n is the capacity to feed the above total load for eight (8) hours. This requirement shall be tested during SAT.

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

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

A low voltage disconnect switch shall be provided for protection of the battery. The 48 Volt DC system distribution panel shall be a fused switch distribution panel board. The low voltage disconnect switch and fuse panel shall be provided with local alarms as well as alarm contacts. The low voltage disconnect switch shall be equipped with external by-pass switch to be used for maintenance purposes.

Detailed drawings and operations manuals shall be provided in duplicate copies and softcopy. Design drawings shall be provided for approval before manufacture.

8.15.6.1 48 V DC Batteries

The batteries shall be of minimal maintenance vented Nickel cadmium type. The type and rating shall be in accordance with the prevailing environment and supply standard voltage level. The batteries shall be mounted on wood or metal stands or racks in a way that all plates of each cell are visible for maintenance purposes. The stands or racks shall have a maximum of two tiers.

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

8.15.6.2 48 V Charger

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

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

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

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

Trickle charging and floating operation 2.3V/cell and stand-by parallel operation 2.23V/cell shall be possible.

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

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

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

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

8.16.7 Alarms and metering

The following alarms and indications shall be provided:

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

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

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

8.16.8 Inspection and Testing

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

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

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

TELECOMMUNICATION SYSTEM

TABLE OF CONTENT

9. Telecommunications 268
9.1 General requirements 268
9.2 ADSS Cable 269
9.2.1. Fiber Optic Ground Wire (OPGW) 270
9.2.2 Non-Metallic Underground Fibre Optic Cable 271
9.2.3 Approach Fiber Optic Cable… 271
9.2.3.1 Optical Distribution Frames (ODF) 271
9.2.4 Fibre Terminal Equipment 272
9.2.4.1 Spare parts and Tools for Test equipment 274
9.2.4.2 Specifications for GPS device……..275
9.2.4.3 Documentation: 275
9.2.4.4 Training 275
9.2.4.5 Testing 276
9.2.4.6 System Acceptance 276
9.3 Remote terminal equipment specifications (RTU)…...276

9 Telecommunications

9.1 General requirements

The objective of the telecommunications system is to transmit and receive data, voice and Teleprotection signals. Telecommunication links based primarily on Fibre (OPGW and ADSS) multiplexers and on some cases Radio shall be established linking various equipment in substations to Regional Control Centers (RCCs). Necessary engineering required for transmitting data and speech signals to the Regional and National Control Centre(s) shall be included. The links shall consist of STM-1/4/16 SDH Terminal equipment(s), and shall be connected to existing KPLC network. KPLC has SDH network with the backbone mainly consisting of STM-1/4/16 network.

The telecommunication system to be provided shall be designed to transmit and receive data, voice, and Tele-protection signals where necessary.

Where the station is for Voltages above 66 kV the SAS and Telecommunications links shall be configured to have connection to both Regional and National Control Centers. These links shall include Tele-protection facilities with for four commands per line. For 33kV substations with a transformation capacity of less than 23MVA, the links shall be designed for connection to respective RCCs.

These specifications describe the basic requirements for the Telecommunications various systems. Tenderers are requested to submit with their offers the detailed catalogues, brochures and technical drawings with the specific items on offer clearly marked for the products they intend to supply. Tenderers must indicate on the specifications sheets whether the equipment offered comply with each specified requirement.

The tender documents shall be accompanied by type test and routine test reports certified by the National Testing or the National standards Institute of the country of origin. At her discretion, all equipment shall be subjected to inspection by the clients Engineers or representative at the place of manufacture where all routine tests on randomly picked sample(s) shall be carried out in their presence. Test reports shall be completed for each equipment and made available to KPLC after the tests have been carried out. All the dimensions and capacities of the equipment to be supplied shall not be less than those required in these specifications. Deviations from the basic requirements, if any, shall be explained in detail in writing with the offer, with supporting data such as calculation sheets, etc. The Procuring entity reserves the right to reject the products, if such deviations shall be found critical to the use and operation of the products.

9.2 ADSS Cable

Where required in the specific line scope of works the ADDSS cable shall meet following technical and general requirements. ADSS can only be installed in an existing 33kv lines, and in that case, it shall be specified in the specific scope of works.

i. Design Principles:

The proposed Fibre cable shall be single mode, 48 core all-dielectric self-supporting cable (ADSS).

The cable shall be designed and manufactured in accordance with the following standards:

- Cable IEEE 1222
- Fiber IEC 60793, ITU-T G.65X series
- Color code ANSI/EIA 359-A, IEC 60304

ii. Route Survey:

Prior to design and installation, the contractor shall visit the route accompanied by KPLC staff to ascertain for themselves the requirements for the link. During this survey a pole count and a sketch for the cable installation shall be carried out. This sketch shall indicate the locations of splice boxes and the approximate distances between them. The poles shall also be assessed for their ability to support the ADSS cable. Any need for modification shall be determined at this stage.

Suitable drum lengths shall also be determined at this stage to reduce the number of joints preferably at section poles. KPLC shall assess the contractor's report and carry out modifications where it is felt necessary.

iii. Installation:

The cable installation shall be aerial on existing power lines. Majority of these lines are on wooden structures and the ADSS cable shall be installed below the power line. The installation shall be done under live line conditions except in some instances where safe working clearance cannot be maintained.

It is not the intention of the employer to recommend any specific installation method but whichever method applied should be in accordance with the international standards, manufacturer's recommendation and within KPLC safety regulations.

iv. Installation Materials & Fittings:

All bolts, nuts and clamps used during the construction shall confirm to IEEE standards that apply to testing and performance of Hardware for All-Dielectric Self-Supporting cable (ADSS)

All fitting materials shall conform to the approve standards by IEEE1222. The bidder shall attach type test certificates from the certifying bodies

v. Splicing & Testing:

All joints shall be fusion spliced. The splice loss shall be equal to or less than **0.1db**. After all the terminations are done the cable shall be tested from ODF to ODF using the OTDR as well as power meter and the results tabulated.

vi. Fittings & Spare Capacity

Unless otherwise specified in this specification, all requirements for individual components and completed cable shall be mainly in accordance with the following standard specifications.

1EE Std 1222, IEC 60794-4, IEC 60793-1, IEC 60793-2, IEC 60794-1, ITU-T G.650, ITU-T G.652, ITU-T G.655, EIA 492A, EIA 472A, EIA 598 or ANSI/EIA 359-A-1985, ISO 9001 and ISO 14001.
The Contractor shall include 10% spare cable capacity for future maintenance work on the link at agreed intervals.

9.2.1 Fibre Optic Ground Wire (OPGW)

The overhead earth wire shall be Fibre Optic Ground Wire (OPGW) with a minimum of 48 strands. The Fibre optic earth wire supplied shall be suitable for installation on transmission line and shall be supplied complete with all necessary fittings and optical joint boxes. The earth wire fittings and optical joint boxes shall be type approved.
The manufacturer of the OPGW shall be responsible for the supervision of installation by the Contractor; to ensure that system reliability requirements are met.
The fibre optic earth wire shall comprise an optical sub-unit containing optical fibres over which shall be laid aluminium, aluminium alloy or aluminium coated steel strands. The clad steel wire incorporated in fibre optic earth wire shall comply with the requirements of IEC 61232. Shaped aluminium or aluminium alloy wire sections shall conform to the requirements of the appropriate IEC standard.
The optical sub-unit shall withstand the temperature rise associated with the specified lightning fault current flowing in the earth wire without damage. The fibre optic earth wire (OPGW) shall be manufactured in continuous lengths of not less than 4,000 m.

The overall system design of the fibre optic system shall meet the following minimum requirements: Single failure or degradation in any optical fibre not more than one year averaged over five years; Failures or degradations affecting more than one optical fibre, not more than one in ten years;
Increase in optical system transmission attenuation due to accumulated ageing and other effects at the end of five years and not more than 0.05 dB/km.
The Contractor shall ensure that the fibre optic cable are not strained or damaged either mechanically or optically during stringing and/ or jointing.
The cable shall be capped before shipment to prevent the ingress of water.

i) Optical Fibres

Optical Fibres shall be 48 core single mode and shall conform to IEC 793-2-BI. The fibre coating material shall be mechanically strippable. The optical fibres shall be capable of being jointed by fusion technique.
There shall be no measurable long term or short-term optical attenuation change due to the temperature rise associated with a fault current flowing in an earth wire, or a lightning strike on the earth wire.

ii) OPGW Fittings

The fibre optic earth wire shall be with approved conductor fittings. The application of these fittings shall not damage the earth wire or fibres, either mechanically or optically.

At each support, a bypass device shall be provided to guide the cable around the earth wire fittings associated with the support.

iii) Optical Joint Boxes

Optical joint boxes shall be provided to protect the splice joint of optical fibres, either when individual lengths of the fibre optic OPGW, are jointed or between the fibre optic earth wire and the underground fibre optic cable.

The joint boxes shall consist of external steel or die cast aluminium housing providing protection to IEC 529 IP 44 and an internal die cast aluminium or high impact plastic ABS box to IEC 529 IP54 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.

iv) Fixing Clamps

A bolted clamping system shall be used to attach the OPGW to the inside of the support, without drilling or modifications to the support steel work. The attachment clamps shall be capable of being attached and detached from the support, without affecting the OPGW. Fixing clamps shall be made from a suitable grade of aluminium alloy complying with the requirements of BS 1490 and / or BS EN 1676. Bolts shall be made from mild steel grade S275JR to BS EN 10 025. Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall unless otherwise specified be threaded ISO Metric Coarse Pitch to BS 3643: Part 2, Tolerance Class 7h/8g.

9.2.2 Non-Metallic Underground Fiber Optic Cable

Where required, the fibre optic cable shall be circular in cross section and shall be designed so that any cable strain is so directly imported on the optical fibres. The cable shall not include any metallic components to prevent high-induced voltages when used in switching or substation compounds.

9.2.3 Approach Fiber Optic Wire:

The ADSS/OPGW cable shall terminate at first structure after the bus bar at the substations. An underground fiber optic cable shall be run from this structure to the building. This approach cable shall be 48 core SM, armored, loose tube cable, with a dielectric central member. The cable shall be Kevlar yarn reinforced, steel tape armor and a UV resistant HDPE outer layer. It is for outdoor applications, in ducts, for direct burial or latched installations

9.2.3.1 Optical Distribution Frames (ODF)

The optical fiber distribution frame (ODF) is installed for terminating optical fiber cables and patch cord. The distribution frame should include the metallic casing, adapter plate, splice tray, and other necessary materials for the termination of optical fiber cable. Therefore it should be designed properly for the fiber splicing and distribution. Separate storage shelf and distribution shelf can be offered if required.

The OFD shall be of corrosion resistance and robust construction; and shall allow both top or bottom entry for access to the splice trays. Specific selection of the entry points shall be made at the time of installation. The ODF shall be installed on the international standard (ETSI 19") equipment rack or cabinet rack. The optical fiber distribution frames shall include all necessary parts to complete the joint. This will comprise all components to protect and store the spliced fiber; and provide sheath continuity. The distribution frame shall be designed with enough spare capacity for fiber splices. The distribution frame shall be made from fabricated mild steel not less than 1.2mm thick or equivalent and painted in good condition. The design of the fiber distribution frame shall allow minor deviations from the ascribed installation procedures without any harm to the fibers and the long-term performance of the installation. The shelf and the connection between shelves shall be designed to maintain minimum bending radius of 30mm. the connectors to be used shall be subject to approval by the Project Manager.

Assignment between station fibre cable and OLTE's shall be made by using patch cords between the termination box and the optic distribution frame. Capacity of the optic distribution frame shall allow free assignment between each individual fibre of the station fibre optic cables and the relevant optical I/O ports of the OLTE's.

The optic distribution frame shall be equipped with low loss optical connectors (< 0.25 dB including the loss in the bulk head, loss in the connector splice & the loss in the pig tail) of the screw-on type. Auxiliary connectors shall be provided to facilitate testing and maintenance of the fibres/equipment. All spare Fibres shall be properly terminated and spliced on connectors of the same type within the frame

9.2.4 Fiber Terminal Equipment

The terminal equipment shall be the type SDH STM-4 optical terminal equipment and shall be supplied from 48VDC source.

SDH (STM-1/4/16) multiplexer shall be installed in racks that are EMC compatible and suitable to work in HV system environments.

The multiplexer shall be based on the SDH technology, working on the basic transmission Bit Rate of

155.520 Mbit/s (STM-1/4/16). It shall be in accordance with the latest ITU-T SDH recommendations such as: G.703, G.704, G774, G.783, G.784, G.785, G.811, G.812, G.813, G.823, G.825, G.826 and M.3010.

The equipment shall be able to perform both, multiplexing and line terminating functions. The SDH Equipment (Terminal Equipment, Add/Drop Multiplex, and Synchronous Digital Cross-Connect) to be offered shall meet the following requirements:

- It shall have at least all the functions outlined in ITU-T G.783.
- The PDH electrical tributary interfaces to the SDH equipment shall conform to ITU-T G.703.
- The SDH electrical and optical interfaces shall conform to ITU-T G.703 and G.957.
- The cross-connect offered shall be capable of providing non-blocking connection between virtual containers.
- The Optical Power to be offered shall be such that under normal operating condition, the BER of the system at the receiver is better than $1x10^{-10}$. Error performance versus the receive

signal shall be verified during the factory acceptance tests.

- The multiplex structure shall conform to ITU-T G.707. Details of the Multiplex structure for the offered equipment including the usage of the overhead bits shall be detailed with the offer.

The synchronous optical interface protection shall be achieved by having 1+1 protection. The laser shall automatically cut-off when the link is disturbed. Redundant cross connect, where failure on either one shall not cause link outage, and path protection on the traffic interface and the 2 Mbit/s levels shall also be provided.

Timing and synchronization shall conform to ITU-T G. 783, G.811, G.812 and G.813. Timing references, number of timing references available, switching time to a different timing reference, type and level of clocks shall be stated in the offer.

The equipment shall automatically switch to another clock if the reference timing is lost and automatically revert back upon restoration. The accuracy of the internal clock as well as the details of the clock signal distribution shall also be stated in the offer.

The equipment shall be capable of diverting timing references between the STM-1, 2 Mbit/s and a G.703 tributary interfaces.

The SDH equipment shall be wired for the full STM-1/4/16 capacity, however equipped under the scope of this specification to receive at least four (4) PCM tributaries as specified below. However, if higher PDH signals other than the 2 Mbit/s are required to be routed through, the same shall be possible just by adding the respective interface cards and no extra wiring needed. It shall have 2 Mbit/s outputs where it can directly be connected to digital telephone exchanges or Teleprotection equipment.

The jitter and wander tolerance for PDH and SDH interfaces shall conform to ITU-T G.823 and G.825. Jitter and wander characteristics of SDH multiplex and line equipment shall conform to ITU-T G.783.

