VOL. II

BIDDING DOCUMENT

LOT 4: 66/33 kV SUBSTATION AT GALANA - KULALU FARM AND 33 kV METERING STATION AND 33 kV RETICULATION

RFX No:1000001030

WORKS REQUIREMENTS AND TECHNICAL PARTICULAR SPECIFICATIONS

TECHNICAL SPECIFICATIONS

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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 optimised 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. Particular technical specifications
3. Project Specific Design Data
4. General technical specifications
5. General Specifications
6. 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

1.1.1 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.

1.1.2 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 licences necessary to achieve the specified functionality as well as the software necessary for programming, testing, service and maintenance through the lifetime of the equipment.

1.1.3 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 Bidder 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 Bidder who shall be responsible for obtaining and determining all applicable knowledge relevant to the works.

1.4 Space Requirement

The Bidder shall check the dimensions of rooms and outdoor plots where electrical equipment is proposed to be erected. The rooms and plots must accommodate the equipment as well as having workspace for operators and maintenance personnel.

The Bidder shall in his bid present arrangement drawings showing how he intends to adapt the equipment to the space available. If the space is not sufficient the Bidder shall indicate necessary enlargements. Failing to do so the Bidder must bear the cost of later modifications of the facilities.

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 millimetres.

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 CD with a format readable in AutoCAD version 14 or another format to be agreed upon in addition to the paper copies.
- All drawings shall be bound in hard covers.

1.5.2 Bid 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 offered 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 emphasised, however, that the main Bid should comply with the principles shown in the enclosed drawings, other arrangements being submitted solely as alternatives to the main offer.

Significant changes in the layouts caused by the Employer may warrant price adjustments. However, no adjustments will be applied for minor changes due to incorporation of the Contractor's equipment.

The Bidder shall in his Bid enclose overall drawings showing dimensions, main working principles, internal components and fixing methods to a detail level allowing the Employer to evaluate the functionality and completeness of the plant and equipment.

The following specific drawings shall be enclosed with the Bid:

- Single Line Diagram for each pant
- Layout proposals for each plant
- Proposal for arrangement of the apparatus and machinery
- Topological drawings of the Control System

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 final “as built” documentation taking into account all changes done under erection and commissioning.

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 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 Bidder shall include in the Bid a documentation of the system with a list of current procedures, an organisation chart of the quality organisation 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 emphasises 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 recognised 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 despatch.

If the Employer at any stage in the design and production period finds out that the sub-contractor do 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 certificates from accredited body 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 stencilled 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

If work is to be done on substations in operation the following factors are of paramount importance: (i) Minimisation 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 Project Manager/Technician who will be authorised to receive work permits at the work sites as required by safety rules. All outages shall be discussed with the Employer and the Project Manager at least one week before the outage is required. The Contractor will normally only 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 authorised 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.

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 recognised 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.

1.9.4 Testing and commissioning

Testing at site shall be carried out by experienced testing engineers approved by the project manager. Functional tests shall be inherent in all test procedures. The Contractor shall record the test results in an approved test 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. The test protocols shall be submitted to the project manager in advance for approval

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.

Once the pre-commissioning tests are complete, the testing engineer shall submit all the preliminary tests reports for review prior to the energising of the equipment. The tests shall be accompanied with a complete procedure for energising and loading of the equipment. The procedure shall include; a detailed commissioning schedule 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.

1.10 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.

1.11 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.

1.12 Spare Parts

Spare parts supplied under the contract shall be packed and preserved for long time storage.

2 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 recognised national standards shall be applied. The rules of CEE (International Commission for the approval of electrical equipment) and the standards of CENELEC (Comité Europeen de Normalisation 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) 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 circuits 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 synchronising) 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 minimised 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 nothing else is specified. For all current carrying parts the permissible short circuit duration shall be at least 1 second. 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.

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 Surface Treatment and Painting, Electrical Equipment

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 galvanising shall be in accordance with BS 729 or other internationally approved standards. Steel below ground shall in addition to galvanising 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.

2.5.5 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 endeavour 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 unauthorised 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 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 Standardisation

The Contractor shall be responsible for the standardisation 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 standardisation. 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
- Oil

Where electrical sockets are installed for lamps, hand tools, measuring equipment etc., local standard sockets with earth connection shall be used for 16 A single phase sockets (lower rating shall not be used). Other sockets shall be according IEC 60309 (CEE type). The Contractor shall endeavour to use components available in the local marked.

2.6.2 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
- Outdoor and wet areas IP 4x
- Indoor IP 2x

2.6.3 Indicators and Instruments

<u>All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools.</u>
In unmanned 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.

All semaphores shall be of LED type.

2.6.4 Fuses and Miniature Circuit Breakers

Miniature circuit breakers shall replace fuses in control and power circuits 63 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 63 amps 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.

2.6.5 Relays and Contactors

All resetting of relays and contactors must be possible without dismantling of 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.

2.6.6 Motors

2.6.6.1 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 In
Motors between 35 and 75 kW	6x in
Insulation class	F
Temperature rise	B
Direct starting range	75 – 110 % of Un

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.

<u>Motors to be connected to variable speed drives shall be special adapted to this.</u>

2.6.6.2 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.

2.6.7 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 utilisation 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.

2.6.8 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).

Programmes 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 licences needed for testing, setting ad reconfiguration. If hardware other than laptop is required for this such shall be included in the supply.

2.7 Construction and Erection

2.7.1 Switchboards, Panels and Cabinets

Switchboards, control, panel boards and cabinets shall be of robust construction, formed of a steel frame and covered with smooth steel plate (outdoor cabinets can be of aluminium). The steel plate shall be properly stiffened to prevent distortion. Panels shall normally be covered at their rear with hinged doors. 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. Panes for power circuits shall be in accordance IEC 6034 (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 16 A 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.

2.7.2 Wiring and Terminal Blocks within Enclosures

All wiring shall be stranded copper conductor, PVC. 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 neighbouring 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.

2.7.3 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 galvanised) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15 % spare capacity. The distance between each tray shall at least be 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 aluminium. Minimum cross sections shall be as follows:

- Measuring cables for current 2.5 mm^2
- Control and other measuring cables 1.5 mm^2
- Power cables according 120 % max load current

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

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

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

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

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.

2.7.4 Earthing (Grounding)

An embedded earthing system shall be designed and supplied by the contractor. The embedded earthing system shall be arranged connected to exposed 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 worked out by main switchgear contractors. For details of the earthing system refer to clause 5.1.1.9.1

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**			
			66 kV	33kV	11 kV
1	System	50 Hz, 3 phase			
2	Neutral point earthing	Solid earthed			
3	Nominal voltage of networks		66 kV	33 kV	11 kV
4	Highest system voltage as defined by IEC-60038		72.5 kV	36kV	12 kV
5	Short circuit and earth fault current, symmetrical r.m.s. value (min breaking current) not less than		31.5 kA	25kA	25 kA
6	Thermal short-circuit current, 3 second not less than		31.5kA	25kA	25kA
7	Dynamic peak current (min making current)not less than		80 kA	63kA	63 kA
8	Rated current of busbars and bus coupler if not given in Scope of Works, for each individual substation		1250 A	1250A	1250 A
9	Minimum rated current of isolating switches and circuit breakers if not given in Scope of Works		800 A	800A	630 A
10	Insulation level according IEC 60071:				
10a	Switching surge withstand voltage				
	Phase-to-earth	N/A	N/A	N/A	N/A
	Longitudinal impulse component of combined test	N/A	N/A	N/A	N/A
10b	Lightning impulse withstand voltage (1.2/50 m/s kV_{peak})		325 kV	170kV	95 kV
10c	Test voltage at power frequency 1 min dry and wet. To earth and between phases		140 kV	70kV	38 kV
11	For the design and erection of the conductors in the switchyard the following minimum distances shall be observed				
11a	Phase to earth [mm]		700	500	500
11b	Phase to phase [mm]		790	435	250
11c	Busbars phase to phase [mm]				1250
11e	Height to live parts above ground [mm]		3500	2900	2900

Item	Parameters	SYSTEM VOLTAGE			
			66 kV	33kV	11 kV
11f	Height to live parts above ground at transformer transport routes [mm]				5000
12g	Lowest part of insulators above ground [mm]	2 500			
12	Maximum temperature rise of conductors above ambient temperature (40 ºC)	40 ºC			
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)			

Note 1)
Ref IEC 60038)

Note 2)
For all current carrying parts the permissible short circuit duration shall be at least 1 second. Indoor equipment shall be arch tested in accordance with IEC 60298 amendment 2. The dynamic or momentary short circuit current on which the equipment design shall be based shall be computed by multiplying the r.m.s. value of the symmetrical short circuit current by the factor 1.8 x $\sqrt{2}$.

Note 3)
Ref IEC 60071)

All High and Medium Voltage equipment shall be designed for installation at 2200 m 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	
Nominal system voltage	415/240 V -15%, +10% (+ or – 6%), TN - CS
System frequency	50 Hz (+ or – 2%)
DC System	110 V, & (48V for communication)
Power frequency Test Voltage 1 min	2.5 kV
Thermal rating of conductors	120 % of load
Max 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 Colour 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
Current transformers	Black
A.C. Circuit	Yellow
D.C. Circuit	Blue
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
Auxiliary DC Supply	Positive	Red
	Negative	Black

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

3.1.5 Environment

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	2200 m	Below 1000m
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	
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 24 hour 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 meter from engine room) max 85 dB(A)

3.1.7 Auxiliary Power

3.1.8 Electric Service during Construction

Metered electric supply at 415/240V, 3-phase, 50 Hz TN-S will be available at the substation sites. All tools and equipment supplied by the Contractor shall be suitable for this supply system. The Employer, while endeavouring at all times to maintain the supply, can accept no responsibility for the consequences that may arise from the failure or cessation of the electric supply.

3.1.8.1 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 uninterrupted supply shall be fed from permanently charged station batteries. If other voltage sources or voltage levels then given below, 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 shall have an automatic change over scheme for the two 415V power supply sources at the substations

3.1.8.2 AC Auxiliary Supply

Components in the AC low voltage main distribution system shall have a voltage rating of 415/240 volts, 50 Hz. The system shall be 3-phase, the transformer neutral grounded (TN-CS)

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

3.1.8.3 DC Auxiliary Supply

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

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

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

3.1.9 220 V AC Un-interrupted supply (UPS)

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

3.1.10 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:

- Supervisory Control from a Supervisory Control and Data Acquisition (SCADA) System. The old system is outdated and a new will be established where 66 kV and below 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 motorised disconnectors. Status indication shall be available in the supervisory system for all HV and MV breakers in the system as well as busbar voltages, line and transformer load in A (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, signalling 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.

3.1.11 Interface between Contractors and towards Employer

For substations to be extended, 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 equipments 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

PARTICULAR TECHNICAL SPECIFICATIONS

3.1.12 Particular technical specifications – SWITCHGEAR

3.1.12.1 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 busbars and apparatus connections, earthing systems, all cabling and connections, control an protection panels as well as any other equipment and materials not specifically mentioned or quantified, but which are required to make a complete and proper functioning substation.

3.1.12.2 **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.
The contractor is free to propose alternative solutions as options.

General Clauses for HV and MV Switchgear

3.1.12.2.1 Breakers and Switches

Breakers and switches equipped with motor drive shall be provided for electrical local and remote control. The control voltage for closing and opening commands and for the energy storage of circuit breakers is 110V DC from station battery. The motor drive for switches shall be AC.

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 10 NO and 10 NC contacts as spare, for 110 V DC 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.

3.1.12.2.2 Circuit Breakers

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

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

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

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

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

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

3.1.12.3 Measuring Transformers

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

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

3.1.12.3.1 Current transformers

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

The rated current of the secondary windings shall be 1 A, 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 1
- 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 0.5s
- Instrument security factor equal to or less than 5

The core(s) for protection:

- Accuracy class 5 P
- Accuracy limit factor equal to or greater than 20

The core(s) for busbar protection:

- To be adapted to the protection scheme offered

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

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

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

3.1.12.3.2 Voltage Transformers

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

- Accuracy (if not otherwise specified in scope of work) class 1

The core(s) for energy metering:

- Accuracy (if not otherwise specified in scope of work) class 0.5s

The core(s) for protection:

- Accuracy class 3 P

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

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

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

3.1.12.4 **SF_6 gas**

3.1.12.4.1 Low Density Warning

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

3.1.12.4.2 Gas Refilling

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

3.1.12.5 High and Medium Voltage Outdoor Switchgear

3.1.12.5.1 General

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

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

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

All breakers and switches shall come ready for distribution automation.

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

3.1.12.5.2 Circuit Breakers

The three-phase circuit breakers shall be of the outdoor, single pressure SF_6 The breakers shall be mounted on steel structures.

For 132 kV and lower voltage three-phase rapid auto-reclosing only is required and the mechanism can be common for all poles.

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

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

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 50 msec.

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

3.1.12.5.3 Disconnectors/Isolators and Earthing Switches

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

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

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

3.1.12.5.4 Measuring Transformers

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

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

3.1.12.5.5 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):

		66kV	33kV	11kV
(1) Continuous operating voltage (r.m.s.)	(kV)	42	22	7
(2) Rated discharge current	(8/20 ms)(kA)	20	10	10
(3) Rated Voltage	(kV)	54	27	9

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

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

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

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

3.1.12.5.6 Line Traps

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

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

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

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

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

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

Every line trap shall be supplied with a line matching unit as per specifications in paragraph 4.1.1.5.8 below.

3.1.12.5.7 Coupling Capacitors

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

3.1.12.5.8 Line Matching Units

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

The high frequency coupling units shall be assembled in a sheet steel box or similar and be suitable for mounting on the pedestal support for the coupling capacitor. The filters are to be suitable for outdoor use in a hot dusty/humid climate and are to have weather proof door seals together with breather holes to avoid condensation. The units are to have an earthing switch which should preferably be interlocked with the box door/lid such that the latter cannot be opened unless the earth switch is closed to earth the device, and clear ON/OFF position of this switch should be indicated. The terminal of the filter, which shall be connected directly to the substation earth, shall be clearly designated. The device shall meet requirements of IEC 60481.

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

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

Technical requirements:

Bypass filter:

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

Drain Coil:

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

Earthing Switch:

- Rated current 300 A rms
- Lightning Arrester:
- Rated voltage 660 V
- Max. 100% impulse spark over voltage 3 300 V
- Rated discharge current 5 kA

3.1.12.6 Conductors, Insulators, Accessories

3.1.12.6.1 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 (equilvalent 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 95 mm^2 copper. Other earth wires shall always be of copper.

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

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

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

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

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

3.1.12.6.2 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.

3.1.12.6.3 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.

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.

3.1.12.6.4 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.

3.1.12.6.5 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.

3.1.12.6.6 Cable Marshalling Kiosks

For each switch bay a separate dust and waterproof, cable marshalling kiosk shall be provided, 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.

3.1.12.7 **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.

3.1.12.7.1 Conductors, Insulators, 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).

3.1.12.7.2 Tests on the Switchyard on Site

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

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

3.1.12.8 **Autoreclosers**

3.1.12.8.1 General

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

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

3.1.12.8.2 Modes of operation

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

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

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

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

3.1.12.8.3 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.

3.1.12.8.4 Power Supply

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

3.1.12.8.5 Control Cabinet

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

3.1.12.8.6 Control Requirements

A microprocessor based control unit for the recloser is required which also integrates the protection relays. The control unit shall have a socket for serial communication and downloading of information to a hand-held external unit from the memory.

The autorecloser shall have facilities for manual tripping and locking out by means of an external handle or similar.

The following control functions shall be provided on the front panel:

- local/remote control selection
- closing/tripping
- autoreclose in/out (one trip to lockout)
- protection engaged/disengaged
- earth fault in/out
- sensitive earth fault in/out
- relay status.
- Energy profiles;
- Demand registers

Local status indications shall be included in addition to the above control functions.

The control unit shall also have facilities for remote control/indication.

3.1.12.8.7 Protection Requirements

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

Dead times and reclaim time shall be selectable in steps.

The protection system shall have facilities for:

- phase faults
- earth faults
- sensitive earth fault.

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

The sensitive earth fault relay shall be of the definite time type with instantaneous element, adjustable between 2 and 10A in steps. Time delay should be settable between 0 and 20 secs. in steps.

The relays shall be equipped with in rush restraint facilities. A counter is to be provided to keep record of the number of in/out operations.

3.1.12.8.8 Insulating and Interrupting Medium

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

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

Where SF6 gas filled autoreclosers are offered, the supplier shall provide the user with necessary instructions for refilling the gas and maintaining its required quantity and quality. The autorecloser shall have facilities for lockout in case of low pressure with an associated indicator flag easily seen from the ground. A pressure gauge easily read from the ground shall also be provided.

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

3.1.12.8.9 Ratings

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

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

3.1.12.8.10 Bushing Current Transformers

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

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

3.1.12.9 Alternative Indoor 66 kV Switchgear

For very confined substations in the Nairobi an alternative with indoor 66 kV switchgear is to be included in the Bid. The 66 kV breakers 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.

3.1.12.10 Medium Voltage Indoor Switchgear

3.1.12.10.1 General

This section covers the manufacture and supply of indoor metal enclosed, metal clad type 33 kV and 11 kV 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.
The following documents were referred to during the preparation of this specification, and may be referred to; however in case of conflict, the provision of this specification shall take precedence.

Unless otherwise specified, the latest revision, edition and amendments of the standard shall apply

- IEC 60298: AC metal - enclosed switchgear and contro1, gear for rated voltages above 1kV and up to 72.5 kV .

- IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories.
- IEC62271-100 - High-voltage alternating circuit breakers.
- IEC 60044-1 : Current transformers
- IEC 60044-2: Voltage transformers
- IEC 60255: Electrical Relays
- ANSI 37: Medium voltage AC metal - enclosed switchgear and control gear

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

3.1.12.10.2 Panels

The whole switchgear equipment and components shall be designed and constructed in accordance with IEC 60298. The board shall be complete with all the relevant components including, busbars, circuit breaker, cable compartment, instrument transformers, protection relays, instruments and controls.