The Contractor shall submit the details of the power budget calculations stating the following (based on 0.25 dB/km optical fibre attenuation at 1550 nm):

- Transmitter Power
- Minimum receive Signal @ BER $1x10^{-10}$
- Connector Loss
- Repair Splice Loss
- Power Penalty (Chromatic dispersion and LD reflection Loss)
- Maintenance Margin (> 2dB)
- Other Loss
- System Margin

The SDH equipment to be offered shall provide the followings:

- A data communication channel to the Telecommunication Management Network, in accordance with ITU-T G.773 for the purpose of integration of the new equipment into the Telecommunication Network Management System.
- A Craft interface in accordance with ITU-T G.773 to allow a local terminal to access the network element.
- An engineer order–wire which shall have conference and selective calling features.
- Performance monitoring in accordance with ITU-T G.784 and G.826.

- Optical safety as per ITU-T G.783.

The alarm functions shall include but not limited to:-

- Alarms classified as critical, major, minor, and information.
- Indications of loss of incoming signal.
- Visual and audible indication of alarms.
- Test function of alarm indicators to ensure workability of alarm indicators.
- Alarm functions shall be detailed by the Contractor, e.g. if implemented in Telecommunication Network Management System.

The offered equipment shall have sufficient capacity for speech, Ethernet data, SCADA data etc. and capable of extension to higher capacity by adding relevant modules.

9.2.4.1 Spares and tools for telecommunication system

Spares for Telecommunications where required under definite scope of substation, shall be one module for each type of the modules supplied. Specialized tests tools and equipment for testing, configuration and maintenance of equipment shall be supplied. This shall include data tester and optical test tools e.g. an OTDR (MTS 8000) or it's Equivalent and other special tools proposed. The equipment shall be of the same type as used by the contractor for erection and commissioning. The test equipment shall be new and shall not however be available to the contractor during erection and commissioning. All licenses required for commissioning of equipment shall be included.

The Contractor shall furnish a list of recommended spare parts for the OLTEs or those indicated in the bill of quantities for materials.

9.2.4.2 Specifications for GPS device

Description	**KPLC Requirements**
Make/Model	Specify
Display size, WxH	Specify
Display resolution, WxH	Minimum 272 x 480 pixels
Display type	bright, transflective 65k color TFT, dual-orientation touchscreen; sunlight readable
Weight	Specify
Battery	Rechargeable lithium-ion
Battery life	up to 16 hours (lithium-ion);
Water rating	IPX7
High-sensitivity receiver	Yes
Interface	High-speed USB
Maps & Memory	
Basemap	Yes
Preloaded maps	Yes (topographic), some models
Ability to add maps	Yes
Built-in memory	6 GB (With Worldwide base map); 3 GB (With TOPO U.S. 100K Maps)
Accepts data cards	microSD™ card (not included)
Waypoints/favorites/locations	4000
Routes	200

Description	KPLC Requirements
Track log	10,000 points, 200 saved tracks
Features & Benefits	
Automatic routing (turn by turn routing on roads)	Yes (with optional mapping for detailed roads)
Electronic compass	Yes (tilt-compensated 3-axis)
Touchscreen	Yes
Barometric altimeter	Yes
Camera	yes (8 megapixel with autofocus and 1080p/30fps video; LED flash; automatic geo- tagging)
Geocaching-friendly	Yes (Paperless)
Custom maps compatible	Yes
Photo navigation (navigate to geotagged photos)	Yes
Hunt/fish calendar	No
Sun and moon information	No
Tide tables	No
Area calculation	Yes
Custom POIs (ability to add additional points of interest)	Yes
Unit-to-unit transfer (shares data wirelessly with similar units)	Yes
Picture viewer	Yes
Additional Features	• Bluetooth® wireless technology • Wi-Fi connectivity • ANT+™ connectivity: • GNSS support: yes (GPS + GLONASS) • Near Field Communication (NFC): • Microphone: yes (internal for audio capture) • Multimedia (audio/video) support: • UV sensor

9.2.4.3 Documentation:

i. The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals. All manuals and As-Built-Drawings documents shall be supplied in three hard copies and a softcopy in PDF.
ii. Functional Design Specification (FDS)
iii. Test Specification for Factory Acceptance Test (FAT)
iv. Operator’s Manual
v. Product Manuals

9.2.4.4 Training:

The Contractor shall provide 1-week training for four KPLC staff at the supplier’s manufacturing premises on Telecommunication system supplied and on site during installation works. All training costs shall be borne by Contractor except KPLC staff welfare i.e. Accommodation and upkeep that shall be borne by KPLC. The scope of training service shall be given. The training content shall be subject to approval of the project Manager.

9.2.4.5 Testing

The formal stages of testing to be performed fall into the following three categories:

- Type Tests Equipment shall pass these tests in order to be accepted for use under this Contract
- Factory Acceptance Tests (FAT) Systems shall pass these tests before they may be shipped to site. The employer shall witness FATs unless he waives this in writing. FAT preparation costs shall be borne by contractor except Air ticket and accommodation. FAT shall be carried by two KPLC staff for a minimum of 5 days.
- Site Acceptance Tests (SAT) Systems shall pass these tests before they may be put into operation and before they are Taken Over

9.2.4.6 System Acceptance

The System will be accepted by KPLC 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 KPLC.
- If either of these conditions has not been complied with, then the necessary corrective action shall be agreed between the Contractor and KPLC**.**

9.3 Remote terminal equipment specifications (RTU)

The equipment shall be supplied in a floor standing modular panel and shall have a minimum capacity for 8 substation bays and 25% spare capacity.

It shall be fully wired with all IEDs, repeater relays and necessary transducers

For detailed equipment and technical specifications refer to attached KPLC Specifications for SCADA equipment paragraph on RTU equipment

PARTICULAR TECHNICAL SPECIFICATIONS

FOR

HIGH AND LV VOLTAGE CABLES

TABLE OF CONTENTS

10 Particular technical specifications Cables ... 279
10.1 Cables ... 279
10.1.1 General ... 279
10.1.2 Conductors ... 279
10.1.3 Cable ... 279
10.1.4 Testing ... 279
10.1.5 Sealing and drumming ... 280
10.1.6 Current carrying Capacity and Design Parameters ... 280
10.1.7 Terminations ... 280
10.1.8 Heat Shrink Materials ... 280
10.2 Installation ... 281
10.2.1 General ... 281
10.2.2 Cable Marker ... 281
10.3 Excavation of Trenches ... 281
10.3.1 Joint Holes ... 282
10.3.2 Backfilling of Trenches ... 282
10.3.3 Pavement Reinstating ... 282
10.3.4 Ducts ... 282
10.3.5 Direct Burial ... 282
10.3.6 Galleries ... 283
10.3.7 Parallel Separation ... 283
10.3.7.1 Low Voltage Cables ... 283
10.3.7.2 Medium Voltage Cables ... 283
10.3.7.3 Telecommunication Cables ... 283
10.3.7.4 Water Steam ... 284
10.3.7.5 Oil Pipe Lines ... 284
10.3.7.6 Sewers ... 284
10.3.7.7 Fuel Storage Tanks ... 284
10.3.7.8 Foundations of Other Services ... 284
10.4 Crossing of Roads and Railway tracks ... 284
10.4.1 Public Roads ... 284
10.4.2 Railroad tracks ... 284
10.4.3 Crossing Other Services ... 284
10.4.4 Low Voltage Cables ... 284
10.4.5 Medium Voltage Cables ... 284
10.4.6 Telecommunication Wires ... 285
10.4.7 Water Steam ... 285
10.4.8 Gas ... 285
10.4.9 Sewers ... 285
10.4.10 Fuel Depots ... 285
10.4.11 Transporting Cable Drums ... 285
10.4.12 Laying of the Cable ... 286
10.4.13 Mechanical Protection ... 286
10.4.14 Warning Signs ... 286
10.4.15 Identification ... 286

10 PARTICULAR TECHNICAL SPECIFICATIONS CABLES

10.1 General

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

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

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

10.1.2 Conductors

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

10.1.3 Cable

The conductor shall be covered with:

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

10.1.3.1 Laying-up and Fillers of Three Phase Cables

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

10.1.3.2 Manufacturer's Identification

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

10.1.3.2 Amour

All cables shall be steel wire armoured according to approved manner and international IEC/BS standards

10.1.4 Testing

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

10.1.5 Sealing and drumming

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

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

10.1.6 Current carrying Capacity and Design Parameters

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

10.1.7 Terminations

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

The terminations for the cables shall be of an appropriate heat shrink design incorporating a suitable arrangement for stress control, and rain sheds for outdoor use.

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

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland

10.1.8 Heat Shrink Materials

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

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

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

10.2 Installation

This extract from KPLC’s “Medium Voltage Underground Distribution Handbook” determines the minimum acceptable conditions for installation of Underground cables.

a.2.1 General

The cables will be laid in trenches that will be as straight as possible avoiding sharp bends.

The areas where trenches are to be excavated will be marked clearly on the ground. If the location of other services is known, they will be marked in order to take necessary precautions.

Before construction commences trial pits will be made in order to confirm the soil strata of the planned trenches and to confirm the location of other services.

Safety precautions such as covering the trench, fencing and warning signs will have to be provided for during the period of work.

When designing the plan for the trench layout, the minimum radius will be as in the following table.

Table 10.1: Bending Radii

Bending radii	Single core	3-core
Recommended	17xD	15xD
Minimum	15xD	12xD
At sealing ends	12xD	10xD

D = cable diameter

a.2.2 Cable Marker

Cable markers shall be installed at the beginning and end of the cable run on the surface all along the route, at all changes of direction, and above all joints, above cable duct entries and exits and at an interval not exceeding 50m along the cable route as approved by the Project Manager. This information as well as details about the joint (i.e. joint location) will be also recorded on a map.

10.3 Excavation of Trenches

The trench will be dug vertically to a minimum depth of 600mm or more as required. All precautions must be made so as not to cover any services e.g. fire hydrants with soil that may be encountered in the path of the trench.

During construction on public roads passage and access of motorists and pedestrians to commercial areas must be maintained.

In order to reduce the cost of reinstatement on roads and pavements the digging shall be done at intervals of 2-3 m and a gallery or tunnel dug underneath.

If trenches are constructed in soggy or inconsistent soil, the cables will be laid inside a duct as a protective measure and precautions taken to prevent the entry of water at the ends or joints of the ducts

The bottom of the trench must be made of firm material in order to prevent collapse of the base that may subject the cable to mechanical stress.

When several cables of different voltages are laid in the same trench they will be placed at different depths. The cables of the higher voltage will be placed deepest.

Where the trench is too deep as to cause instability to the walls of the trench shoring will be placed to provide lateral support to the trench walls.

The separation between two groups of cables will be a minimum of 250mm. If this separation cannot be attained, they will be laid in ducts or will be separated by a layer of bricks.

10.3.1 Joint Holes

Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

10.3.1.1 Laying of the Cable

The cable drum will be installed on the site in such a way that the cable is reeled out of the top part of the drum and is not forced when the cable is laid.

During cable laying the drum will always be supported by means of a mechanical jack and a bar of the appropriate strength.
The base of the jacks will be sufficiently large as to ensure stability during operation.

When taking off the wood stoppers care must be taken to ensure that the material used in nailing them does no damage to the cable.

The cables must always be unrolled and laid with the greatest care to avoid torsion or kinks and always maintaining the correct bending radius of the cables.

When the cables are being laid the workers must be distributed uniformly along the trench. The cables should

Necessary cable trenches shall be prepared instead to the satisfaction of the client's project Manager

10.3.2 Backfilling of Trenches

Once the cable has been laid the trenches must be back filled to an adequate compaction level. Care must be taken to ensure that the first layer will be free of rocks or any sharp mechanical objects.

The back fill will be laid in layers of 150mm, which should be compressed and watered if necessary, in order to make the soil sufficiently compact.

10.3.3 Pavement Reinstating

The pavement shall be reinstated back to the standard of the original pavement. New materials will generally be used in accordance with Municipal regulations.

10.3.4 Ducts

Road crossings, when necessary, will be done with ducts in the following manner

b) they will be installed in a level position and concreted where possible to provide mechanical protection throughout its length, they will have a depth of 1.2m.
c) future expansion will be provided for by providing one or several spare ducts depending on the location of the crossing.
d) at all times the cables should be adequately protected.
e) road and railway crossings must be planned in full detail.
f) drainage of the trenches must be provided for during and after construction

In crossings with other normal underground services, a prudent distance will be maintained in view of future excavations, and when there is a possibility of service interference, as is the case of other electric cables, waste water sewers etc.

The ducts will be fabricated from PVC or concrete with a smooth interior surface and an interior diameter of not less than 2 times the diameter of the cable to be housed inside it, and in no case will this diameter be less than 150mm.

The joints of ducts will be sealed with cement, in which case the bottom of the trench must be carefully levelled after setting down a layer of fine sand or red soil in order to permit continuous joints.

The ducts will be laid in such a manner that there is no abrasion between the insulation of the cable and the surface of the duct.

In the cases of single core cables the cable will have to be anchored to prevent movement due to magnetic effects by concreting the ducts at the ends of the joints. This shall not apply to three core cables.

When constructing a duct a length of wire will be left inside to facilitate the fitting of cleaning elements as well as the cables themselves.

The cleaning will consist of passing inside a cylinder in order to remove concrete that will pass through the joints and later passing a broom or a rag to remove the residue.

also be laid using cable rollers.

10.3.5 Direct Burying of Cables

For armoured cables the following criteria for burial will be met:

- the trench must have a 150mm layer of fine sand upon which the cable shall be laid to protect the cable from mechanical damage due to sharp objects. On top of the cable another 150mm of fine sand will be laid. Both layers will cover the entire width of the trench.
- the sand should be well graded
- any materials used for back filling the trench must meet the approval of the KPLC Construction Supervisor in charge.
- the cables must be buried at a depth of not less than 600mm. Exceptions could be made for rocky areas where the minimum depth cannot be attained in this case the cable will be laid in a duct.

Cables must be protected with a layer of protecting slabs, which will also indicate their presence.

For armoured cables the excavated materials without mechanically sharp objects will be adequate enough to backfill the trench.
Cables shall not be buried in areas within the substation boundaries.

10.3.6 Galleries

When the number of cables justify the use they shall be laid in galleries. The cables will be fixed to the cable trays by means of brackets or clamps.
All metallic elements will be earthed with independent connectors if there are circuits of different voltages. Electric cables will not be installed where there are inflammable materials.

10.3.7 Parallel Separation

10.3.7.1 Low Voltage Cables

Medium Voltage cables may be laid parallel to Low voltage cables as long as there is always a minimum distance of 250 mm between them. When this distance cannot be attained, a solid brick wall shall separate them or they will be placed in ducts.