The switchgear board, shall be constructed to **1P41** degree of protection in accordance with IEC 60529. A type test report for the degree of protection of the switchgear panels from a third party reputable testing laboratory or certified by the national standards and testing authority (NSTA) or a laboratory accredited to the NSTA shall be submitted with the tender for evaluation purposes.

The panel shall have restricted dimensions suitable for installation in limited spaces. Inparticular and without compromising the insulation level, busbar current rating and short circuit current performances, the width of the panels shall not exceed **800mm.**

The LV compartment shall not be less than **650 mm** in height, to ensure adequate space for mounting the relays and other devices and accessories and adequate space for the cable trucks, terminal blocks and wiring. The depth of the switchgear, i.e., from the front to the back shall be kept to the minimum and in any case not exceeding **1800 mm.**

The switchgear panel or cubicle shall be built up of separate metal clad-compartmented cubicles with earthed metal partitions. The compartments shall be for busbar, cable connection, circuit breaker, current transformer and control (LV) compartments.

The circuit breakers shall be mounted on an inbuilt carriage to facilitate isolation and withdrawal of the circuit breaker. Where the carriage is fixed in the compartment and does not allow complete withdraw of the circuit breaker outside it's compartment, then a purposely built trolley shall be provided equipped with a lowering/raising gear to lower the circuit breaker to the floor, and to raise the circuit breaker to it's compartment by one person. This requirement shall be demonstrated during FATs

The complete switchgear shall be such that the complete switchboard is of flush-front design

Each of the switchgear panels shall have four separate compartments as follows:-

- LV Compartment
- Circuit Breaker Compartment
- Busbars Compartment
- Cable, CTs, VTs and Earth Switch compartment

The circuit breaker, busbars and cable compartments shall be provided with arc venting outlet to the top of the switchgear board.

The top of the complete switchgear board shall be equipped with arc by-products venting chamber to direct the arc by products outside the switchgear room. The design of the arc chamber shall be adequate to handle arc by products at the rated withstand level of the switchgear board of 25 kA, 3 seconds. The design of the arc chamber shall be complete in every way with provision of connection to the switchgear wall at least at two points and the terminal explosion flaps to be fitted on the switch gear wall.

The low voltage section shall be completely separate from the high voltage section. All the protection relays, auxiliary relays, energy meters indication lamps, instruments, control and selection switches and any other associated accessories will be mounted in this compartment.

The switchgear shall be designed for erection with the rear side close to a wall as well as for free standing erection. The manufacturer shall provide a single line layout drawings giving the requirements to be provided(built into) in the switchgear room.

The switchgear shall be of arc resistant design as per IEEE/ANSI C37.20 and hence ensure complete safety for a switching personnel standing in-front or at the rear of the switchgear board. A copy of the type test report shall be submitted with the bid for tender evaluation purposes.

Where the venting is intended to penetrate an external wall, the vent shall be covered such that it meets all environmental conditions (e.g. rain-proof, dust-proof, vermin-proof).

The cable compartment should have an anti vermin guard plate giving protection against rats, rodents etc

The circuit breaker compartment door shall be provided with provisions for padlocking.

The doors shall he capable of withstanding the effects of maximum internal arcing fault without being blown off and causing danger to personnel and other equipment. This should be proven by successful testing, as per ANSI C37.20.7 or equivalent IEC standards.

The busbar shall be single, three phase, air insulated. The primary busbars and connections shall he of high conductivity and electrolytic material, high grade copper, and shall be in unit lengths. The busbars shall preferably have a PVC cover to prevent accidental short-circuits

Busbars, connections and their support shall be rated 1500 A as required continuously under ambient conditions and capable of carrying the short-time current associated with the short circuit ratings of the circuit breakers, for **3** Seconds.

Busbars shall he extensible at both ends, such extension shall entail the minimum possible disturbance to the existing busbar.

Provision shall be made for locking busbar and circuit shatters separately in the circuit breaker compartment. These shutters shall open and close automatically during the racking in and racking out of the circuit breaker
Provision shall be made for integral circuit earthing and for busbar earthing. Means of earthing shall be by circuit breaker or purposely built earth switch. Mechanical interlocks to ensure correct switching operation shall then be provided. It shall not be possible to close the earth switch on the incomer panel, when the incoming 11kV cable is live.

The earth switch shall be easy to operate by one operator and he spring loaded to ensure effective make operation independent of the operator action.
The Status of the earth Switch shall be visible from the front of the Panel. It shall not be possible to rack-in the circuit breaker into the service position with the earth switch in closed position. The mechanical interlock between the circuit breaker and the earth switch shall be strong enough to guarantee safety of the switching personnel and the switchgear.
The earth switch shall be equipped with auxiliary contacts for local and supervisory indication of the status of the earth switch. The earth switch operating lever shall be covered by a shutter and shall only be accessible when it is permitted to operate the earth switch.

The operation of the Earth Switch shall be set in such a way that during both the close and open operations, a clearance of at least 9 inches shall be maintained between the operating handle and the bottom of the switchgear panel.
It shall not be possible to insert the earth switch operating handle into position except when the circuit breaker is in the test or isolated position. The earth switch shall be equipped with padlocking facilities when in the closed position
All earthing facilities shall be rated for fault making at the rated switchgear short-circuit current.
Earthing switches shall be provided for earthing each of the Busbar Sections separately. All the interlocks required to ensure safe operation of the busbar earth switch shall be built into the switchgear board. In particular it shall not be possible to close the earth switch when any of the circuit breaker on that part of the busbar is in service position, i.e., all the circuit breakers shall be withdrawn for the Busbar earth to be closed. Once the Busbar earth has been closed, it shall not be possible to rack-in any circuit breaker.

Indications for busbars earth On and OFF shall be provided and visible from the front of the board.
The Panel wiring for protection, instruments, indication and metering circuits and other control accessories shall be completely done. All circuits for connection to external cables such DC & AC auxiliary supplies, external tripping, supervisory control and indications shall be wired up to the terminal Block at the Back of the panel where external cables shall be connected. A t least 12 spare terminals shall be provided on the terminal board for any future requirements.

It is emphasized that Each Switchgear panel will have a terminal block at the back of the panel where all external cables such as for 110V DC supply, 240V AC supply, connection of SCADA, measurands/commands and alarms shall be made.
110V DC, 110V AC and 240V AC supplies for circuit breaker control, alarm circuits, protection relays, metering and motor supply for each panel, shall be controlled by suitably rated miniature circuit breakers.
The switchgear panels shall be tropical vermin proof. The plates shall be of high quality mild steel of at least 2mm thickness thoroughly cleaned by shot blasting or other approved methods.
They shall then be given a primary coat and two coats of contrasting colour of durable andeather resisting paint. The final coat shall be gloss and **Admiralty Grey (shade No.632) as specified in BS 381C**. The final thickness of the paint shall not be less that 80 Microns at any point within the switchgear panel.

Anti-condensation heaters shall be provided inside each switchgear panel. They shall belocated so as not to cause injury to personnel or damage to equipment. The heaters shall becontrolled by a hygrostat with a variable humidity and temperature setting. The heaters shall be dimensioned to ensure that condensation cannot occur within the switchgear panel. Heaters of adequate rating shall be provided for the circuit breaker, cable and LV compartments.The 240V AC supply, for the heaters shall be controlled by a suitably rated single poleminiature circuit Breaker.

The circuit breaker cubicle shall have a limit switch which shall be wired to provide SCADA indications on whether the breaker is fully racked in or fully racked out(withdrawn).

Suitable means shall be provided to monitor the status of the HV cable, i.e., whether it is live or dead. The monitoring device shall be a three phase device with illumination in red colour for live status visible from the front of the panel without opening any compartment doors. The indications shall be labeled R, Y & B or L1, L2 & L3. The device shall meet the requirements of IEC 61243-5.
Each switchgear panel shall be provided with Tinned Copper earth bar of adequate cross section area to be able to withstand the rated short-circuit current of 25 kA for 3 seconds, and arranged so that the bars of adjacent panels are joined together to form a common earth busbar. Provision shall be made at either end the assembled switchgear board for connection of the earthing bar to the substation earthing grid.
Manual close & open push buttons shall be provided on the circuit breaker compartment door for manual close and open of the circuit breaker both in the service and in the test(withdrawn) position. The manual close and open push

buttons shall be clearly labeled with CLOSE and OPEN Labels and with I(red) and O(Green) Symbols and colour codes as per the IEC standard.

The complete switchgear board shall be equipped with **ARC protection, consisting of ARC protection relays and arc sensing devices located in the Cable, Circuit Breaker and Busbar Compartment of each panel.** Optical sensors shall be used. The sensors shall operate upon occurrence of a flash (light) from the ARC. The sensors shall be connected to the ARC protection Relays via fiber cables or any other suitable means that is already in use. The ARC protection relay shall monitor both the operation of the Optical sensors and overcurrent relay and shall only operate upon operation of both the sensing devise and the pickup of the overcurrent element. it shall also be possible to select the operation of the scheme due to the operation of the sensor but with longer time delay. Upon operation of the ARC protection, all circuits within the fault zone shall be tripped by the arc protection relay. The ARC protection scheme shall have means for indicating the ARC occurred. The scheme shall be secure and immune to mal-operation, the fundamental operating time of the ARC protection scheme shall preferably be 50ms and in any case not more than 100ms. However adjustable time delay and overcurrent pick-up shall be provided.

The design of the complete scheme shall be to the approval of the employer. A single line
drawing shall be enclosed with the bid to show how the scheme is implemented.

3.1.12.10.3 Circuit Breakers and Disconnectors

The three phase circuit breakers shall be vacuum type for 66 and 33 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 restriking during breaking operation cannot occur.

A spring-operated mechanism shall be provided and the mechanism shall be equipped for electrical local (from switchgear) and remote control (from control centre). If not otherwise stated in Scope of Works, the control voltage for closing and opening commands and for the operating mechanism motor(s) shall be:

110 V DC + 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.

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 110 V DC 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.

3.1.12.10.4 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.

3.1.12.10.5 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 a 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 12 kV or 36 kV.

3.1.12.10.6 Shutter Mechanism

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

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

3.1.12.10.7 Earthing

All cubicles shall be connected to earth via conductors with min. 70 mm2 cross section.

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

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

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

Capacitive voltage indicators shall be arranged to avoid closing of earthing switches against energised components.

3.1.12.10.8 Cable Connection

The cable termination compartment for feeders shall have adequate space for housing of cable terminals up to, 2x3x1 core 300 mm^2 Al XLPE (two single core set) for the and shall be complete with cable terminations, bolts, nuts and cable glands (the cable terminals shall be for 1x3x150 mm2 Cu cable) The cable termination compartment for the connections to the 66/11kV transformers must allow for cables dimensioned for 24 MVA.

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

3.1.12.10.9 Measuring Transformers

3.1.12.10.9.1 Current Transformers

All current transformers shall have bar primaries and shall be resin encapsulated and generally comply with IEC 60044. All current transformers shall have a maximum short-time current rating for one second.

<u>Feeder circuits shall be equipped with a current transformer on three phases with four cores:</u>

For measuring and instruments, not less than 15 VA, Class 0.5:
33kV: Ratio 200-400/1 amp

11 kV: Ratio 1500/1 amp

For overcurrent and earth fault protection, not less than 15 VA, Class 5P20:
33kV: Ratio 200-400/1amp

11 kV: Ratio 1500/1 amp

For overcurrent and earth fault protection, not less than 15 VA, Class 5P20:
33kV: Ratio 200-400/1amp

11 kV: Ratio 1500/1 amp

Busbar protection core as per the design
<u>Transformer bushings shall be equipped with a current transformer on each phase with four separate cores:</u>

For differential protection and restricted earth fault, not less than 15 VA, Class X

33kV: Ratio adapted to transformer rating
11 kV: Ratio adapted to transformer rating

For instruments, not less than 15 VA, Class 0.5:

33kV: Ratio adapted to transformer rating

11 kV: Ratio adapted to transformer rating

<u>Loose Transformers for Transformer Neutral</u>
(a) Two lose single phase current transformers for connection of Restricted Earth fault Protection and Neutral Overcurrent Protection
Ratio as per design

3.1.12.10.9.2 Voltage Transformers

<u>Three phase voltage transformers shall have the following characteristics</u>

Ratio $\frac{66000}{\sqrt{3}} / \frac{110}{\sqrt{3}}$ for 66 kV switchgears

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

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

with accuracy class 0.5 for the measuring winding and class 3 P of capacity between 100 to 200 VA for the protection winding in accordance with IEC 60186.

Each busbar section and each 33 kV 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.

3.1.12.11 Protection and Control

3.1.12.11.1 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.

3.1.12.11.2 Arc Detection

The complete 33KV board shall be fitted with arc detection or pressure detection devices in the cubicles which instantaneously trips the incomer circuit breakers or those in a combination with the bus-section breaker, to isolate the faulty part in case of a short circuit on the busbar or in a circuit breaker cubicle. The arch detection shall be insensitive to sunlight and flashlight. Rapid tripping scheme shall not influence the test requirements given above. The scheme is to be approved by the Project Manager.

3.1.12.11.3 Optional Equipment and Accessories

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

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

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

3.1.12.12 MV Cables and Accessories

3.1.12.12.1 General

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

All cables shall be suitable for operation:

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

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

3.1.12.12.2 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.

3.1.12.12.3 Cable

The conductor shall be covered with:

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

3.1.12.12.4 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.

3.1.12.12.5 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

3.1.12.12.6 Armour

All cables shall be armoured according to approved manner

3.1.12.12.7 Testing

Notwithstanding that cables are manufactured to approve 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.

3.1.12.12.8 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.

3.1.12.12.9 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

3.1.12.12.10 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

3.1.12.12.11 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.

3.1.12.13 **Auxiliary Supply and Substation Lighting**

3.1.12.13.1 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.

3.1.12.13.2 Switchboards and Panels AC

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 busbars).

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

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

3.1.12.13.3 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.

Undelayed 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 50 A and higher shall be withdrawable

3.1.12.13.4 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 20.

Power frequency test voltages, 1 minute:

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

3.1.12.13.5 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.

3.1.12.13.6 Tests

Tests shall be made in accordance with the applicable standards.

3.1.12.14 415/240 v Auxiliary Supply

3.1.12.14.1 Auxiliary Transformers

Station transformers are part of the scope of supply.

3.1.12.14.2 Distribution Boards

Current carrying capacity of main transformer circuit breaker shall not be less than 1250 A. Automatic switchover between the sources shall be arranged within the main board. The board shall be equipped with instruments for measuring of current and voltage in all phases as well as energy meters for recording of energy consumption. The board shall be equipped with tariff metering. Continuous current rating of the phases and neutral from the transformer and of the busbars in the main switchboard shall be at least 1250 A. The current rating of the feeders shall be ample for the actual load and have at least 50% reserve capacity compared to the actual load. The figures given in these specifications are indicative only. Only a limited number of different makes, types and ratings shall be used, for the purpose of standardisation and interchangeability.

3.1.12.14.3 Switchyard Lighting

The switchyard lighting shall be by means of floodlights with 400 W for bay lighting and 70 W 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.

3.1.12.14.4 DC Emergency Lighting

Emergency lighting is provided for in under Civil Works.

3.1.12.14.5 Hand Lamps and Portable Hand Sets

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

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

3.1.12.14.6 Clock

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

3.1.12.15 DC SUPPLY

3.1.12.15.1 General

This section covers the technical requirements of the batteries and battery chargers, the main DC switchboards and the sub-distribution boards and panels for the DC auxiliary supply of the plants.

3.1.12.15.2 Distribution Boards

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

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

For HV stations the 110 V DC 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 110 V 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.

3.1.12.15.3 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 busbars of the main distributions) shall be at least 90% of the rated voltage with the batteries being loaded as specified.

The 30 V or 110 V batteries shall be loaded with the switchyard load.

Alarms shall be provided for battery faults.

The batteries shall be of the Nickel Cadmium type.

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.

3.1.12.15.4 Chargers

The rated current of the battery chargers shall be selected to allow for recharging a fully discharged battery in 5 hours, in addition to simultaneously supplying the DC load.

In addition the chargers shall comply with the following technical data and requirements:

Power supply	415 V AC three-phase or 240 V AC single-phase
Output voltage adjustable between	110 V or 30 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
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 110 V or 30 V 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/Regional Control Centre.

3.1.12.15.5 Battery Conductors and Fuses

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

The conductors shall lead through insulating pipes in the wall of the battery room to closed fuse boxes made of insulating material on the wall outside the battery room. For the 110 V or 30 V DC system there shall be one box for pole. The wall-holes shall be tightened against gas intrusion.

4 PARTICULAR TECHNICAL SPECIFICATIONS SUBSTATIONS CONTROL, PROTECTION.

4.1.1 Control, protection and cabling – Substations

4.1.1.1 Control Protection and Metering

4.1.1.1.1 General

The sections below cover the technical requirements for the systems of control, protection, metering and signalling 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.

Overview of Substation Automation SAS

This Substation Automation System (SA) 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, interbay bus, intelligent electronic devices (IED) for bay control and protection.

The communication gateway shall secure the information flow with Regional Control Centres. The interbay 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 within the manufacturer's responsibility, but subject to approval by KPLC.

This specification covers the design, manufacture, inspection, training and testing at the manufacturer's works and at site, delivery to site, installation and commissioning.

4.1.1.1.2 Design of SAS

The Substation Automation System (SA) 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, IEC60870-5-101,103,104 for operation under electrical conditions present in high-voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SA 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, signalling 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.