10.3.7.2 Medium Voltage Cables

The distance to be maintained in the case of parallel situations of underground Medium Voltage lines is 250mm. If this distance cannot be achieved a protective brick wall will be installed between them, or one of them will be installed within ducts.

10.3.7.3 Telecommunication Cables

In the case of parallel laying of subterranean electric cables and telecommunications wires, they must be as far as possible from each other. As long as the cables both electric and telecommunications are buried, a minimum separation of 2 meters must be maintained at all times. This distance could be reduced further to 250mm between ducts.
The clearances must be in accordance with agreements between KPLC and Telecommunication services

10.3.7.4 Water Steam etc.

In parallel layouts between power cables and buried water pipes a minimum distance of 0.5m will be maintained in a horizontal projection. If these clearances cannot be maintained the cables will be laid in ducts.

10.3.7.5 Oil Pipe Lines

The minimum distance between the cables and the oil pipelines will be 0.5 m. The cable will be protected from any gas leaks.

10.3.7.6 Sewers

In parallel layouts of electric cables with sewerage conduits, a minimum distance of 0.5 m will be maintained, the cables will be adequately protected if this distance cannot be maintained.

10.3.7.7 Fuel Storage Tanks

There will be a minimum distance of 1.20 meters between cables and fuel storage tanks, apart from providing adequate protection for the electric cables.

10.3.7.8 Foundations of Other Services

When there are structural supports for public transport, suspended telecommunication wires, street lighting, the electric cables will be laid at a distance of at least 500mm from the outer extremities of the supports or foundations of the structures. This minimum distance shall further be increased to 1.5m if the support or foundation is subject to continuous stress towards the curb sides.

If this separation cannot be maintained a resistant mechanical safety measure must be used throughout the length of the support and its foundation, extending to a length of 500mm, on both sides of outer extremes.

10.4 Crossing of Roads and Railway Tracks

10.4.1 Public Roads

When crossing streets and roads cables must be laid at depths of at least 1.2m. The ducts must be durable and mechanically strong, and must have a minimum diameter of 150mm in order to permit the easy passage of the cables within the tubes. Conditions specified in the Electric Power Act must be observed at all times. Spare ducts must be provided where necessary.

10.4.2 Railway tracks

Crossing railroad tracks must be done with conduits laid perpendicular to the tracks at a minimum depth of 1.6 m. This depth must be measured from the bottom side of the track’s crossbars. It is recommended that the crossing takes place at the narrower points of railroad areas. Conditions specified by municipalities and the Railroad companies shall take precedence.

10.4.3 Crossing Other Services

Any other services to be closed by the lines shall meet the recommended clearances as per IEC standards.

10.4.4 Low Voltage Cables

When medium voltage cables cross low voltage cables, a minimum distance of 250mm must be kept between them. If this cannot be achieved, medium voltage and low voltage cables must be separated by pipes, conduits, or solid brick divisor walls.

10.4.5 Medium Voltage Cables

When crossing other medium voltage cables, the minimum distance to be observed between them is 250mm. If this distance cannot be maintained solid bricks must be laid between them.

10.4.6 Telecommunication Wires

When crossing telecommunication wires, the electric cables must be situated within conduits of appropriate mechanical resistance, maintaining a minimum distance of at least 250mm, between the outer sides.

The electric cable must be protected in PVC or concrete duct and in such a way that it guarantees that the distance between the cables is greater than the minimum established for parallel layouts.

The crossing must be at least 1m from a junction box for telecommunications wires and joints for electric cables will not be installed next to crossings of telecommunications cables.

10.4.7 Water Steam etc.

There should never be a water pipe joint over the cable. A water pipe joint must be at least 2.0 m from a crossing.

10.4.8 Gas

The minimum distance in crossings with gas pipelines shall be of 250mm. The crossing shall not be made over gas pipelines joints.

10.4.9 Sewers

In crossing sewage pipes, it is recommended that the electric cable should be above the sewer line where possible.

10.4.10 Fuel Depots

Electric cable crossings over fuel deposits will be avoided at all times, the electric cables must be laid bordering the fuel tanks, maintaining a minimum distance of 1.2 meters.

10.4.11 Transporting Cable Drums

Loading and unloading from trucks or appropriate trailers will always be made through an adequate bar that passes through the centre of the cable drum.

The cable drums will always be transported upright and never on its side.

When several cable drums are transported together, they must be aligned back to back and have stopping blocks to prevent movement.

The stoppers should be uniform so that they do not pierce the cable insulation. The stoppers should span the whole length of the cable drum.

An alternative to stoppers may be to have wooden pieces nailed to the platform supporting cable drums. The stoppers will be placed at the reels of the cable drums.

The cable drum must not be tied down with ropes, cables or chains. Upon off-loading the cable drum, the roll must not drop down from the truck or trailer, a provisional ramp with an inclination of not more than 1/4 will instead be constructed in the case where there are no pulleys for lifting the drum. The roll can be rolled of the ramp by means of guide ropes. Sand can be placed at the bottom of the ramp to act as shock absorber and brake for the cable drum.

When rolling the drum on the ground the rotational direction must be observed so that the cable does not come loose.

When the drum is rolled care must be taken to ensure that the drum is not rolled on rough ground. Care must also be taken to ensure the reel is not broken because the splinters can puncture the cable.

Where possible the cable drums should not be exposed to the elements.

10.4.12 Laying of the Cable

The cable drum will be installed on the site in such a way that the cable is reeled out of the top part of the drum and is not forced when the cable is laid.

During cable laying the drum will always be supported by means of a mechanical jack and a bar of the appropriate strength.
The base of the jacks will be sufficiently large as to ensure stability during operation.

When taking off the wood stoppers care must be taken to ensure that the material used in nailing them does no damage to the cable.

The cables must always be unrolled and laid with the greatest care to avoid torsion or kinks and always maintaining the correct bending radius of the cables.

When the cables are being laid the workers must be distributed uniformly along the trench. The cables should also be laid using cable rollers.

10.4.13 Mechanical Protection

Underground electric lines must be protected against possible breakdowns caused by landslides, contact with hard bodies, and clashing of metal tools. For this purpose, a protective layer of Hatari slabs of class 15 concrete will be placed.

10.4.14 Warning Signs

All cables must have a protection slab placed over the cables buried at least 200 mm above the cable layer. When the cables or groups of cables of different voltages are placed in vertical layers the protection slab must be placed over each layer.

10.4.15 Identification

The cables must bear marks indicating the year of manufacture, manufacturer’s name, and cable characteristics (size and voltage level).

GUARANTEED TECHNICAL PARTICULARS

FOR

MAJOR MATERIALS AND EQUIPMENT

10 GUARANTEED TECHNICAL PARTICULARS.. 289
Preamble 289
Schedule 1: Guaranteed technical particular - Phase conductor 290
Schedule 2: Guaranteed technical particulars -Outdoor circuit breakers...291
Schedule 3: Guaranteed technical particular- Disconnector/Isolators 293
Schedule 4: Guaranteed technical particular - Outdoor Current transformers 295
Schedule 5: Guarantees technical particulars -Outdoor Voltage transformers 296
Schedule 6A: Guarantees technical particulars -Composite Insulators (Tension & Suspension) …………………..297
Schedule 6B: Guarantees technical particulars -Composite Post Insulators (Vertical and Horizontal) 298
Schedule 6C: Guaranteed Technical Particulars Pin Insulators ………………………………………..299
Schedule 7: Guarantees technical particulars – Surge Arrestors 300
Schedule 8: Guaranteed technical particulars -110V and 48V Batteries 301
Schedule 9: Guaranteed technical particulars – 110V and 48V Battery Chargers 304
Schedule 10: Guaranteed technical particulars –Concrete Poles 306
Schedule 11: Guaranteed technical particulars – Power transformer 307
Schedule 12: Guaranteed technical particulars - Distribution transformers………………………………311
Schedule 13: Guaranteed technical particulars - Protection IEDs (Relays)... 313
Schedule 14: Guaranteed technical particulars -OPGW 324
Schedule 15: Guarantee technical particulars - Measuring Instruments...326
Schedule 16: Guaranteed technical particulars- LV cables 327
Schedule 17: Guaranteed technical particulars- Auto reclosers…..329
Schedule 18: Guaranteed technical Particulars - Earthing conductor… 331
Schedule 19: Guaranteed technical Particulars - RTU Panel…..333

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11. GUARANTEED TECHNICAL PARTICULARS

11.1 Preamble

11.1.1 The Guaranteed Technical Particulars Schedules MUST be filled in, signed and stamped by manufacturer for each LOT and submitted with the bidding document. Type test reports and Certificate of Accreditation from testing body/Laboratory MUST be provided for evaluation. Also, all relevant manufacturer's equipment technical documents MUST be provided for reference to support the guaranteed values.

11.1.2 Bidder shall offer only one type of equipment/material for each of the equipment/material required and from ***one manufacturer only.*** No more than one equipment/material of each type required shall be offered from more than one manufacturer. Where the bidder offers more than one equipment/material of one type from different manufacturers contrary to this clause, the employer shall choose ***only one of the equipment for evaluation***. All other equipment shall not be considered.

11.1.4 Only guaranteed technical particulars provided herein shall be filled **(*Do not fill technical guarantees in the attachments of KPLC material specifications).***

11.1.5 All data entered in the Guaranteed Technical Particulars are guaranteed values by the manufacturer and shall not be departed from whatsoever.

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SCHEDULE 1: GUARANTEED TECHNICAL PARTICULAR - PHASE CONDUCTOR

GURANTEES FOR PHASE LINE CONDUCTOR			Guaranteed Value			Ref. Doc
Item	**Particulars**	**Unit**	**75mm^2**	**150mm^2**	**300mm^2 AAAC**	
1	**Phase Stranded conductor**					
	Manufacturer and Country of manufacture					
	Year of service outside the country of manufacture (5 years Minimum)	Years				
	Manufacturing experience (7 years minimum)	Years				
	Type of Conductor/Code Name	State				
	Reference IEC/BS Standards	State				
	Type test reports and Accreditation certificate	State				
	Aluminium wire	Nos/mm				
	Steel wire	Nos/mm				
	Overall conductor diameter	mm				
	Nominal cross-sectional area of conductor	mm^2				
	Minimum current rating	A				
	Cross-section of Aluminium area	mm^2				
	Cross-section of Steel area	mm^2				
	Weight per km	kg				
	Rated tensile strength	KN				
	Maximum DC resistance at 20 ^oC	Ω/m				
	Maximum AC resistance at 75 ^oC	Ω/m				
	Resistivity at 20 ^oC	mm^2/m				
	Continuous max. operating temperature	^oC				
	Modulus of Elasticity	kg/mm^2				
	Conductor lay	state				
	Minimum weight of grease	Kg/km				
	Length of conductor per drum	m				
	Approximate net weight per drum	kg				
2	**Individual wires before stranding**					
	Tolerance of diameter of Aluminium wire	%				
	Tolerance of diameter of Steel wire	%				
	Minimum tensile strength of Al. wire	kg/mm^2				
	Minimum tensile strength of Steel wire	kg/mm^2				
	Conductivity of AL	%				
	Minimum twisting number of steel wire: -100 x diameter (length)	Nos.				
	Galvanization: - Min. coating weight of Zinc	grams/m^2				

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SCHEDULE 2: GUARANTEED TECHNICAL PARTICULARS - OUTDOOR CIRCUIT BREAKERS

GURANTEES FOR OUTDOOR CIRCUIT BREAKERS			Guaranteed Values		Refer. Doc
Item	**Particulars**	**Unit**	**11KV**	**33 KV**	
1	Circuit Breakers type (Model)	State			
2	Manufacturer and Country	State			
3	Reference IEC/BS Standards	State			
4	Year of service outside the country of manufacturer (5ears minim)	Years			
	Manufacturing experience (10 years minimum)	Years			
5	Operating service conditions (Altitude and temperature)	State			
6	Type test reports and Accreditation certificate	State			
7	Arc quenching Medium	State			
8	Pole design operation (ganged)	State			
9	Tank design type	State			
10	Highest rated voltage	kV			
11	Nominal rated Voltage	kV			
12	Rated frequency	Hz			
13	Rated continuous current at 40 ^{o}C	A			
14	Lightning Impulse withstand voltage 1.2/50µs	kVpeak			
15	One minute power frequency withstand voltage, dry and wet	kVrms			
	Rated short-time (short circuit) current/3sec.	kArms			
	Rated short circuit making current for 3 Sec	kApeak			
16	Maximum contact resistance of Main Contact	Ohms			
17	Rated operation Sequence	State			
18	Rated Current Breaking capacity	kApeak			
19	Bushing type	State			
20	First pole to clear factor	State			
21	Minimum creepage distance of Insulator	mm			
22	Minimum clearance between phases	mm			
23	Minimum clearance to Earth	mm			
24	Opening time	State			
25	Closing time	State			
26	Operating mechanism type	State			
27	Rated control voltage Tripping/Closing coil	Vdc			
28	Spring charging motor/Control voltage	Vdc			

29	Main contact material	State			
30	Charging spring status indication	State			
31	Terminal connector material (Tinned Bi-metallic)	State			
32	Number of Auxiliary contacts (NO and NC)	No			
33	Minimum Operations permissible before maintenance	No			
34	Manual ON and OFF operation Switch	State			
35	Anti-Pumping device	State			
36	Auxiliary supply (Single phase)	State			
37	Circuit Breaker Position Indication	State			
38	Heaters and Hygrometer	State			
39	Mechanical Trip/Close device	State			
40	Control cubicle IP Class	State			
41	Control cubicle powder coating colour shade	State			

SCHEDULE 3: GUARANTEED TECHNICAL PARTICULAR FOR ISOLATORS WITH/WITHOUT EARTH SWITCH

Item	Particulars	Unit	Guaranteed Value		Refer. Doc
			11 KV	33 KV	
1	Disconnector type/Model	State			
2	Manufacturer and country	State			
3	Disconnector design type (Double side break and horizontally opening)	State			
4	Operating service conditions (Altitude and temperature)	State			
5	Reference Standards	State			
6	Type test reports and Accreditation certificate	State			
7	Manufacturing experience (10 years minimum)	Years			
8	Years of service outside country of manufacture (5 years min)	Years			
9	Rated Voltage	kV			
10	Nominal voltage	kV			
11	Lightening Impulse withstands voltage 1.2/50ms				
	Contacts Closed	kV peak			
	Contacts Open	kV peak			
12	Rated Power frequency withstand Voltage(Wet and dry)				
	Contacts Closed	kVrms			
	Contacts Open	kVrms			
13	Rated frequency	50 Hz			
14	Rated Continuous operating current	Amps			
15	Rated short circuit withstand current for 3 seconds	KA/3Sec			
16	Minimum creepage distance of Insulators	mm			
17	Mechanical endurance (Min. Open–Close)	Cycle			
18	Maximum open and Closing time	Seconds			
19	Drive mechanism Motor protection	State			
20	Contact resistance of Main contacts	micro-Ω			
21	Main contact material (Tinned Copper)	State			
22	Thickness of Silver/Tin coating	microns			
23	Isolator Mechanical handle	State			
24	Electrical and mechanical operations before maintenance	State			
25	Motor Control Voltage	Vdc			
26	Auxiliary supply (Single phase)	Vac			
27	Integral earths Switch where required	State			