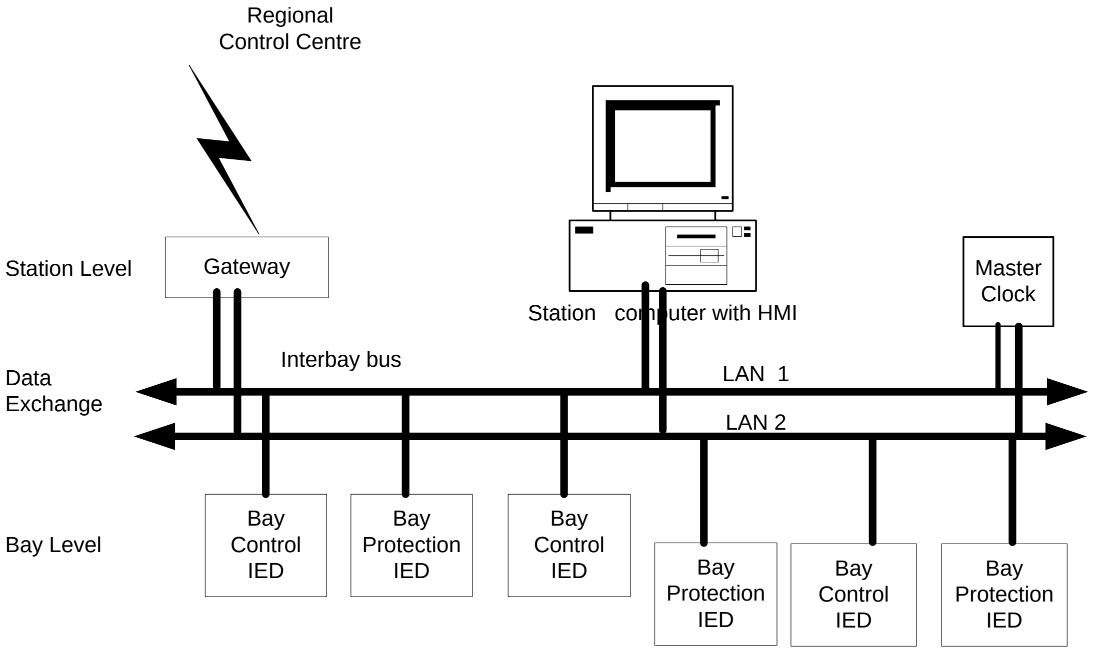
The typical SA layout shall be structured in two levels, i.e. in a station and a bay level.

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 MVA_r) 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.



System Architecture of Substation Automation

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 interbay 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 interbay bus.

The SA shall contain the following main functional parts:

- Human Machine Interface (HMI) with process database
- Separate gateway for remote supervisory control via SCADA
- Master clock (e.g. GPS receiver)
- Collection of the relevant data concerning the substation and distribution of the data where needed
- Bay and station level devices for control, monitoring and protection
- Bay-oriented local control panels.

4.1.1.1.2.1 Signal List

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

- Commands for all CBs and motorized switchgear
- Status Indications
- Alarms
- Set Point Regulation
- Measurands

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 SCMS SA system shall include the following;

- Control mode selection
- Select-before-execute principle
- Command supervision:
  Interlocking and blocking
  Double command
- Autoreclosing
- 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

4.1.1.1.2.2 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.

4.1.1.1.2.3 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.

SCMS 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 SCS 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
  - ❖ Protections 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 SCS.

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.

4.1.1.1.2.4 SCMS Equipment

Substation Computer

- The substation computer coordinates the operation of the SCS. The functionality shall include:
  - Alarm Grouping
  - Event Logging
  - SCS Management software
- The substation master control shall be capable of automatic restart in the event of power failure
- without loss of functionality or local database. It shall be readily possible to update the substation
- computer software to alter or extend the SCS functionality. The Tenderer shall state how this is achieved.

Substation Local Area Network

Local substation communications shall use Ethernet LAN to connect the components of the SCS using IEC 61850 protocols. The LAN may be of star-coupler configuration. Fibre 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 protocols.

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Operator Workstation

- The Operator workstations / HMIs shall consist of high performance computer and monitor with computer desk. It shall be fully integrated into the SCS on the substation LAN. The proposed HMIshall 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.

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 Colour Printer to print screen shots or other information

Satellite Clock

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

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 SCS (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.

4.1.1.1.2.5 Data Transmission

- The SCS 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 SCS via the SCADA system. The protocols currently supported are IEC 60870-5-101 &IEC 60870-5-104.
- This communication link must be via an approved communication mode complete with the terminal equipment all supplied, installed & commissioned by the Contractor.

Common Bay Unit

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

4.1.1.1.3 Control Stations

4.1.1.1.3.1 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 galvanic ally 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.

4.1.1.1.3.2 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 60870-5-101 protocol. The following SCADA facilities shall be available from the substation.

- Supervisory control of all circuit breakers and motorized line and bus bar isolators. Remote controls 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, 30, 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.
- 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. Either undefined sates 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.

The Contractor shall as part of his supply fill in I/O lists for each substation in the format to be specified by the employer. The I/O lists will comprise the name tag, address tag (fitted to the SCADA Contractor's system of addressing the information), ASDU type in accordance with the agreed interoperability list and other information as required.

4.1.1.1.4 Automatic Voltage Regulator

The transformer bay shall be equipped with an automatic voltage regulator acting on the on line 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 the transformers shall be regulated in a master-slave, circulating current or negative reactance system where each transformer can be selected as master. If the master is tripped 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.

4.1.1.1.5 Indicating and Metering Instruments and Metering Transducers (if used)

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 96 x 96 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 SCS 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 110 V or 30 V DC.

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.

4.1.1.2 **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 measurements and controls are simulated.

4.1.1.3 **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
- Protection device settings and configurations

4.1.1.4 **Spare Parts and Tools**

The Contractor shall furnish a list of recommended spare parts and test equipment for the purchased SA system to maintain reliable SCMS operation. The spare parts list shall be subdivided into:

- Short-term spare parts that is 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.
- Long-term spare parts that is necessary for ten (10) years of operation.

4.1.1.5 **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 SCMS.

4.1.1.6 **Protection**

4.1.1.6.1 General Requirements

The protection relays to be installed for the protection of transmission lines, transformers and other HV/MV equipment shall be numeric of robust type, insensitive to changes of temperature, vibration, etc.

Input from the measuring transformers shall be based on 1A, 110 V AC. The relay's power supply must accept a rated operating voltage input range from 24-240 V AC/DC 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 24-240 V AC/DC 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.

4.1.1.6.2 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 earthfault 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 users 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.

4.1.1.6.3 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 licences needed for testing, setting and reconfiguration of the relays. If hardware other than laptop is required for this such shall be included in the supply.

4.1.1.6.4 Fault Clearing Time

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

4.1.1.6.5 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.

4.1.1.6.6 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.

4.1.1.6.7 Supervision

The supply shall include hardware and software for remote setting, supervision and data acquisition of the protection relays, fault locators and fault recorders. The software will be installed on a central PC with ‘windows XP and windows 7’ operating system. This PC will be shared with other Contractors. The centrally installed software shall make it possible to contact the relays over the telephone network via modems installed in each substation. The Contractor shall supply and install the modems, connect the relays and test the complete chain of control.

The protection relays shall also communicate with the bay control units over the open protocol IEC 870-5-103.

4.1.1.6.8 Protection of HV system

4.1.1.6.8.1 66 Transmission 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 fused 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 line protection schemes shall contain the following protection relays:

(i) Distance Protection Relay
(ii) Three phase directional over current and Earth fault relay
(iii) Sensitive Earth fault relay
(iv) Auto reclose Relay
(v) Trip circuit supervision visible from the front of the panel without having to open the panel door.
(vi) Autoreclose IN/Out switch
(vii) Breaker maintenance
(viii) Breaker failure

<u>Distance Protection</u>
One complete distance relays of 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 characteristics:

- Ratings: AC Inputs: 110V, 1Amp (three phase).
- Power Supply Voltage: 110VDC. (Universal power supply of 30-300VDC is preferred).
- The relays shall be of Numeric design.
- 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 1 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.
- Three sets of Installation, Commissioning and maintenance manuals 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.

<u>Three phase numeric directional over current and earth fault relay</u>

Should incorporate the following features:

- Relay must be of Numerical design.
- 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 BS 142 or IEC 60255 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
- Highset 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.
- Must provide all technical and operations manuals and configurations and settings software.

Sensitive Earth Fault Relay.

Should incorporate the following Features;

- Relay must be of Numerical Type
- Current setting range for earth fault relay 0.005In-0.8In
- 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%

Autoreclose relay

- 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.

4.1.1.6.8.2 Transformer Protection 66-33kV Transformers (HV side)

The protection contains the following protection relays on the HV side:

(i) Biased differential protection relay for two winding Transformer.
(ii) HV & LV restricted earth Fault relay. This should include stabilising resistor and voltage dependent resistor (metrosil)
(iii) HV Three-Phase Over current and Earth fault Protection Relay
(iv) Auxiliary relays with annunciator for the following transformer functions
   - Tx Buchholz gas
   - Tx Buchholz surge
   - OLTC Buchholz gas
   - OLTC gas relay
   - Pressure relief
   - Winding temperature Alarm
   - Winding temperature trip
   - Oil temperature alarm
   - Oil temperature trip
   - Tx oil level low
   - OLTC oil level low

(v) Standby earth fault relay.
(vi) HV Master trip

(vii) Trip circuit supervision relay for HV breaker

Biased differential protection for a two winding transformer.