Item	Particulars	Unit	Guaranteed Values		Refer. doc.
28	Earth switch Mechanical and electrical operation before maintenance	State			
29	Earth Switch mechanical handle	Provide			
30	Isolator and Earth switch mechanical interlock (Available /Not available)	State			
	Isolator and Earth switch Electrical interlocks (Available/not Provided)	State			
31	Minimum no. of spare Auxiliary NO and NC contacts	Nos			
32	Control Box IP degree of protection	State			
33	Padlocking facility required	State			
34	Thickness of zinc galvanization of ferrous parts	State			
35	Earthing points	State			
36	Insulator material (Brown glazed porcelain)	State			

SCHEDULE 4: GUARANTEED TECHNICAL PARTICULAR - OUTDOOR CURRENT TRANSFORMERS

Item	Particulars	Unit	Guaranteed Values		Refer doc
			11KV	33 KV	
1	Current transformer type (Oil-hermetically sealed)	State			
2	Manufacturer and Country	State			
	Manufacturing experience (10 years minimum)	Years			
3	Service operating conditions (Altitude/Temperature)	State			
4	Years of service outside country of manufacture(5 years min.)	Years			
5	Type test reports and Accreditation certificate	State			
6	Reference IEC/BS standards	State			
7	Rated Highest voltage	kV			
8	Nominal Voltage	kV			
9	Current transformer tank design type (Dead tank)	State			
10	Rated frequency	Hz			
11	One-minute Power frequency withstand Voltage				
a	Primary winding	kVrms			
b	Secondary winding Insulation level	kVrms			
12	Lightning impulse withstand voltage 1.2/50µms	kVpeak			
13	Primary Rated currents ratios	A			
14	Rated secondary current	A			
15	CTs Core, Class and Burden	Core 1 Core 2 Core 3 Core 4			
16	Short circuit withstand current for 3seconds	kA peak			
17	Safety factor	State			
	Instrument Security factor	State			
18	Maximum Temperature rise (Winding/Oil)	State			
19	Number of cores	No			
20	Primary and Secondary winding material	State			
21	Primary terminal material	State			
22	Bushing type	State			
23	Minimum creepage distance of insulator	mm			
24	Secondary and Primary Earthing points	State			
25	IP Class of terminal box	State			
26	Marking/Labelling	State			

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SCHEDULE 5: GUARANTEED TECHNICAL PARTICULARS - OUTDOOR VOLTAGE TRANSFORMERS

GURANTEES FOR 33 AND 11KV VOLTAGE TRANSFORMER					
Item	**Particulars**	**Unit**	**Guaranteed Value**		**Refer. doc.**
			11KV	**33KV**	
1	Voltage transformer type	State			
2	Manufacturer and Country	State			
	Manufacturing experience (10 years minimum)	Years			
3	Years of service outside country of manufacture (5 years Min.)	Years			
	Service operating conditions (Altitude and temperature)	State			
4	Type test reports and Accreditation certificate	State			
5	Reference IEC/BS standards	State			
6	Rated Highest voltage	kV			
7	Nominal Voltage	kV			
8	Voltage transformer tank design type	State			
9	Rated frequency	Hz			
10	One-minute Power frequency Voltage withstand	State			
a	Primary winding	kVrms			
b	Secondary winding Insulation level (minimum 2.5kV)	kVrms			
11	Lightning impulse withstand voltage 1.2/50µs	kVpeak			
12	Short circuit withstand current for 3 Seconds	kApeak			
13	Burden and Accuracy class	State			
14	Number of cores	State			
15	Protection winding Class, Burden at 0.8Pf lagging	State			
16	Measuring winding Class and Burden at 0.8Pf lagging	State			
17	Voltage Ratio (Primary/Secondary)	State			
18	Maximum Temperature rise (Winding/Oil)	State			
19	Rated Voltage safety factor	State			
20	Instrument Security factor	State			
21	Permissible partial discharge (PD): PD test Voltage (r.m.s) = $Um/\sqrt{3}$ PD test Voltage (r.m.s) = $1.2Um\sqrt{3}$	State			
22	Primary and secondary winding material	State			
23	Primary terminal	State			
24	Bushing type (Brown glazed porcelain)	State			
25	Minimum creepage distance	mm			
26	Secondary and Primary Earthing Point	State			
27	IP Class of terminal box	State			
28	Markings/Labelling	State			

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SCHEDULE 6A: GUARANTEED TECHNICAL PARTICULARS FOR COMPOSITE INSULATORS (TENSION AND SUSPENSION TYPE)

Item	Particulars	Unit	Guaranteed Value				Refer Doc.
			Suspension type		Tension type		
			11KV	33KV	11KV	33 KV	
1.	Insulator type (Polymeric)	State					
2.	Design type/Model	State					
3.	Manufacturer and Country	State					
4.	Reference IEC/BS Standards	State					
5.	Service operating condition	State					
6.	Manufacturing experience (10 yrs min.)	Years					
7.	Year of service outside country of manufacture (5 yrs min.)	Year					
8.	Type test reports and Accreditation certificate	Provide					
8.	Rated highest Voltage (kV)	kV					
9.	Nominal Voltage	kV					
10.	Failing tensile load/strength	KN					
	Cantilever failing load	KN					
11.	Pollution Category	State					
12.	Dielectric material	State					
13.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}					
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}					
15.	Minimum creepage distance	mm					
16.	Insulator Housing characteristics						
	One-minute power frequency withstand voltage, 50Hz, wet and dry	kV_{rms}					
	Lighting impulse withstand voltage, 1.2/50µs wet	kV_{peak}					
17.	Short circuit withstand current for 3sec	kA					
18.	Housing shield resistance	kΩ					
19.	Permissible head load (Static)	N					
	Permissible head load (dynamic)	N					
21.	Insulator of fittings	Provide					
22.	Material of housing and sheds (HTV silicon)	State					
23.	Minimum distance between sheds	State					
24.	Zinc coating thickness of ferrous parts	State					
25.	Colour of final insulator housing	State					
26.	Minimum sheath thickness of Silicon	State					

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SCHEDULE 6B: GUARANTEED TECHNICAL PARTICULARS FOR POST INSULATORS (VERTIVAL/HORIZONTAL)

Item	Particulars	Unit	Guaranteed Value		Refer Doc.
			11KV	33KV	
1.	Insulator type (Polymeric for Line)	State			
	Insulator type Porcelain for Substation)	State			
2.	Design type	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Service operating conditions (Altitude and temperature)	State			
6.	Manufacturing experience (10 years min)	Years			
7.	Year of service outside the country of manufacture (5 years min.)	Year			
8.	Type test reports and Accreditation certificate	Provide			
9.	Rated highest Voltage (kV)	kV			
10.	Nominal Voltage	kV			
11.	Maximum Mechanical failing Load	KN			
12.	Pollution Category	State			
13.	Dielectric material (Silicon rubber)	State			
14.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}			
15.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
16.	Minimum creepage distance	mm			
17.	Nominal total height	mm			
18.	Short circuit withstand current/3sec	kA			
19.	Housing shield resistance	kΩ			
20.	Shed spacing–projection ratio	state			
	Minimum distance between sheds	mm			
21.	Creepage clearance ratio	State			
22.	Cantilever failing load	kN			
23.	Maximum Puncture rated voltage	kV			
24.	Insulator of fittings	Provide			
25.	Minimum sheath thickness	mm			
26.	Material of housing and sheds	State			
27.	Minimum distance between sheds	State			
28.	Zinc coating thickness on ferrous parts	State			
29.	Colour of final insulator housing	State			

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SCHEDULE 6C: GUARANTEED TECHNICAL PARTICULARS FOR 33 AND 11KV PIN INSULATORS

Item	Particulars Specifications	Unit	Guarant Value		Refer Doc.
			33KV	11KV	
1.	Insulator Type (Polymeric)	State			
2.	Design type	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Manufacturing experience (10 years min)	Years			
6.	Year of service outside the country of manufacture (5 years min)	Year			
7.	Type test reports and Accreditation certificate	Provide			
8.	Rated Highest Voltage (kV)	kV			
9.	Nominal Voltage	kV			
10.	Maximum Mechanical failing Load	kN			
	Maximum bending load and Cantilever load	kN			
11.	Pollution Category	State			
12.	Dielectric material (Silicon rubber)	State			
13.	One-minute power frequency withstand voltage, 50Hz, wet and dry	kV_{rms}			
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
15.	Minimum creepage distance	mm			
16.	Nominal total height	mm			
17.	Short circuit withstand current/3sec	kA			
18.	Housing shield resistance	KΩ			
19.	Shed spacing –projection ratio	State			
	Minimum distance between sheds	mm			
20.	Creepage clearance ratio	State			
21.	Specified mechanical load, tension (Minimum)	kN			
22.	Insulator of fittings	State			
23.	Minimum sheath thickness	mm			
24.	Material of housing and sheds (HTV silicon)	State			
25.	Minimum distance between sheds	State			
26.	Zinc coating thickness on ferrous parts	State			
27.	Colour of final insulator housing	State			
28.	Minimum sheath thickness of Silicon	State			

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SCHEDULE 7: GUARANTEED TECHNICAL PARTICULARS FOR SURGE ARRESTORS

11KV AND 33KV SURGE ARRESTORS					
Item	**Particulars**	**Unit**	**Guaranteed Values**		**Refer. doc**
			11KV	**33KV**	
1	Surge arrestor type (Metal Oxide (MOV) Gapless	State			
2	Manufacturer and country of origin	State			
3	Service operating conditions (Altitude and temperature)	State			
4	Reference IEC/BS Standards	State			
5	Type test reports and Accreditation certificate	Provide			
	Manufacturers experience (10 years minimum)	Years			
6	Minimum years of service outside country of manufacture (5 years minimum)	Years			
7	Surge arrestor housing (Polymeric)	State			
8	Highest system Voltage (Um, KV)	kV			
9	Rated frequency	Hz			
10	Rated Voltage (Ur, KV)	kV			
11	Max, continuous Operating Voltage	kVrms			
12	Nominal discharge current	kA			
13	Nominal discharge current	kA			
14	Short circuit withstands current Asymmetrical peak	kA			
15	Maximum duration of Earth fault as per IEC 60099-4	Sec			
16	Long duration discharge class	A/µS			
17	Partial discharge	pC			
18	Energy discharge capability at Ur	KJ/KV			
19	Temporary Over voltage with stand for 1Sec.	kV rms			
20	Temporary Overvoltage withstand for 10 Sec.	kV rms			
22	Distribution and Discharge class	kA/Class			
23	Earth fault factor as IEC 60099-4	State			
24	Maximum response time/operation time	Micro-sec			
25	System Lightning Impulse withstand voltage 1.2/50µs	kV peak			
26	One minute System power frequency withstands Voltage, dry and wet	kV rms			
27	Short circuit current withstands	kA/3Sec.			
28	Housing shield resistance	kΩ			
29	Creepage distance	mm			
30	Maximum residual Voltage at steep lightning and switching impulse currents at;				
a	10kA (1/2µS)	State			
	40kA (80/20µS)	State			
b	500kA (30/70µS)	State			
	2kA (30/70µS)	State			
	Max. Lightning Impulse Protection Level	kVpeak			

31	Steep current impulse protection level	kVpeak			
32	Operation counter	State			
33	Leakage current meter/Indicator	State			
34	Mounting base type	State			
35	Number of units per complete insulator (1)	No			

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SCHEDULE 8: GUARANTEED TECHNICAL PARTICULARS FOR BATTERIES

48V AND 110 VDC VENTED NICKEL CADMIUM BATTERIES					
Item	**Particulars**	**Unit**	**Guaranteed Value**		**Refer doc.**
			110V/165Ah	**48V/100Ah**	
1	Battery type (Vented nickel- cadmium)	State			
2	Manufacturer and Country	State			
3	Reference IEC/BS Standards	State			
	Manufacturing experience (10 years min)	Years			
4	Year of service outside the country of manufacture (5 years min)	Years			
5	Type test reports and Accreditation certificate	State			
6	Ambient operating temperature	^oC			
7	Maximum operating temperature	^oC			
8	Rated Capacity at C_5 (5 hour rate) at 20^0C				
9	Discharge end voltage per cell at 20 ± 5^0C	V			
10	Battery unit design (one or Two cells per unit)	State			
11	Minimum number of cells per bank (92/40)	no			
12	Cell container (High grade translucent methacrylate butadiene styrene) as per IEC 60622)	State			
13	Container shape (prismatic /rectangular)	State			
14	Cell rated Voltage (IEC 60623 at 20 ± 5^oC)	State			
	Nominal Voltage	V			
	Float voltage	V			
	Boost voltage	V			
15	Design life span (minimum)	years			
16	Nominal charging current at 20 ^OC (Maximum)	A			
17	Nominal Charging voltage 20 ^OC	State			
18	Charge coefficient	State			
19	Internal Resistance	State			
20	Charge efficiency (minimum)	%			
21	Operating temperature range	State			
	a) Discharge	State			
	b) Charge	State			
	c) Storage	State			
22	Charging Current at 40^oC	State			
	265Ah battery (Maintenance /Boost)	A			
	165Ah battery (Maintenance /Boost)	A			
23	Positive plate material (Nickel hydroxide)	State			

24	Negative plate material (Cadmium hydroxide)	State			
	Terminal marking (+VE and –VE)	State			
25	Separator material (Layers of Polypropylene)	State			
26	Terminal Material (Nickel plated steel	State			
27	Electrolyte (Battery grade Potassium hydrochloride (As per IEC 60993)	State			
28	Reserve electrolyte per cell	State			
29	Anti-Splash Venting device with Flame arrestor, plugs and Clip cover	State			
30	Inter cell connection plates (Silver plated copper)	State			
31	Battery rack epoxy anti-acid coating	State			
32	Battery rack material (Phosphatized steel)	State			
33	Temperature monitoring device	State			
34	Technical data labelling on each battery	State			
35	Venting device	State			

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SCHEDULE 9: GUARANTEED TECHNICAL PARTICULARS FOR CHARGERS

110V AND 48V BATTERY CHARGERS					
Item	**Particulars**	**Unit**	**Guaranteed Value**		**Refer. Doc.**
			110 VDC	**48 VDC**	
1	Charger type/ Model	State			
2	Manufacturer and Country	State			
3	Reference IEC/BS Standards	State			
4	Year of service outside the country of manufacture (5 years)	Years			
	Manufacturer's experience (10 years min)	Years			
5	Type test report and Accreditation certificate	State			
6	Service condition	State			
7	Ambient operating temperature	^oC			
8	Maximum operating temperature	^oC			
9	Design type (Floor standing)				
10	Input Voltage 3phase (415V±10%) at 50Hz±5%	Vac			
11	48Vdc Charger output (Charging Voltage)				
	Nominal Voltage	V			
	Float Voltage Range	V			
	Boost Voltage	V			
12	48Vdc charger output current				
	Rated output current	A			
	Trickle current	A			
	Boast current	A			
13	110Vdc Charger output (Charging Voltage)				
	Nominal Voltage	V			
	Float Voltage Range	V			
	Boost Voltage	V			
14	110 VDC charger output current				
	Rated output current	A			
	Trickle current	A			
	Boast current	A			
16	Output Voltage Regulation (RMS) for the chargers				
	Float mode (+/- 1%)	V			
	Boost mode (+1% - 4%)	V			
	Full load and within the input supply limits (0- 100%)	State			
	Battery capacity (7%)	State			
17	Cooling (natural air convection)	State			
18	Operating temperature (-1 to 40^{o}C)	State			
19	Fault Protection (Earth and Short circuit)	State			
20	Reverse polarity protection	State			
21	Automatic current-limiting into load fault condition	State			
22	Current limiting protection to 100% full load	State			
23	Flush mounted measuring instruments (Digital/ Analogue/LCD)	State			
24	Controls for the chargers	State			

	AC On/Off mains input MCB	State			
	Manual float/boost selection switch	State			
	Ammeter and Voltmeter selector switch	State			
	Alarm cancellation/Reset push button	State			
25	Load supplies: At least 4 pairs protected with MCBs	State			
26	LED indications to display in front panel	State			
	Charger failure (output failure)	State			
	Mains supply failure	State			
	Indications for each phase supply	State			
	Boost charge On and failure	State			
	Float charge On and failure	State			
	Battery temperature cut off alarm	State			
	Battery Under and Over voltage	State			
	Positive and negative earth fault	State			
	a) Over current cut off Alarm	State			
	b) Main load MCB trip	State			
27	Audible Alarm annunciator for charge failure	State			
28	Bus bar material Copper/silver plated copper	State			
29	Auto change over from float to Boost charge	State			
30	Constant current Charging method	State			
31	Alarm repeat relay for remote communication	State			
32	Paint and shade (Powder coated, admiral grey color shade no. 632 of BS381C	State			

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SCHEDULE 10: GUARANTEED TECHNICAL PARTICULARS FOR CONCRETE POLES

LINE CONCRETE POLES				
Item	**Particulars**	**Employer's requirement**	**Guaranteed Value**	**Refer doc.**
1	Name and Address of the Manufacturer	State		
	Minimum years of manufacturing (7 years min)	State		
	Minimum years of poles service in Kenya (5 years min)	State		
	Model of the offered poles	State		
	Manufacturer's warranty and guarantee	Provide		
2	Sizes of the Poles Offered	State		
3	Reference Design Standard of manufacture	State		
4	Reference testing Standard	State		
5	Type of pole offered — Reinforced	State		
	Type of pole offered — Pre-stressed	State		
6	**Minimum poles requirement**			
a	Design Strength	State		
b	Quality of finish	State		
c	Admixture	State		
d	Mode of compaction	State		
e	Finished pole free from honeycombing	State		
7	Earthing (Conductor material size)	State		
8	Provision of Earthing Ferrules	State		
9	**Size and strength Class of poles**			
a	Pole taper	State		
b	Safety Factor	State		
c	Color of finished poles	State		
d	Manufacturing Capacity (units per month)	state		
e	Type Test Reports and Accreditation certificate	provide		
f	Type test Certificate from KBES as per ISO/IEC 17025	provide		
g	Acceptance tests to be witnessed by KPLC Engineers	List		

SCHEDULE 11: GUARANTEED TECHNICAL PARTICULARS FOR POWER TRANSFORMER

GUARANTEES FOR POWER TRANSFORMERS					
Item	Particulars	Unit	Guaranteed Value		Refer. Doc.
			2.5 MVA	7 .5 MVA	
1.	Power transformer Make/Model	State			
2.	Manufacturer and Country	State			
3.	Minimum Manufacturing experience (13 years)	Years			
4	Minimum years of service outside country of origin (7 years)	Years			
5.	Design Service operation conditions (Altitude and Temperature)	State			
6.	Type test reports and accreditation certificate	Provide			
7.	Reference IEC/BS standards	State			
8.	Transformer nominal capacity	MVA			
9.	Rated voltage and Frequency	kV/Hz			
10.	Vector Group as per given region	State			
11.	Nominal Voltage	kV			
12.	One-minute Power frequency Voltage withstand, 50Hz, 60 sec, wet				
	Primary winding Insulation level	kVrms			
	Secondary winding Insulation level	kVrms			
13.	Lightning impulse withstands voltage 1.2/50µs, wet +Ve	kVpeak			
	Primary winding	State			
	Secondary winding	State			
14.	Continuous maximum rating current on Nominal and extreme tapping at ambient temperature	A			
15.	Capacity during ONAN Cooling (Maximum)	MVA			
16.	Rated No-load voltage at rated frequency on:				
17.	HV, principal tapping	kV			
	HV, Highest tapping	kV			
	HV, Lowest tapping	kV			
	LV winding	kV			
18.	Tapping ranges from principal tapping				
	HV no of plus tappings	No			
	HV no of minus tappings	No			
	Neutral positions				
	HV steps in % of rated voltage	State			
19.	No-load losses at:				
	90 % rated voltage and frequency	kW			
	100% rated voltage and frequency	kW			
	110% rated voltage and frequency	kW			
20.	No-load current at rated voltage and frequency	A			
21.	Total No load loss (Core +Stray loss) at rated current at 75º C (%)	kw			
22.	Total losses at 75ºC on principal tapping at unity power factor and rated currents (ONAN)	Kw			
23.	Impedance at rated current and frequency at 75º C				
	Positive sequence at nominal tap	%			

	Positive sequence at Max. Voltage tap	%			
	Positive sequence at Min. Voltage tap	%			
24.	Maximum temperature rise on continuous operation at rated MVA for:				
	Top oil (by thermometer)	ºC			
	Windings (by resistance)	ºC			
25.	Efficiency at 75ºC on principal tapping, at unity power factor and at 0.8 pf lagging				
	120% full load	%			
	100% full load	%			
	75% full load	%			
	50% full load				
26.	Regulation at full load at 75ºC on principal tapping				
	At unity power factor:	%			
	At 0.8 power factor Lagging	%			
27.	HV, LV and Neutral windings insulation type	State			
28.	Maximum working flux density at rated voltage on principal tapping and rated frequency:	T			
29.	Core design type	State			
30.	Grade of laminated and maximum thickness	mm			
31.	Magnetizing current at nominal voltage at principal tapping	A			
32.	Maximum hot spot temperature of winding	ºC			
33.	Equivalent resistance referred to HV side	ohms			
34.	Equivalent reactance referred to HV side	ohms			
35.	Maximum current carrying capacity of bushings				
	HV bushings	A			
	LV bushings	A			
36.	Maximum noise level	State			
	Transformer and tap changing equipment energized and at no-load with ONAN cooling	dB			
37.	Number of core legs	State			
38.	Type of windings:	State			
	HV	State			
	LV	State			
39.	Winding conductor material (HV/LV/Neutral)				
40.	Bushing’s material (HV/LV/Neutral)	State			

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Item	Description	Unit	Guaranteed Value			Refer. Doc.
41.	Principal bushing insulator materials (HV/LV/Neutral)					
42.	Creepage distance of Bushing (HV/LV)					
43.	Thickness of transformer tank (Sides/Bottom/Top)	mm				
44.	Thickness of tank paint coating	mm				
45.	Type of Gasket material and Manufacturer	state				
46.	Transformer color coating (Admiral grey)	State				
47.	Thickness of radiator plates	mm				
48.	Thickness of radiator hot dip zinc galvanizing coat	micron				
49.	Number of radiators	No				
50.	Total weight of the transformer with and without oil	kg				
51.	Inspection manholes and sizes	No/mm				
52.	**On-load tap changer**					
53.	Model and manufacturer	state				
54	Type Vacuum (In-tank)	state				
55	Total number of tappings including principal	17				
56	Rated currents of					
57	Selector switch	A				
58	Diverter switch	A				
59	Resistors	A				
60	Driving motor power consumption	kW				
61	Driving motor (3-phase, 415Vac/50hz)					
62	Control cabinets with heaters					
63	Voltage regulating relay supply	Vdc /Vac				
64	Motor drive unit Control Voltage (230Vac/50Hz)	1phase				
65	Paralleling circuit wired, Master–Follower Mode of operation	State				
66	RTCC Panel with AVR relay	State				
	Off - Load Tap changer					
67	Model and manufacturer	State				
68	Number of off loads tappings including principal	5				
69	Rated currents of					
70	Selector switch	A				
71	Overall dimensions of transformer (LXWXH)	mm				
72	Winding and Top oil temperature indicators	State				
73	Pressure relief device	State				
74	Silica gel breathers	State				
75	Buchholz relays	State				
76	Alarms and trip to be provided including;	State				
	Oil/gas flow transformer, alarm	State				
	Oil/gas flow transformer, trip	State				
	Oil gauge low level, alarm	State				
	Oil gauge low level, trip	State				
	Top oil temp. high, alarm	State				

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	Top oil temp. critical, trip	State				
	Winding temp. high, alarm	State				
	Winding temp. critical, trip	State				
77	Temperature indicators required:	State				
	HV and LV winding	State				
78	Oil level gauges required	State				
	Main conservator tank	State				
79	Bushing CTS to be provided as per VOL. II Biding document works requirements	Required				

SCHEDULE 12: GUARANTEED TECHNICAL PARTICULTARS FOR AUXILIARY TRANSFORMER

AUXILIARY TRANSFORMERS 100KVA, 33/0.42 KV				
Item	**Particulars**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
1	Transformer Make/Model	State	100 KVA	
2	Manufacturer and Country	State		
3	Minimum years of service outside country of origin (7 years min)	Years		
	Minimum manufacturing experience (13 years min)	Years		
4	Design Service operating condition (Altitude and temperature)	State		
5	Type test reports and accreditation certificate	Provide		
6	Reference IEC/BS standards	State		
7	Transformer capacity	MVA		
	Highest rated voltage (HV/LV)	kV		
8	Rated Frequency	Hz		
9	Vector Group (Dyn11)	State		
10	Nominal Voltage (HV/LV)	kV		
11	One-minute Power frequency Voltage withstand			
	Primary winding	kVrms		
	Secondary winding (0.42)	kVrms		
12	Lightning impulse withstands voltage 1.2/50µs - Primary winding	kVpeak		
13	Continuous maximum rating on any tapping when operation under the ambient conditions	KVA		
14	**Off- load tap changer**			
	Rated Off-load Voltage at rated frequency on:			
	HV, principal tapping	kV		
	HV, extreme plus tapping	kV		
	HV, extreme minus tapping	kV		
15	Tapping ranges from principal tapping:			
16	HV no of plus tappings	No		
	HV no of minus tappings	No		
	Total tap positions (5)	No		
17	HV steps in % of rated voltage (± 2 x 2.5%)	%		
18	No-load losses at 75^{o} C	kw		
19	Load losses at 75^{o} C			
	50 % loading, rated voltage and frequency	kW		
	75% loading, rated voltage and frequency	kW		
	100% loading, rated voltage and frequency	kW		
	125% Loading, rated voltage and frequency	kW		
21	No-load current at rated voltage and frequency	A		
22	Total No load loss (Core +Stray loss) at rated current at 75^{o} C (%)	kw		

AUXILIARY TRANSFORMERS 100 KVA, 33/0.42 KV TRANSFORMER				
Item	**Particulars**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
23	Total load losses at 75^{o}C at rated currents	KW		
24	Impedance voltages at rated current, Unity power factor and frequency at 75^{o} C at nominal tap	%		
25	Max temperature rise at			
	i) Top oil	^{o}C		
	ii) Winding	^{o}C		
26	Efficiency at 75^{o}C on principal tap, at unity power factor and at 0.8 power factor lagging;			
	120% full load	%		
	100% full load	%		
27	HV and LV windings insulation type			
28	Maximum working flux density at rated voltage on principal tapping and rated frequency:	Tesla		
29	Core design type	State		
30	Grade of laminated CRGO and manufacturer	State		
31	Winding conductor material (HV, LV and Neutral)	Copper		
32	Bushing material (HV and LV)	State		
33	Total creepage distance for porcelain Bushing (HV/LV)	State		
34	Thickness of transformer tank (minimum)			
a	Corrugated sides	3.0mm		
b	Bottom	5.0 mm		
c	Top	5.0 mm		
35	Thickness of tank paint coating (minimum)	micron		
36	Finished transformer color (Admiral grey)	State		
37	Following devices shall be installed:			
	Pressure relief	State		
	Oil level indicator visible from ground	State		
	Non-standard Nuts/Bolts on top cover	State		
	Lifting lugs and Arcing horns	State		
38	Sound level at 100% Load	State		

SCHEDULE 13: GUARANTEED TECHNICAL PARTICULARS - PROTECTION IEDS (RELAYS)

SCHEDULE 13A: GUARANTEES FOR DISTANCE PROTECTION RELAY				
Item	**Particulars**	**Units**	**Guarat Value**	**Refer. Doc**
1.	Manufacturer's Name and Country	State		
	Type or designation name of Relay	State		
	Minimum of 10 years Manufacturing experience	state		
	Minimum of 5 years in service outside country of manufacture	state		
	Type test report and Accreditation certificate	Provide		
	Manufacturing reference standards	State		
	Ratings: Ac Inputs: 1-5Amp	State		
	Power Supply Voltage: 110VDC or (Universal 24-240Vdc).	State		
	Evidence of sales in 3 other continents outside the continent of manufacture (state Countries)	State		
	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
	Model design type (numerical)	state		
	Supported communication protocols 60870- 5-103, 61850-9-2	State		
	Mounting design (Flush)	State		
	suitable for use on a feeder in a 1&1/2 Breaker substation arrangement. (suitable/not suitable)	state		
2.	High speed output relays for circuit breaker opening (state no. of output relay).	State		
	Full Scheme Distance relay (scheme type)	state		
	Number of similar Relay sold to date to the export market: requirement; minimum number 1000	State		
	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
	Operating time for fast operating output relays	State		
	Operating time for other output trip relays	State		
3.	Tripping logic			
4.	Number of Zones of protection (state 1 or 2 or 3 or 4)	State		
5.	Zone Impedance Comparator Characteristics (state: mho, Quadrilatel.)	State		
6.	Impedance setting range for each Zone (state for Z1,Z2,Z3 and Z4)	State		
7.	Communication Aided Schemes for Distance Protection	state		
8.	Communication Aided schemes for Directional Earth Fault (DEF) Protection	state		
	Pick up setting range for the DEF element (state in amps)	state		
	Load Encroachment Discrimination feature(available/not available)	state		
9.	Fuse Failure Supervision (available/ not available)	state		
10.	Weak end in feed & Echo feature (available/not available)	state		
11.	Current reversal guard Feature(available/not available)	state		
12.	Power Swing Tripping & Blocking function(available/not available)	state		
13.	Voltage Memory Function (available/not available)	state		
14.	SOTF Function (available)	state		
	Settings range for the SOTF Function (time delay)	State		