Overall differential protection equipped with over current stabilising for external faults and insensitive to in-rush current. The operating time of the protection shall be less than 20ms. This is considered main 1 transformer protection

This should incorporate the following features:

- Relay Must be of Numerical design
- Pick up setting range, 0.1 to 0.5In
- Should incorporate a high-set Element with a setting range of up to 20In.
- Magnetising 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.
- Overfluxing restraint
- Overfluxing protection with Alarm and Trip functions
- 5th harmonic restraint feature on the differential Element.
- Appropriate Dual Bias characteristic to ensure relay stability for heavy through faults
- 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.

Three phase numeric IDMTL over current and earth fault relay

Should incorporate the following Features;

- Relay must be of Numerical Type
- 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
- Highset 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%

<u>Restricted Earth fault relay</u>

- Relay must be of Numerical type
- Relay should reject harmonics produced by C.T saturation
- The offer should include the associated stabilising resistor and voltage dependent resistor (metrosil)
- Current setting range 0.05-0.8In
- Operating time < 25ms at 5 times the setting

Restricted earth fault and differential protection functions shall be provided in separate units.

LV side protection defined below.

4.1.1.6.8.3 Transformer Protection 66-33kV Transformers (LV side)

The protection shall be as follows:

(i) Three phase over current and earth fault relay
(ii) Three phase directional over current and earth fault relay
(iii) LV Master trip relay
(iv) Trip circuit supervision visible from front of panel without opening relay compartment door.

The characteristics of the relays shall be as above.

4.1.1.6.8.4 Under Frequency Relay

Each busbar shall be equipped with a separate under frequency relay for load shedding of all outgoing breakers. Each trip circuit 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 0.1 Hz.

4.1.1.6.8.5 Busbar Protection 66 kV and above.

Busbar protection schemes shall be provided at busbars for voltages 66 kV and above. Low impedance schemes will be acceptable provided full busbar 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 more than two criteria checks before tripping. The busbar protection relays must be of the numeric type with full discrimination between the busbars even with closed bus coupler. It shall have CT supervision,

4.1.1.6.8.6 Breaker Backup Protection

The breaker backup protection shall only isolate the busbar to which the faulty breaker is connected. I.e. the station shall, as far as possible, remain in operation by a breaker failure. The busbar protection can be used for selection of breakers to be tripped.

4.1.1.6.8.7 Bypass Trip Logic, Bus Coupler

Where bus coupler is specified or already installed, the trip signals of any bypassed 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 busbars.

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.

4.1.1.6.9 Synchronizing Equipment

Circuit breakers and the secondary side transformer circuit breakers at 66 kV and above shall have check synchronism (controlled closure) equipment.

Closure of the circuit breaker shall only be possible when the phase angle, slip and voltage difference between the measured voltages are within preset 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%.

4.1.1.6.10 Relay Test Equipment

The relay test equipment shall be a portable three phase unit with facilities for testing of 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 1 ms. It shall be possible to connect the unit to a personal computer and necessary software for data recording and data handling shall be included.

4.1.1.6.11 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.

4.1.1.7 Metering

All metering equipment shall meet the requirements in IEC 60687 and IEC 61036.

Meters shall be designed for 110 V+15/25 %, 50 (47-53) Hz and 1/5 A secondary voltage/current from measuring transformers. Auxiliary supply for the meters shall be 110 V, 50 Hz from the voltage transformers, or 110 V DC from the DC supply system. Secondary current 1 or 5 A from current transformers shall be decided on a later stage for each individual meter.

4.1.1.7.1 Meters for Outgoing 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 Wh meters and recorders shall be of class 0.5 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 60870-5-103 protocol.

4.1.1.8 LV cables and Cable Racks

4.1.1.8.1 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 Chapter 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.

4.1.1.8.2 Technical Requirements

4.1.1.8.2.1 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 ^{o}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 standardised 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.

Further requirements are stated in General Specification of Works, "Wiring and Terminal Blocks".

4.1.1.8.3 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.

4.1.1.8.4 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.

4.1.1.8.5 Tests

Factory tests and site tests shall be performed in accordance with the applicable IEC recommendation.

Type test certificates shall be submitted on request.

4.1.1.9 Earthing (Grounding) System

4.1.1.9.1 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 2500 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.

4.1.1.9.2 Technical Requirements, General

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 0.5 ohm 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 between 10 and 20 ohms. If necessary, additional earthing rods shall be applied to achieve the specified value.

The dimensioning shall be co-ordinated 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 under ground surface. Connections above earth shall be screwed and shall be easily accessible for control. All connections shall be protected against corrosion.

4.1.1.9.3 Earthing Electrode 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 95mm2 stranded wire. Copper-weld with approximately the same conductivity may be used.

Risers shall be copper stranded wire at least 95 mm2.

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 10 m. 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 30 cm 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.

4.1.1.9.4 Earthing Electrode System of the Switchyard

The conductors shall be of electrolytic copper with dimensions at least 30 x 3 mm for the flat bar or at least 95 mm2 stranded wire. Copper-weld with approximately the same conductivity may be used.

The risers shall be of at least 95 mm2 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 25 cm of the same material shall be placed over the conductor. The conductor shall at no place be less than 80 cm 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.

4.1.1.9.5 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 150 mm² for flat bar or 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 m.

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.

4.1.1.10 **Site and Commissioning Tests**

4.1.1.10.1 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.

4.1.1.10.2 Test of Wiring

a. Insulation Resistance Test at 2.5 kV a.c. for one minute shall be carried out on all A.C 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.

4.1.1.10.3 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.

a. 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 stabilising 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.

4.1.1.10.4 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.

4.1.1.10.5 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.

4.1.1.10.6 Tests on Conductors, Insulators and Accessories

None required.

4.1.1.10.7 Tests on the Switchyard on Site

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.

4.1.1.10.8 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.

4.2 PARTICULAR TECHNICAL SPECIFICATIONS-TRANSFORMERS

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 auxiliary 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.

Power Transformers

Design Criteria

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 2 200m asl.

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 5 ºC (at rated power on any primary tapping).

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.

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.

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 energising at full rated voltage and when delivering any load up to the continuous maximum rating.

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.

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 31 mm/kV line voltage in Coast and industrial area and 25 mm/kV for inland installations. 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.

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 busbars.

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.

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 this specifications shall not exceed 1.9 Tesla.

Thermal ability.

The transformer shall be capable of withstanding the fault level at its rated voltage and impedance for 2 seconds. The design should cater for the expected lifetime of the transformer. The thermal ability to withstand short circuit shall be demonstrated by calculation as per IEC 60076-5 and the calculation shall be submitted with tender. The duration of the current to be used for the calculation of the thermal ability to withstand short circuit shall be 2 seconds while the maximum permissible value of the average temperature of each winding shall be as per IEC 60076-5. As a minimum, the short-circuit apparent power of *I* I kV and 33kV systems shall be taken as 500MVA and 1000MVA respectively (as per IEC 60076-5) in order to obtain the value of the symmetrical short circuit current to be used for the design and tests.

Construction

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 manufacturers 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.

Cores

The transformer core shall be built up of laminations of the best quality non-ageing 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 2 kV, 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.

Windings

The windings shall be circular and consist of high quality rectangular section copper, 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.

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, carbonise 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 centres 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 of the 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 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.

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.

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 70 kPa without any permanent deflection of any parts. The tank must also be capable of withstanding a vacuum of 50 mm 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 150 mm 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 25 kg 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 500 mm above ground level and four holes with a diameter of not less than 50,8 mm 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 (millimetres 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.

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.

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 shall be used for temperature indication.

Current Transformers

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

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).

Painting and Galvanising

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 0.16 mm.

The radiator external surfaces shall be hot-dip galvanised 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.

Fittings

The transformer shall be supplied with the fittings specified in Scope of Works. These fittings shall comply with the following clauses.

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.

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.

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 litres 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.

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.

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 ^{o}C to 115 ^{o}C. 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 compartments compartment shall have separate Buchholz relays. However the OLTC chamber shall be equipped with pressure rise relay instead.

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 45 ^{o}C and 150 ^{o}C 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 ^{o}C 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.

Cooling

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.

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.

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 galvanised 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.

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 preset temperatures.

Indicate setting values are as follows:

	On	Off
Stage 1	65°C	50°C
Stage 2	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, galvanised steel, or other corrosion-resistant metal and shall be designed to keep noise and vibration to a minimum. All fans shall be provided with galvanised wire-mesh guards. It shall be possible to remove fan assemblies complete without dismantling other equipment.

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.

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.
- A "Cooler Auto" - "Cooler-Manual" 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 and terminal boards to approval to make a complete assembly.

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

Off-load Tap Changer

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

Tap changers with mercury sealing glands are not acceptable.

The tapping range shall be as specified in Scope of Works.

Drain, Filter and Sampling Valves

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 ^{o}C.

Drain Valves

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

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.

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.

Valve Entries

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

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.

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 l and be full. A separate price shall be quoted for transformer oil.

On-Load Tap Changers

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 the 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. All tap changers for transformers shall be of the vacuum type.

Generation 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.

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 no 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.

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.

Operation

The tap changer shall be operated in the following modes:

- From an automatic voltage regulator in the substation (normal control).
- The control is part of the switchgear 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. Cray 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 240V AC.

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

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.