15.	Back-up Overcurrent and Earth fault protection function	State		
	(available/not available)			
16.	Under-Frequency and rate of frequency change Protection function	State		
17.	Settings range for the Backup Overcurrent and Earth Fault Protection	state		
18.	Circuit Breaker contact wear feature(available/unavailable)	state		
19.	Broken Conductor detection(available/unavailable)	state		
20.	Auto-reclose Function that is able to operate as per the specifications	State		
21.	Accuracy for Distance to Fault Location (in %)	State		
	Automatic display of fault details on the Relay- List the fault data displayed	State		
22.	Storage capacity for disturbance records, trip/fault records and events records (No. of events and No of records)	indicate		
23.	Fault Locator with automatic Distance to Fault indication on the LCD screen in km. (available/unavailable)	state		
24.	Relay configuration & parameter settings, Event & Fault records and LED status are retained upon loss of relay DC Power supply	State		
25.	Metering provided	State		
26.	Number of Binary Inputs	State		
27.	Number of Binary outputs	state		
28.	Ratings for output relay contacts (current and voltage)	State		
29.	Number of LEDs	indicate		
30.	Communication protocols	state		
31.	Communication ports provided	State		
32.	Type and size of connection terminals for cable termination at the back of relay (type and diameter size)	state		
33.	Relay to Laptop connection cables offered (number and type).	state		
34.	Software for relay configuration and parameter setting and fault data Analysis offered with the relay in CD form.	indicate		

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Item	13 B: GUARANTEED TECHNICAL PARTICULARS FOR LINE DIFFERENTIAL RELAY			
	Particulars	**Employers' requirement**	**Guar. Value**	**Refer. Doc**
1.	Country of manufacture/origin			
2.	Manufacturer's Name	State		
3.	Type or Designation name of Relay	State		
4.	Test reports and accreditation certificate of testing laboratory	provide		
5.	mounting design (Flush)	state		
6.	Design (Numerical, modular, others)	State		
7.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
8.	Experience in manufacture of Line Current Differential relay (minimum 13years)	state		
9.	Minimum of 7 years of relay service outside country of manufacture	state		
10.	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
11.	Minimum operating current /relay sensitivity	State		
12.	Minimum operating time	State		
13.	Simultaneous Tripping at both ends of the line even with no in feed at one end.			
14.	Phase segregated measurement of current magnitude and phase angle (phase segregation available/unavailable)	State		
15.	High Speed relay operation suitable for protection of Transmission Line (high speed relay available, time of tripping)	state		
16.	Transformer Inrush restraint and ratio and phase angle compensation (available/unavailable)	State		
17.	Direct Transfer of Trip Function between the relays via fibre optical cable (available/unavailable)	State		
18.	Operates with directly connected fibre cables (direct connection/via multiplexer)	state		
19.	Differential Protection blocks upon loss of communication to prevent mal-operation (blocks/does not block)	State		
20.	Auto-reclose Function: Available modes of Auto-reclose (SPAR+DAR)	State		
21.	Integrated Distance Protection (available/unavailable)	State		
22.	Number of Zones for integrated distance Protection	State		
23.	Zone Impedance Comparator Characteristics (mho, quadrilateral, both)	state		
24.	Impedance Settings range for each Zone	State		
25.	Automatic Display on the LCD screen of Distance to Fault in km (available/unavailable)	State		
26.	Back up Overcurrent and Earth Fault Protection (available/unavailable)	State		
27.	Settings range for Back up Overcurrent and Earth fault Protection Elements (current range)	state		
28.	Storage capacity for **disturbance records**, **trip records** and **events record**	capacity for each		
29.	Metering capability (U,I,P,Q,S,F,F&CosØ)	State		
30.	Number of Binary Inputs	State		

31.	Number of Binary outputs	state		
32.	Ratings for relay output contacts (current, voltage)	state		
33.	Ratings for relay input contacts	State		
34.	Number of LEDs	State		
35.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/unavailable)	State		
36.	Communication protocols	State		
37.	Communication ports provided	state		
38.	Type and size of connection terminals for cable termination	state		
39.	Relay to Laptop connection cables offered	State		
40.	Software for relay configuration and parameter setting and fault data Analysis offered for use with the relay. Software to be offered in CD form	Indicate		

13 C: GUARANTEES FOR RESTRICTED EARTH FAULT RELAY				
Item	**Particulars**	**Units**	**Guarat. Value**	**Refer. doc**
1.	Manufacturer and country of origin name	State		
2.	Model and designation name of relay	indicate		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal24-240VDC).	State		
5.	Design type: Numerical conforming to protocol IEC 61850-8-1and Goose messaging	State		
6.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
7.	Relay must have been sold to other two continents outside continent of manufacture (give names of the continents)	state		
8.	Experience in manufacture of Restricted Earth Fault Relay (number of years of manufacture)	Years		
9.	Minimum of 10 years Manufacturing experience	state		
10.	Minimum of 5 years in service outside country of manufacture	state		
11.	Complete order number for offered Relay	State		
12.	Applicable for High Impedance operating principle	indicate		
13.	Minimum pick up & setting range	State range		
14.	Relay Operating time at 5 x setting current (time in seconds)	indicate time		
15.	Number of LEDs	State		
16.	Number of Binary inputs	State		
17.	Number of Binary outputs	State		
18.	Ratings of output relay contacts (current and voltage)	State		
19.	Keypad for relay parameter settings and data access (available/unavailable)	State		
20.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/unavailable)	State		
21.	Software for relay configuration and parameter setting. Software to be offered in CD form(yes/no)	Indicate		
22.	Connection cable from Laptop to Relay to be offered(yes/no)	Indicate		
23.	**Stabilizing Resistor**			
24.	Type and reference number of Stabilizing Resistor offered.	State		
25.	Setting Range of Offered resistor in Ohms (range in ohms).	State		
26.	Maximum through fault for the REF scheme calculation (in kA).	State		
27.	**Voltage Dependent Resistor (Metrosil)**			
28.	Type and reference number of Voltage Dependent Resistor (VDR) Metrosil offered. Rated voltage of VDR based on maximum fault current of 25kA.	State		
29.	Both Stabilising Resistor and Voltage dependent resistor are housed in a single box with external connection terminals suitable panel mounting.	State		
30.	Software for relay configuration and parameter setting	State		
31.	Communication cable from Laptop to relay offered	State		

SCHEDULE 13 D: GUARANTEES FOR 3PHASE UNIDIRECTIONAL OVERCURRENT & E/ FAULT RELAY				
Item	**Particulars**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or Model of the relay	type		
3.	Complete order number for offered Relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
7.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
8.	Experience in manufacture of Three Phase Overcurrent and Earth Fault relay (10 years minimum)	state		
9.	Years of Service outside country of Origin (Minimum 5 years)	state		
10.	Design (Numerical type)	State		
11.	Mounting design (Flush)	State		
12.	Protection Functions offered and parameters setting range for all protection elements	indicate		
13.	Time-current characteristics available for various Overcurrent, Earth fault elements and other protection elements	State		
14.	Broken Conductor Function (available/unavailable)	State		
15.	Under frequency Protection(available/unavailable)	state		
16.	Circuit Breaker contact wear feature(available/unavailable)	State		
17.	Number of LEDs provided	state		
18.	Number of Binary Inputs	state		
19.	Number of Binary outputs	state		
20.	Ratings of output relays contacts (current, voltage)	state		
21.	Communication ports (type and number)	state		
22.	Communication protocols	state		
23.	Circuit Breaker maintenance(available/unavailable)	state		
24.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/not available)	indicate		
25.	Configuration of Start and trip contacts (possible/not possible)	State		
26.	Storage capacity for disturbance, event and trip/fault records	State		
27.	Metering/Measurement capability (P,Q,I,V,CosØ)	Indicate		
28.	Size of LCD screen	State		
29.	Relay Keypad for relay parameter setting and data access	state		
30.	Software for relay configuration and parameter setting.	State		
31.	Connection cable from Laptop to Relay offered	state		
32.	Type and size of relay terminals for cable connection			

SCHEDULE 13 E: GUARANTEES FOR SENSITIVE EARTH FAULT RELAY				
Item	**Particulars**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of relay	Type		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 30-300VDC).	State		
5.	Experience in manufacture of SEF Relay (10 years minimum)	state		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1	State		
7.	Years of Service outside country of origin (5 years Minimum)	state		
8.	Complete order number for offered Relay	State		
9.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
10.	Current setting range for earth fault relay - 0.005In-0.8In	State		
11.	Definite time delay characteristic; Setting range, 0- 30 Seconds.	State		
12.	Circuit Breaker Maintenance function	State		
13.	Fault records, Event Records and disturbance records.	State		
14.	Drop off /pickup ratio >90%	State		
15.	Low transient overreach < 10%	State		
	Auto reclose function			
i.	Autoreclose function shall be enabled in the distance relay or in the overcurrent and earth fault rely	State		
ii.	Selectable 1 - 3 Autoreclose shots	State		
iii.	Independent set dead time for each shot	State		
iv.	Independent set dead time for each shot	State		
v.	Autoreclose inhibit after manual close	State		
vi.	Autoreclose inhibit for Overcurrent high set-element	State		
16	Connection cable from Laptop to Relay offered	state		
17	Software for relay configuration and parameter setting.	State		

13 F: GUARANTEES FOR BIASED DIFFERENTIAL RELAY FOR TWO WINDING TRANSFORMER PROTECTION				
Item	**Particulars**	**Units**	**Quart. Value**	**Ref. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of the relay offered	State		
3.	Complete order number of offered relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Mounting design (Flush)	State		
7.	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
8.	Design type numerical	State		
9.	Number of similar Relay sold to date to the export market: (requirement minimum number 1000)	State		
10.	Evidence of sales in 3 other continents outside the continent of manufacture (state countries)	State		
11.	Experience in manufacture of Biased Differential Protection relay (minimum 10 years)	state		
12.	Minimum of 5 years in service outside country of manufacture	state		
13.	Minimum operating current for biased differential /relay sensitivity and setting range	Indicate		
14.	Minimum operating time at 2 x setting	Indicate		
15.	Provision of unrestrained High-set differential element and setting range	Indicate		
16.	Magnetizing Inrush detection method(s) and settings range	Indicate		
17.	Provision of Integral CT correction ratio feature and setting range(available/unavailable)	State		
18.	Integral Vector Group compensation feature(available/unavailable)	State		
19.	Display of HV & LV differential and bias currents on the LCD screen(available/unavailable)	State		
20.	Storage capacity for Disturbance, Event and Trip/Fault records (disturbance, events and trips)	Indicate		
21.	Display of Fault currents on the LCD (available/unavailable)	State		
22.	Provision of over-fluxing Alarm and Trip functions	State		
23.	5^{th} Harmonic restraint feature and settings range	Indicate		
24.	Dual- Bias characteristics (available/unavailable)	State		
25.	Relay trip Indication by Red LED (available/unavailable)	State		
26.	No of Binary Inputs and Binary Outputs	State		
27.	Ratings of relay output contacts (current and voltage)	State		
28.	Number of LEDs	State		
29.	Ability to latch output contacts (available/unavailable)	State		
30.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/Unavailable)	Indicate		
31.	LCD screen and Keypad for programming relay parameter settings and data access(available/unavailable)	Indicate		
32.	Communication protocols	State		
33.	Communication ports provided	State		

34.	Type and size of terminals for cable connection	State		
35.	Software offered for relay configuration and programming	Indicate		
36.	Communication cable to Laptop (offered /not offered)	Indicate		
37.	Metering capability (U,I,P,Q,S,F,F&CosØ)	Indicate		

13 G: GUARANTEES FOR FEEDER PROTECTION AND BAY CONTROL IED				
Item	**Particulars**	**Units**	**Guara Value**	**Refer. Doc**
1.	Manufacture and country	State		
2.	Applicable protocol IEC 61850-8-1and Goose messaging	State		
3.	Model of the IED	State		
4.	Manufacturing reference standards	State		
5.	Ratings: Ac Inputs: 1-5Amp	State		
6.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
7.	Number of similar Relay sold to date to the export market: Required minimum1000 pcs	State		
8.	Experience of 10 years in manufacture of BCU/BCPU	state		
	Years of Service outside country of Origin (5 years minimum)	state		
9.	Numerical design (numeric)	State		
10.	Protection functions and features in the IED i. Three phase overcurrent ii. Earth fault iii. Sensitive Earth Fault iv. Broken Conductor detection v. 3phase Autoreclose function vi. Under and Over Frequency Protection	State		
11.	Earth Fault and Sensitive Earth Fault Protection in separate element	State		
12.	Earth Fault and Sensitive earth fault elements shall have separate CT Inputs.	State		
13.	Two stages of High Set Element for both overcurrent and earth fault protection function-setting range of 1-20In (minimum) and a definite time delay setting of 0-60 seconds (minimum).	State		
	Current setting range for overcurrent 0.5In-2.0In (minimum)	State		
14.	Current setting range for earth fault 0.05In-0.8In (minimum)	State		
15.	Auto reclose function: i. Three phases auto reclose ii. Selectable 1-3 autoreclose shots iii. Independently set dead time for each shot iv. Autoreclose inhibit after manual close v. Autoreclose inhibition for over current high set element	State		
16.	Minimum of eight (8) each LEDs for alarms and trip annunciation.	State		
17.	Binary inputs and Outputs- minimum twelve (12 each)			
18.	Mounting design (Flush)	State		
19.	Number of CT inputs	State		
20.	Number of VT inputs	State		
21.	Protection and control Functions: Parameter setting range for each function including time-current characteristics O/C, E/F, SEF, etc.	State		

SCHEDULE 13 H: GUARANTEES FOR BUS BAR PROTECTION IED (IF OFFERED)				
Item	**Particulars**	**Employer's requirement**	**Guara. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Model of offered relay	State		
	Manufacturing reference standards	State		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
5.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
6.	Protection principle (low impedance on numeric principle)	State		
7.	Minimum of 10 years' experience in manufacture of Bus bar protection Relay	state		
8.	Minimum of 5 years in service outside country of Origin	state		
9.	Bus bar protection- centralized and phase segregated	State		
10.	Dynamic bus replica feature for each zone of protection	State		
11.	Mounting design (Flush)	State		
12.	Reference standards	state		
13.	Number of similar Relay sold to date to the export market: - (Required minimum number is1000)	State		
14.	Evidence of sales in two other continents outside the continent of manufacture (state countries)	State		
15.	Minimum operating time	Indicate		
16.	Check criteria for trip (check relay, zone relay)	Indicate		
17.	Detection of CT saturation within a few milliseconds into an external fault	State		
18.	Integral CT correction ratio feature and setting range	required		
19.	CTs trouble monitoring for each protected zone	required		
20.	Display of differential and Line current on LCD screen	required		
21.	Storage capacity for disturbance, Event and Fault records and Oscillographs (Input analogue to cover 20nos. bays)	indicate for each		
	Relay trip Indication by Red LED	required		
22.	No of Binary Inputs	State		
23.	No. of Binary Outputs	State		
	Ratings of relay output contacts (current and voltage)	State		
24.	Number of LEDs	State		
25.	Ability to latch output contacts	required		
26.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/Unavailable)	required		
27.	LCD screen and Keypad for programming relay parameter settings and data access (available/unavailable)	required		
28.	Communication protocols (IEC 61850-8-1)	State		

29.	Communication ports provided	State		
30.	Overcurrent back up and end-fault protection (available/Not available)	State		
31.	Type and size of terminals for cable connection	State		
32.	Software offered for relay configuration and programming	Indicate		
33.	Laptop to relay connection cable (offered /not offered)	Indicate		
34.	Metering capability (U,I,P,Q,S,F,F& Cos Ø)	Indicate		
35.	Connection cable from Laptop to Relay offered	State		
36.	Software for relay configuration and parameter setting.	State		

SCHEDULE 14: GUARANTEED TECHNICAL PARTICULARS FOR OPGW CABLE

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guart. Value**	**Refer. Doc**
1	Manufacturer and Country		State		
2	Minimum experience in manufacture of OPGW	Years	10		
3	Minimum years of service outside country of Origin	Years	7		
4	Number of fibers	OPGW	≥48		
	Single mode fiber type		G655		
5	Core diameter	µm	8.3/9 with 3% tolerance		
6	Fiber Cores per loose tube		12		
7	Fiber Color Coding –12 number		TIA-598 - C		
8	Clad diameter	µm	125.0 + 2		
9	Core-clad concentricity		< 2%		
10	Coating diameter	µm	250.0 + 15		
11	Coating concentricity	>	0.70		
12	Attenuation: 1310 nm 1550 nm	dB/km	< 0.40 < 0.25		
13	Bending attenuation: 1310nm 1550nm	dB/km	≤ 0.40 < 0.25		
14	Temperature dependence	dB/km	≤0.05 (-20°C to +85°C)		
15	Cut-off wavelength	nm	< 1250		
16	Chromatic dispersion:				
17	Zero dispersion at	nm	1310 ± 12 1550 + 15		
18	Zero dispersion slope (max.)	ps/nm^2 (km)	0.092 0.085		
19	Mode field diameter				
	1300 nm 1550 nm	m m	9.30 ± 0.50 10.50 ± 1.00		
20	IL-proof test level	g/m2	35 x 106		
21	Splice attenuation	dB/ splice	0.02		
22	Connector loss	dB/connector	< 0.5		
	Approach Underground Cable				
23	Manufacturer's Name and country	-	State		
24	Type	-	Armoured		
25	Number of fibers	-	>48		
26	Fibers per tube	NO	12		
27	Long term Loading tensile	IEC 60794-1-2-E1A	1200N		
28	Short term Loading tensile	IEC 60794-1-2-E1B	2700N		
29	Crush Performance, Long term	IEC 60794-1-2-E3	800N/10cm		

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guarat Value**	**Refer. Doc/.**
30	Crush Performance, Short term	IEC 60794-1-2-E3	3000N/10cm		
31	Minimal installation Bending radius	IEC 60794-1-2-E11	15 x OD		
	ODF				
32	Manufacturer's Name and country	-	State		
33	Type/model	-	State		
34	Number of fiber interconnections	-	≥48		
35	Connector loss	DB/connector	< 0.5		
36	Screw on type connectors	-	yes		
37	Wall mounted cabinet	-	yes		
38	Fiber Optic Cable routine tests as per IEC 60794-1-2E/F	No	State all tests		

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SCHEDULE 15: GUARANTEED PARTICULARS FOR MEASURING INSTRUMENTS

GUARANTEES FOR MEASURING INSTRUMENTS				
Item	**Particulars**	**Unit**	**Guaranteed. Value**	**Refer. doc**
1	**Indicating Instruments**			
	AC and DC Ampere meter, and Voltmeter, Wattmeter, VAr - meter, Frequency-meter and other indicating instruments:	State		
i	Physical dimension Instrument for: (A, V (AC), V (DC), W, etc.)	(mm)		
ii	-Reference standard	list		
iii	- Error	%		
iv	- Max. admissible current	$\%.I_N$		
v	- Max. admissible voltage	$\%.I_N$		
2	**Energy meters (to be filled for each meter)**			
i	Meter for (MWh, MVArh) Physical dimension	mm		
ii	-Error with 5% load	%		
iii	-Error with 10% load	%		
iv	-Error with 20% load	%		
v	-Error with 100% load	%		
vi	-Max. admissible current	$\%.I_N$		
3	**Metering Converters (Transducers)**			
i	- Converter for (MW, MVAr, A, etc):			
ii	- Error	%		
iii	- Linearity	%		
iv	- Max. admissible current for 0.5 seconds	$\%.I_N$		
v	- Max. admissible current continuously	$\%.I_N$		
vi	- Max. admissible voltage for 0.5 seconds	$\%.I_N$		
vii	- Max. admissible voltage continuously	$\%.I_N$		
4	**Alarm/Trip Annunciators**			
i	- Reference standard	State		
ii	- Digital type	State		
	(i) Digital and Analogue inputs/output	State		
iii	- Number of windows per annunciators (minimum 8)	No		
iv	- Physical size of each annunciator (area of the cap)	mm		
	i) Reset and mute button	State		

Note: To be filled in for each Instrument

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SCHEDULE 16: GUARANTEED TECHNICAL PARTICULRAS FOR LV CABLES

	GUARANTEES FOR CONTROL AND SIGNAL CABLE				
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guant. value**	**Refer. Doc**
1	**Low Voltage Cables (Auxiliary Supply)**				
i	- Conductor material		Copper		
	Design type		Concentric and stranded		
ii	- Current carrying capacity at 75^{O}C	A	State		
	(iv) Rated Voltage	kV	state		
	(v) 1min. power withstfrequency voltage	KVrms	state		
iii	(vi) Short circuit current withstands for 3secs	KA	State		
iv	- Insulation material		PVC		
v	- Steel wire Armoure and screen		Required		
vi	- Protective coating		Required		
vii	- minimum nominal diameter		$25mm^2$		
viii	- Weight of heaviest reel, including cable - Number of cores	Kg No	Kg four		
2	**Control, Protection and Measuring Cables**				
i	- Conductor material		Copper		
	ii) Design type		Concentric and stranded		
ii	- Insulation material		PVC		
	- Current carrying capacity at 75^{O}C	A	State		
	(viii) Rated Voltage	kV	1		
	(ix) 1min. power frequency voltage withstand	KVrms	3		
iii	- Steel wire Armouring and screen		required		
iv	Protective coating		required		
v	- Nominal diameter per core		$2.5mm^2$		
vi	- Overall diameter of cable and number of core	mm/No	state		
vii	- Weight of heaviest reel, including cable	kg	state		
viii	- Size of biggest reel, diameter/width	mm/mm	state		
3	**Telecommunication and Relay/Control Panel internal wiring cables**				
i	- Conductor material		Copper		

ii	Design type		Concentric and stranded		
iii	- Rated voltage	V	600		
iv	- Insulation material		PVC		
v	-1min. power frequency voltage withstand	KVrms	state		
vi	- Flexible stranded single core		state		
vii	- Nominal diameter per core (minimum)		$1.5mm^2$		
viii	- Overall diameter of cable and number of cores	Mm/No	State		
ix	- Weight of heaviest reel, including cable	Kg	State		
x	- Size of biggest reel, diameter/width	mm	State		
4	**Special Cables (where applicable)**				
i	-Special signal and data applicable		state		
ii	-Conductor material		state		
iii	-Insulation material		state		
iv	-Mode of protection		state		
v	-Diameter per core		state		
vi	-Overall diameter of cable reel		state		

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SCHEDULE 17: GUARANTEED TECHNICAL PARTICULARS FOR AUTO RECLOSERS

GUARANTEES FOR 11 AND 33KV AUTORECLOSRER					
Item	**Description**	**KPLC's Requirements**	**Guaranteed Value**		**Ref. Doc.**
			33KV	**11KV**	
1.	Manufacturers Country	state			
2.	Model or type of Autorecloser	state			
3.	Equipment applicable reference standards	state			
	Design service operating conditions (Altitude and temperature)	State			
4.	Minimum Autorecloser Manufacturing experience (10 years)	state			
5.	Minimum years of service outside country of Manufacture (5years)	state			
6.	Autore closer tank material	state			
7.	Arc interruption and insulation medium	state			
8.	Status Indication	state			
9.	Inbuilt current transformers and ratings (630A and STC of ≥ 16 kA)	Provide			
10.	Material of conductive parts (Copper with the contacts silver-plated)	state			
11.	Local Mechanical trip facility and interlocks.				
12.	HV bushing material (HCEP or silicon rubber, UV treated)	state			
13.	Primary terminal clamps (Bimetallic, min. Φ20mm)	state			
14.	Surge arrestor and earthing points	state			
15.	Operating mechanisms type (Magnetic actuator) and number of trips in a cycle	state			
16.	Autorecloser Lockout link, electrical and mechanical interlocks	list			
17.	Manual closing, and Automatic Blocking Device for Manual Opening	state			
18.	Visible on the ground reflector mechanical open/closer indicator	state			
19.	Operation counters	state			
20.	Padlocking facility	state			
21.	Number of operations to the first maintenance	state			
22.	Equipment rated Voltage	state			
23.	Rated continuous operating current (minimum)	state			
24.	Minimum Power Frequency Withstand Voltage, rms (50Hz, 60s)	state			
25.	Minimum Lightening Impulse Withstand Voltage, 1.2/50µs, +ve, dry, KV_{peak}	state			
26.	Minimum rated short time withstand current for symmetrical fault for 3 seconds, kA	state			
27.	Rated short circuit breaking current (kA)	state			
28.	Rated peak value withstand current kA(peak)	state			
29.	Opening Time	state			

30.	Closing Time	state			
31.	Interrupting Time	state			
32.	Rated recloser Operating Sequence	state			
	Control enclosure [IP] class of protection	state			
	Min. creepage distance of insulator	state			
	Min. clearance - phase to phase to phase to earth	state			
	Min. number of Mechanical & Full Load Operations in life time	state			
33.	Electronic modules for upgrade and communication	state			
34.	Control and communication cable to Laptop	state			
35.	Communication port USB (latest), RS 232, RS 485 and Ethernet	state			
36.	**Control Box features**	state			
37.	Programmable digital (alphanumerical) keypad	state			
38.	LCD Screen	state			
39.	Control /Functions Keys	state			
40.	Electrical Close and Open Push-button	state			
41.	Indications and Status display	list all			
42.	Auto reclosers Control Failure	state			
43.	Auto reclosers Safety Control	state			
44.	Application Software	provide			
45.	auto reclosers control and setting software (No expiry license	state			
46.	Manufacturer's warranty (18 month minimum)	state			
47.	Auxiliary DC supply via rechargeable Battery (12/24Vdc)	state			
48.	SCADA communication support via IEC 61850 and IEC 60870-5-101/104 communication Protocol.	state			
49.	230Vac/50Hz Auxiliary Power Supply (External VT)	state			
50	**Protection and Control Functions**				
	a) Three Phase Over-Current Protection				
	Relays Operating Characteristics	state			
	Protection Functions Available	state			
	b) Earth Fault Protection Function				
	Setting Ranges for Earth Fault Protection (50N/51N)	state			
	Setting Ranges for Sensitive Earth Fault Protection (50N-2/51N-2)	state			
	Sensitive Earth Fault Functions and settings	state			
	Cold load pick up function	state			
	Inrush feature	state			
51.	Auto Reclose Function				
	Sequence of trip and auto-reclose characteristics	state			
	Setting Ranges for Auto Reclose Function (1….4 Shots to Lockout Independently selectable for OC & EF)	state			
52.	Software Functions/Features				
	Trips to lock-out	state			
	Operations counters	state			
	Fault and Event Records logging	state			
53.	Energy and Power Measurements				

	Measurands displayable on the LCD screen	state			
	Instantaneous values rms (I, V, kW, kVA, kVAR, pf)				
	Energy measurements (KW, KVA, I, KVAR kVARh, kWh)	state			
54.	Remote Operation and control Via Scada and Laptop	state			
55.	Events & Fault Records Lists	state			
56.	Battery guarantee and warranty of at least 5 years.	state			
57.	Spare Auxiliary contacts – minimum Nos.	state			
58.	Applicable FAT Routine Tests as per IEC standards	state			
59.	Type Test and Accreditation Certificate as per ISO/IEC 17025 of Testing Laboratory	list			
60.	Name plate and marking	provide			
61.	Phase Markings/Identification	provide			

SCHEDULE 18: GUARANTEED TECHNICAL PARTICULRAS FOR EARTHING CONDUCTOR

GUARANTEES FOR EARTHING CONDUCTOR					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guar. Value**	**Ref. Doc**
1	Maximum Earth ground resistance desired values				
2	Under the Control building	Ohms	State		
	Under the Switchyard (HV Earthing system)	Ohms	State		
	LV Earthing system	Ohms	State		
3	Material for Main Grid and Risers earthing conductor		Copper		
4	Resistance of Main earth grid conductor at $20^{O}C$	Ω/km	State		
5	Minimum nominal cross section area of main grid and risers	mm^2	95		
6	Max. temperature of earth conductor during 3 Sec. rated phase - ground fault	$O^{0}C$	State		
7	Rated Phase to ground fault current of main grid conductor at rated maximum temperature	kA	State		
8	Material for Earth rods		Copper		
9	Maximum resistance of each Earth rod	Ohms	State		
10	Length and diameter of earth rods	m/mm	State		
11	Method of interconnecting earth grid conductors		State		