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, 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.
- Gas relay transformer, alarm.
- Gas relay transformer, trip.
- Protective 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 operated, trip.
- Pressure relief device OLTC operated, trip.
- Top oil temperature high, alarm.
- Top oil temperature critical, trip.
- Winding temperature high, alarm.
- Winding temperature critical, trip.

Local Control Cubicles and Wiring Cabinets

Each power transformer shall be provided with a weatherproof (IP 54) 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 and equipment included in the Bid price each item to be identified with its function.

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.

Wiring and Terminal Blocks

The switchgear 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.

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.

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 despatched 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 Employer/Project Manager.

Factory 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.

Transformer Tests

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 transformer:

- Resistance measurements of all windings for 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 70 kPa. 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.

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.

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.

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.

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 have 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.

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 to 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.

Evaluation of Losses

Guaranteed Output and Losses, Liquidated Damages

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

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 2 577 per kVA.

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 capitalised 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.

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 that 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.

Evaluation of Losses

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

Load losses:	USD 1070/kW
No load losses:	USD 4300/kW

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.

Drawings to be submitted with Bid

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).

a. 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).

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

d. Complete details of the tap changer.

c. Detailed drawings of the tapping switch showing internal details of switch and mechanism, tapping connections and change-over link board.

e. Fully dimensioned drawings of all proposed bushings including cross-sections and full electrical characteristics.

f. A calculation of the thermal ability to withstand short-circuits.

e. Schematic wiring diagrams of automatic voltage control, cooler control, and protection systems with fully detailed description of the operation.

  - Drawings of proposed rating and diagram plates.

f. Catalogues of all accessory equipment and fittings.

4.2.1 Distribution and Auxiliary Transformers

General

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

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 Dynll.

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 non-standard 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.

Windings

Tappings 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 to be provided.

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 cupper. No foil windings shall be used.

Designs shall be such that electrical stresses are as uniform as possible throughout the 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.

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.

Particular attention shall be paid to maintaining low core loss consistent with sound design.

Tapping Switches

The transformer shall be provided with approved off-circuit type tap changing equipment.

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. tappings : Minus 2.5% : 0% : Plus 2.5% : Plus 5% : Plus 7.5%.

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 31 mm/kV in Coast and industrial area and 25 mm7kV in inland installations. Arcing horns shall be fitted on all transformer bushings. As an alternative factory mounted surge arresters are acceptable.

Tanks and Conservators

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 Project Manager shall approve the colour.

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.

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.

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 5 ºC 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 wit the level at 20ºC 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 to be fitted on the L.V. end of the transformer.

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

Accessories and Fittings

All transformers shall be provided with accessories and fittings in accordance with Table 1, unless otherwise specified in the enquiry.

Rating and diagram plates shall be of engraved steel, brass or other approved incorrodible material.

Where a thermometer pocket is provided, it shall be of a thin walled metal mounted in the tank cover.

The pocket shall project 25mm 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

Item No	15-315 kVA
Transformer Tank Fittings	
1. Conservator (Sealed type)	N
2. Drain valve with captive sealing plug	Y
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 (if LA offered)
10 Arching Horns	Y
11. Lightning Arrestors	Y (as alternative)
11.Dial type thermometer	N
12 Jacking pads	Required only when the mass of the complete transformer is 1000 kg or more
13.Oil gauge	Y
14.Mounting plate for Item 5 (to be suitable for mounting marshalling box Item 16)	N
15.Lashing down facilities	Y
16.Marshalling box for Item 10 of Tank fittings and Item 7 of Conservator Fittings	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

Insulating Oil

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

Tests

The following tests shall be carried out:

a) Routine covering test certificates 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 to 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 certificates.

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.

Drawings and Diagrams

With Bid

The following drawings shall be supplied with any 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:

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.

Detail dimensioned drawings of tapping switch illustrating type of material, clearances, between tapping points and to earth and method of operation.

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.

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.

Evaluation of Losses

As for the main transformers

5 PARTICULAR SPECIFICATIONS SUBSTATIONS CIVIL WORKS

5.1.1 PARTICULAR SPECIFICATION CIVIL WORKS

5.1.1.1 General

5.1.1.1.1 Location of the Works

The locations of the sites are as described under the relevant clauses in scope of works in Volume 2.

5.1.1.1.2 Type of Works

The works to be constructed under this Contract include the following:

Work for access road
- Earthworks for sub-station platform
- Subsoil drains and storm water drains
- 100 mm thick layer of stone to platform surface
- Fencing
- Concrete bases and Stub columns
- Cable Trenches
- Switchgear Building

Transformer foundations
- Any other works necessary for full completeness

5.1.1.1.3 Switchgear Building

The switchgear building shall contain the following rooms:

- Switchgear room to accommodate all the switchgear panel plus a space that would accommodate 6 more feeder panels in the future.
- Battery room (to accommodate both protection and communication batteries)
- Office room (4mX4m). Office furniture (cabinets, chairs and office table)
- Kitchen
- Communication equipment room (5mX4m)
- Toilet facility
- Control and protection Panel room to accommodate the necessary Protection and control panels and space for future expansion.

In addition a guardhouse with toilet facilities located at the main gate shall be constructed. The guardhouse area shall be clearly demarcated from the restricted area.

All the rooms shall be pressurised to avoid dust.

5.1.1.1.4 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 programme.

5.1.1.1.5 Drawings

The Drawings issued with these documents are for tendering purposes only. Drawings for this project shall be made by the Contractor or his civil consultant, and be to the approval of the Project Manager.

5.1.1.1.6 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. Where it is necessary for persons on foot or in vehicles, including other Contractors, to cross the site whilst work is in progress, 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.

5.1.1.1.7 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 programme 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 organisation 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 Constructional Plant and Temporary Works proposed.

5.1.1.1.8 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.

5.1.1.1.9 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, sumps and other measures and provisions necessary for such purposes and for clearing away and making good to the satisfaction of the Project Manager damage caused thereby.

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.

5.1.1.1.10 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.

5.1.1.1.11 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.

5.1.1.1.12 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, authorised 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 authorised 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 minimised. 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 programme 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.

5.1.1.1.13 Water Supplies for the Works

The Contractor shall make his own arrangements for the supply of potable water for his staff on site and water for the Works.

The Contractor must make all arrangements including the supply of pumps and motors, labour 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 utilise 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 utilising any water source for the Works.

5.1.1.1.14 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.

5.1.1.1.15 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.

5.1.1.1.16 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.

5.1.1.1.17 Basic Survey and Setting Out

The Contractor will survey the sites 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.

The Works are located on the drawings and the Contractor shall appoint a suitably qualified Surveyor to set out the Works from the beacons and shall plot cross sections at 20 m intervals and submit to the Project Manager for approval.

No separate payment will be made for any work in connection with the setting out of the Works, nor any other Works required by the Contractor to ensure the accurate location and construction of the Works.

5.1.1.2 EARTHWORKS

5.1.1.2.1 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.

5.1.1.2.2 Access and Internal Roads

Where necessary access roads to the substation sites shall be constructed. Internal substation road and walk paths shall be compacted to 100% MDD after grading shall have a well done paving block finish that can withstand load weight of not less than 80mm , 49N/mm2. The road shall also be lined with kerbline and channels and shall be constructed to a fall that will allow proper drainage of the road. The road shall have adequate drainage provided.

A-Gravel Access and Internal Roads (Gravel Wearing Course – GWC)

A.1 General

All new access and internal roads will be gravel standard and their alignments will be designed to accommodate construction and future maintenance traffic.

Any damage occasioned by whatsoever cause during construction shall be repaired by spot gravelling, reshaping and re-compaction at the end of contract such that the road to be handed over will be defects free.

A.2 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 ravelling 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		
Sieve 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.

A.3 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. 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.

a) Existing Bitumen Standard Access and Internal Roads

All shall be reinstated to their original standard of materials and construction.

b) Quality Control

Tests shall be performed by the contractor on soils and gravels undergoing compaction under the supervision of and at frequencies determined by the Project Manager and shall include:

- Determination of the Atterberg Limits in accordance with BS 1377.
- Determination of particle size distribution in accordance with BS 1377.
- Determination of dry density / moisture content relationship in accordance with BS standard compaction and modified AASHTO T180 as appropriate.
- California Bearing ratio (CBR) in accordance with AASHTO T193.
- Field dry density as set out in BS 1377.

5.1.1.2.3 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.

Overburden in the borrow pit shall also be stripped to a depth specified by the Project Manager and stockpiled for later use in rehabilitation.

5.1.1.2.4 Classification of Materials

Materials excavated and either placed in the Works for the formation of the platform or carted to spoil will be paid for in the following three classes of material:

<u>"Rock"</u>
"Rock" shall include all material which requires blasting for its removal or cannot be extracted by ripping with a single tine heavy duty ripper of at least 5 tonne mass towed by a crawler tractor in good condition with a net available flywheel power rating of not less than one hundred and thirty-five kW engine power and with a minimum bare tractor mass of 15 tonne. The use of explosives by the Contractor to excavate does not in itself imply that a material is Rock in terms of this Contract. Individual boulders greater than 0.2 m3 in volume shall be included in this class when their nature and size are such that they cannot be removed without recourse to blasting.