SCHEDULE 19: GUARANTEED TECHNICAL PARTICULRAS FOR RTU (SAS) EQUIPMENT

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particulars**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
1.	Manufacturers Name and address	State		
2.	Country of Manufacture	State		
3.	Model or Type of RTU	State		
4.	Equipment applicable standards	State		
5.	Minimum RTU Manufacturing experience (10 years)	State		
6.	Minimum years of service outside country of Manufacture (5years)	State		
7.	Service working conditions	Specify		
8.	Safety and environmental compliance	State		
9.	Free standing Panel dimension	Specify		
10.	Relays shall be encapsulated type	Specify		
11.	Accommodate signal from both Analogue and Digital transducers	Specify		
12.	Tele information plan requirement interfacing	required		
13.	single command outputs, double command outputs	Specify		
14.	regulation command outputs e.g. raise/lower command outputs for transformer tap changer control	Specify		
15.	analogue set point transmission and output	Specify		
16.	single, double and multiple state digital inputs	Specify		
17.	analogue measured inputs	Specify		
18.	metering pulse inputs for acquisition of energy meter values	Specify		
19.	Sequential Event recording (SER) with time stamping of events at the RTU	Specify		
20.	RTU time synchronization	Specify		
21.	Self-testing and diagnostic functions for detection and reporting of any error	Specify		
22.	Automatic re-starting function corresponding control centre with downloading function.	Specify		
23.	Support encryption and LAN/WAN Access	Specify		
24.	Shall support IEC 61850 protocol for process communication	Specify		
25.	RTU to be fully equipped for 8 substation bays plus spare capacity of 25% for each type of data	Specify		
	RTU shall be expandable in the field by at least 50% of the size of the initial point capacity by addition of Input and Output cards only	Specify		
	Addition of enclosures, internal cabling/wiring, chassis, or power supplies shall not be necessary when adding these I/O cards.	Specify		
26.	RTU shall be accessible through the communication network for the Supervisory Control & Data Acquisition (SCADA) System at the National Control Centre (NCC) and Regional Control Centres (RCC) to scan.	Specify		
27.	Plug-in type relays shall be used with sockets directly mounted on a DIN rail.	Specify		
	RTU firmware requirements			
28.	RTU firmware characteristics	Specify		
29.	Use of standard firmware	Specify		

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particulars**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
30.	It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU	Specify		
31.	all firmware delivered must be up to date and in final form, including all standard firmware changes	Specify		
32.	Firmware shall be loadable by service notebook locally at minimum, download of firmware and parameter sets trough SCADA system, using the data communication links.	Specify		
33.	Changing of EPROMs or similar devices shall not be necessary when updating RTUs firmware	Specify		
34.	230V AC power outlets	Provide		
35.	DC Power supply			
36.	Any hardware required to convert the 48 V battery voltage to the required internal voltages for the RTU hardware shall be provided and adequate	Specify		
37.	The RTUs shall be capable of operating with ungrounded or grounded (either polarity) input power.	Specify		
38.	Dielectric strength/Impulse voltage test (≥2.5kV, 1 minute)	Specify		
	Interposing Relays	Specify		
39.	Tele commands	Specify		
40.	Coil voltage shall be 48 VDC; Coil voltage variation shall be ±20%.	Specify		
41.	Signal voltage on the contact circuit shall normally be 110 VDC	Specify		
42.	The rated contact current shall be minimum 5ADC making/breaking.	Specify		
43.	Telecommunication indications	specify		
44.	Coil voltage shall be 110 VDC; Coil voltage variation shall be ±20%.	Specify		
45.	Signal voltage on the contact circuit shall normally be 48VDC	Specify		
46.	The rated contact current shall be minimum 3ADC making/breaking.	Specify		
47.	2NO and 2NC contacts for interposing relay	Specify		
48.	Relays shall be fitted with a visual operation indicator (either mechanical or LED)	Specify		
	Transducers			
49.	Electrical parameters – Current, voltage, active power, reactive power, apparent power, frequency and power factor transducers	requires		
50.	Four programmable analogue outputs, two digital outputs and RS-485 Modbus functionality for transducers.	Specify		
51.	programmed via easy-to-use software compliant with IEC 60688	Specify		
52.	Relays Characteristics of the digital programmable transducers	Specify		
53.	Measurement Accuracy Class (0.2 and 0.5)	specify		
54.	Current circuit (In)	1-5 A		
55.	Transducer supply- 40-120 VDC /110Vac	Specify		
56.	Communication Ports	Required		
	Serial USB port-USB Mini-B connector Modbus RTU 38400 baud (auto)	Specify		
	Serial RS485 port- Three screw terminals for ≤ 6 mm2 Modbus RTU 1200 – 38400 baud	Specify		
57.	Digital outputs (No)	2		
58.	Analogue outputs (No)	4		
59.	MFM devices	Required		

12. SECTION V - ATTACHMENTS TO GUARANTEED TECHNICAL PARTICULARS (GTPs)

1. KPLC detailed technical specification for equipment and materials

SECTION V- FORMS FOR CHANGE IN WORK ELEMENT

Form 1: Take-Over/Completion Certificate

Date: ____________________

Tender No: ____________________

____

To: ________________________________

Dear Ladies and/or Gentlemen,

Pursuant to clause 10 of the General Conditions of Contract entered into between yourselves and the Employer dated ___________, relating to the ________________, we hereby notify you that the following part(s) of the Facilities was complete on the date specified below, and that, in accordance with the terms of the Contract, the Employer hereby takes over the said part(s) of the Facilities, together with the responsibility for care and custody and the risk of loss thereof on the date mentioned below.

1. Description of the Facilities or part thereof: ________________________
2. Date of Completion: _______________

However, you are required to complete the outstanding items listed in the attachment hereto as soon as practicable.

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

____

Title
(Project Manager)

Form2: Operational and Acceptance Certificate

Date: ____________________

Tender No: ____________________

To: ________________________________

Dear Ladies and/or Gentlemen,

Pursuant to Clause 10.7 of the General Conditions of the Contract entered into between yourselves and the Employer dated ____________, relating to the ____________________________, we hereby notify you that the performance Guarantees of the following part(s) of the Facilities were satisfactorily attained on the date specified below.

1. Description of the Facilities or part thereof: _________________________

2. Date of Operational Acceptance: ___________________

This letter does not relieve you of your obligation to complete the execution of the Facilities in accordance with the Contract nor of your obligations during the Defect Liability Period.

Very truly yours,

____

Title
(Project Manager)

Form3: Request for Change Proposal

(Employer's Letterhead)

To: ______________________________ Date: _________________

Attention: ________________________________

Contract Name: ____________________________

Contract Number: __________________________

Dear Ladies and/or Gentlemen:

With reference to the captioned Contract, you are requested to prepare and submit a Change Proposal for the Change noted below in accordance with the following instructions within ____________ days of the date of this letter ________________.

1. Title of Change: ____________________

2. Change Request No. __________________

3. Originator of Change: Employer: __________________________
   Contractor (by Application for Change Proposal No. _____:

4. Brief Description of Change: ____

5. Facilities and/or Item No. of equipment related to the requested Change: ___________

6. Reference drawings and/or technical documents for the request of Change:

   Drawing No./Document No. Description

7. Detailed conditions or special requirements on the requested Change: _____________

8. General terms and Conditions:

(a) Please submit your estimate to us showing what effect the requested Change will have on the Contract Price.

(b) Your estimate shall include your claim for the additional time, if any, for completion of the requested Change.

(c) If you have any opinion negative to the adoption of the requested Change in connection with the conformability to the other provisions of the Contract or the safety of the Plant or Facilities, please inform us of your opinion in your proposal of revised provisions.

(d) Any increase or decrease in the work of the Contractor relating to the services of its personnel shall be calculated.

(e) You shall not proceed with the execution of the work for the requested Change until we have accepted and confirmed it in writing.

____

(Employer's Name)

____

(Signature)

____

(Name of signatory)

____

(Title of signatory)

Form 4: Estimate for Change Proposal

(Contractor's Letterhead)

To: ______________________________ Date: __________________

Attention: _______________________________

Contract Name: _______________________________

Contract Number: _____________________________

Dear Ladies and/or Gentlemen:

With reference to your Request for Change Proposal, we are pleased to notify you of the approximate cost of preparing the below-referenced Change Proposal in accordance with General Condition of Contract. We acknowledge that your agreement to the cost of preparing the Change Proposal, in accordance with GCC is required before estimating the cost for change work.

1. Title of Change: ________________________

2. Change Request No./Rev.: ____________________________

3. Brief Description of Change: __________________________

4. Scheduled Impact of Change: ___________________________

5. Cost for Preparation of Change Proposal-(N/A)

(a)	**Engineering**		**(Amount)**
(i)	Engineer	_______ hrs x _______ rate/hr =	_________
(ii)	Draftsperson	_______ hrs x _______ rate/hr =	_________
	Sub-total	_______ hrs	_________
Total Engineering Cost			_________
(b)	Other Cost		_________
	Total Cost (a) + (b)		_________

____
(Contractor's Name)

____
(Signature)

____
(Name of signatory)

____
(Title of signatory)

Form 5: Acceptance of Estimate

(Employer's Letterhead)

To: ________________________ Date: ________________

Attention: _________________________

Contract Name: _______________________
Contract Number: _____________________

Dear Ladies and/or Gentlemen:

We hereby accept your Estimate for Change Proposal and agree that you shall proceed with the preparation of the Engineering design for the change Proposal

1. Title of Change: _____________________
2. Change Request No./Rev.: ________________________
3. Estimate for Change Proposal No./Rev.: ________________________
4. Acceptance of Estimate No./Rev.: ________________________
5. Brief Description of Change: ________________________

Other Terms and Conditions: In the event that we decide not to order the Change accepted, you shall be entitled to compensation for the cost of preparation of Change Proposal described in your Estimate for Change Proposal in accordance with the General Conditions of contract.

____
(Employer's Name)

____
(Signature)

____
(Name and Title of signatory)

pl

Form 6: Change Proposal

(Contractor's Letterhead)

To: ___________________________ Date: __________________

Attention: ___________________________

Contract Name: ___________________________
Contract Number: ___________________________

Dear Ladies and/or Gentlemen:

In response to your Request for Change Proposal No. ___________________________, we hereby submit our proposal as follows:

1. Title of Change: ___________________________

2. Change Proposal No./Rev.: ___________________________

3. Originator of Change: Employer: [___________________________

   Contractor: ___________________________

4. Brief Description of Change: ___________________________

5. Reasons for Change: ___________________________

6. Facilities and/or Item No. of Equipment related to the requested Change: ___________________________

7. Reference drawings and/or technical documents for the requested Change:

   Drawing/Document No. Description

8. Estimate of increase/decrease to the Contract Price resulting from Change Proposal

		(Amount)
(a)	Direct material	____________________
(b)	Major construction equipment	____________________
(c)	Direct field labor (Total ______ hrs)	____________________
(d)	Subcontracts	____________________
(e)	Indirect material and labor	____________________

(f) Site supervision ____________________

(g) Head office technical staff salaries

Process engineer	_______ hrs @ _______ rate/hr		_____________
Project engineer	_______ hrs @ _______ rate/hr		_____________
Equipment engineer	_______ hrs @ _______ rate/hr		_____________
Procurement	_______ hrs @ _______ rate/hr		_____________
Draftsperson	_______ hrs @ _______ rate/hr		_____________
Total _____________________	hrs	_______________________	

(h) Extraordinary costs (computer, travel, etc.) ____________________

(i) Fee for general administration, _______ % of Items ____________________

(j) Taxes and customs duties ____________________

Total lump sum cost of Change Proposal ____________________
(Sum of items (a) to (j))

Cost to prepare Estimate for Change Proposal ____________________
(Amount payable if Change is not accepted)

9. Additional time for Completion required due to Change Proposal

10. Effect on the Functional Guarantees

11. Effect on the other terms and conditions of the Contract

12. Validity of this Proposal: within *[Number]* days after receipt of this Proposal by the Employer

13. Other terms and conditions of this Change Proposal:

(a) You are requested to notify us of your acceptance, comments or rejection of this detailed Change Proposal within ____________ days from your receipt of this Proposal.

(b) The amount of any increase and/or decrease shall be taken into account in the adjustment of the Contract Price.

(c) Contractor's cost for preparation of this Change Proposal

____
(Contractor's Name)

____
(Signature)

____
(Name of signatory)

____
(Title of signatory)

pl

Form 7: Change Order

(Employer's Letterhead)

To: __________________________ Date: __________________

Attention: __________________________

Contract Name: __________________________
Contract Number: __________________________

Dear Ladies and/or Gentlemen:

We approve the Change Order for the work specified in the Change Proposal (No. ______), and agree to adjust the Contract Price, Time for Completion and/or other conditions of the Contract in accordance with General Conditions of contract.

1. Title of Change: __________________________

2. Change Request No. /Rev.: __________________________

3. Change Order No. /Rev.: __________________________

4. Originator of Change: Employer: __________________________
   Contractor: __________________________

5. Authorized Price:

   Ref. No.: __________________________ Date: ______________________

   Foreign currency portion ________ plus Local currency portion ________

6. Adjustment of Time for Completion

   None________________Increase ________ days Decrease ________ days

7. Other effects, if any

Authorized by: ______________________________________ Date: ______________
(Employer)

Accepted by: ______________________________________ Date: ______________
(Contractor)

pl

Form 8: Pending Agreement Change Order

(Employer's Letterhead)

To: ___________________________ Date: _________________

Dear Ladies and/or Gentlemen:

We instruct you to carry out the work in the Change Order detailed below in accordance with the General Conditions of contract.

1. Title of Change: ___________________________
2. Employer's Request for Change Proposal No. /Rev.: ________________________dated: _________
3. Contractor's Change Proposal No. /Rev.: _________________________ dated: _________
4. Brief Description of Change: ___________________________
5. Facilities and/or Item No. of equipment related to the requested Change: ___________________________
6. Reference Drawings and/or technical documents for the requested Change:

   Drawing/Document No. Description

7. Adjustment of Time for Completion:
8. Other change in the Contract terms:
9. Other terms and conditions:

____
(Employer's Name)

____
(Signature)

____
(Name of signatory)

____
(Title of signatory)

pl

Form 9: Application for Change Proposal

(Contractor's Letterhead)

To: ________________________ Date: ______________________________________

Attention: __________________________

Contract Name: __________________________

Contract Number: __________________________

Dear Ladies and/or Gentlemen:

We hereby propose that the below-mentioned work be treated as a Change in the Facilities.

1. Title of Change: __________________________
2. Application for Change Proposal No./Ref.______________________. dated: ____________
3. Brief Description of Change: __________________________
4. Reasons for Change:
5. Order of Magnitude Estimation (in the currencies of the Contract):
6. Scheduled Impact of Change:
7. Effect on Functional Guarantees, if any:
8. Appendix:

____

(Contractor's Name)

____

(Signature)

____

(Name of signatory)

____

(Title of signatory)