<u>"Hard Material"</u>
"Hard Material" or "Decomposed Rock" shall include all material such as consolidated gravels, decomposed or stratified rock, stones or boulders less than 0.2 m3 in volume which cannot be classified as "Rock" but which in the opinion of the Project Manager requires additional processing, such as ripping or breaking down by compressor tools before normal loading processes may be employed. For the purpose of this clause normal loading processes will include the use of graders or dozers to stockpile material.

<u>"Common"</u>
"Common Material" shall be all material not defined as Rock or Hard Rock.

All materials shall be classified as "Common" unless otherwise certified by the Project Manager. Should the Contractor during excavation encounter any material which in his opinion should be classified as rock or hard material, then he shall request the Project Manager to so certify the material before excavation of that material commences.

5.1.1.2.5 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.

5.1.1.2.6 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 but 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 of 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

5.1.1.2.7 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.

5.1.1.2.8 Expansive Material

When expansive material is encountered, it shall be removed to a depth 600 mm 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.

5.1.1.2.9 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.

5.1.1.2.10 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.

5.1.1.2.11 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.

b) Backfilling for Surfaces

Any excess excavation in rock below the formation shall be backfilled and compacted. 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 free drainage of water.

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 prised 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.

5.1.1.2.12 Setting Out and Preparation for Earthworks

The Contractor shall set out the earthworks and the tops of cuttings and toes of embankments at intervals 10 m. 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.

5.1.1.2.13 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.

5.1.1.2.14 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.

5.1.1.2.15 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.

5.1.1.2.16 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.

5.1.1.2.17 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.

5.1.1.2.18 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 and - 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 centre lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

5.1.1.2.19 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.

5.1.1.2.20 Grassing of Slopes

The surface of embankment slopes, after placing of top soil, shall be planted with grass. 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.

5.1.1.2.21 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.

5.1.1.2.22 Soil Sterilisation

In order to stop the growth of vegetation and incidence of ants, the Contractor shall apply an approved herbicide before any spreading of stone over the platform area.

Insecticide to be used around Switchgear building.

5.1.1.2.23 Earth Electrode

The Contractor shall install earthing electrodes in trenches as outlined in the Specifications for Earthing in chapter 4.1.Particular specifications.

5.1.1.2.24 Platform Areas

The substation platform areas shall be at least 1.5 times the area required by to equipment to be installed.

5.1.1.3 **MATERIALS FOR THE WORKS**

5.1.1.3.1 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 for the approval of the Project Manager the names of the firms from whom he proposes to obtain such materials, etc., together with a list of the materials and manufactured articles giving the origin, quality, weight, strength, description, etc., which he proposes that the firms should supply. No materials or manufactured articles shall be ordered or obtained from any firm of which the Project Manager shall not have previously approved.

All materials shall be delivered to the site a sufficient period of time before they are required for use in the Works to enable the Project Manager to take such samples as he may wish for testing and approval. Any materials condemned as unsuitable for Works shall be removed from the Site at the Contractor's expense.

The Contractor may propose alternative materials to those specified, provided that they are of equivalent quality and, subject to the Employer's or the Project Manager's approval such materials may be used in the Works.

5.1.1.3.2 Standards

Concrete pipes, porous concrete pipes, cast iron manhole covers and gratings, bricks, concrete kerbs, bituminous surfacing, cement, steel and aggregates shall comply with local or regional standard to be approved.

5.1.1.3.3 Filter Backfill for Sub-soil Drains

This shall be graded crushed stone as for platform surfacing (below).

5.1.1.3.4 Stone for Pitching

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.

5.1.1.3.5 Stone for Platform Surfacing

The stone shall be hard and durable crushed rock with a maximum particle size of 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.

5.1.1.4 **DRAINAGE AND STORM WATER**

5.1.1.4.1 Drainage

The Contractor shall provide sub-soil and storm water drainage, including drainage of cable ducts. The drainage system shall be to the approval of the Project Manager.

Drainage shall be in accordance with relevant Codes for Practice published by authoritative Standards organization such as the British Institution, e.g. BS 8301, BS 6031 and CP 2005.

A surface water drainage system covering the entire substation site shall be installed to allow total drainage of the substations. The number of runs and outfalls and pipe sizing must be sufficient to cope with the severest precipitation, 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.

Embankments and cuttings are to have drainage facilities at their top or bottom. The formation level of the site is to be formed with uniform cross-falls of about 1 in 300 in the same direction as the natural drainage path of the surrounding environment.

Surface water from roofs of buildings except the equipment room shall be drained to down pipes, which connect with the general site drainage system. Surface water from the equipment building roof shall be drained to the main reservoir tank.

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.

The contractor shall install precast 600 mm concrete culverts for storm drain with the 200mm thick concrete haunching for the purpose of providing free flow of storm water drain at the substation entrances and or exits. Also 200mm thick reinforced concrete plastered head walls shall be installed.

Foul drainage

The foul drainage will be connected to a sewage drainage system where applicable or to standard septic tank for 20 persons to be constructed by the contractor. All the necessary authority shall be sought by the contractor prior to connection, and all regulations of the council shall be adhered to.

5.1.1.5 FENCING

5.1.1.5.1 Fencing

The Contractor shall construct fencing along the perimeter of sub-stations, including gates where necessary and shall comply with the requirements of the following Clauses.

All the substation fences shall be of dressed Natural stone. The substations shall have electric fence and a razor wire on top of the perimeter wall.

5.1.1.5.2 Dimensions

Height of the stone fence:	2 700 mm
Height of chain link fabric:	2 000 mm

Barbed wire: 3 wires above fabric, height of 300 mm, on supporting arms facing outwards from Site at 450 angle.

Maximum distance between posts or columns: 3 000 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 1 100 mm

- End posts 1 200 mm
- Gate posts 1 400 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.

Gate width: free distance between 2 gate posts, 1 500 mm for single gate, 5 000 mm double gates.

Double gates: one leaf for normal traffic, other leaf to remain closed by means of drop bolt locking into centre rest, inoperable from exterior.

Gates: able to open in either direction to 900.

Gate hardware: three hinges, latch with padlock accessible from either side of gate, latch catch.

Top of posts and uprights: weatherproof tops.

5.1.1.5.3 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 F 626, hot-dipped zinc coated according to ASTM A 123.

Barbed wire: ASTM A 121, 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: 20MPA at 28 days

5.1.1.5.4 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.

5.1.1.6 **CONCRETE AND BUILDING WORKS**

5.1.1.6.1 Earthworks

Preliminary design and calculations of foundations

The Contractor may ascertain for himself the nature of the sub-soil conditions over the sites of the works for his additional data, which he may require, for preparation of his bid. The contractor may collect any other data he deems necessary for his bid.

Soil Investigations

The Contractor shall be required to perform sub-soil tests within the area of the switchyard to the depth and by the method of test specified by the Project Manager. The details of performing the test, tools and equipment to be used for, shall be submitted to the Project Manager for approval.

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.
The soil tests should result in parameters significantly different from those given for tendering purposes; price adjustments for foundations may be adjusted proportionally, subject to negotiations.

Excavation

Excavation for concrete foundations shall be carried out in strict accordance with the requirements of the Project Manager and to fit in with the programme of construction.

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. For the purpose of measurement the following categories of shoring shall apply:

Dewatering

The whole Works shall be constructed in the 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.

Excavation to be Approved

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.

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.

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.

Backfilling

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 for dense compaction.

Compaction shall be to approved standard.

5.1.1.6.2 CONCRETE, FORMWORK AND REINFORCEMENT

Material

Aggregates

a) Shall conform to BS 882.

b) Shall be heaped separately on hard, self draining surfaces.

c) Normal size of coarse aggregate shall be 20 mm.

Water

Shall be fit to drink

Reinforcement

Shall conform to BS 4449.

Cement

Shall

a) Conform to BS 12.

b) Be either normal Portland or P.C. 15.

c) Be used within 6 weeks of manufacture.

d) Be stored in a manner to exclude any moisture.

e) Be stored in a manner to ensure use of the earliest consignment.

f) Different types of cement from different manufacturers shall not be mixed for a single cast or structural element.

g) If concrete is to be exposed Item 4.f to apply for whole project.

Additives shall not be used

Before concreting

Design Mixes

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 by recognised laboratory that the proposed mix will meet the requirements must accompany the statement.

The proportions stated may not later be altered without the written approval of the Project Manager.

Cost of mix designs to be borne by the Contractor.

Formwork

Formwork shall be sufficient to leave the concrete finishes specified on drawings and to be within the tolerances specified in the following table and to provide an acceptable surface for applied finished, where required.

Line and Level	1 mm per metre not exceeding 5 mm
Pockets, Sleeves etc.	+/- 5 mm
Bases	+/- 50 mm

The concrete shall have a smooth finish free of projections, voids, etc. 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 Employer's or 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.

Reinforcement

Shall not be heated or re-bent without the Employer's or the Project Manager's permission.

Shall be free from any material likely to impair bond or initiate corrosion.

Shall be bent and fixed according to the Project Manager bending schedules.

Shall be tied with soft iron wire.

Shall be supported to maintain the following minimum cover during concreting.

a) The greater of the diameter of the bar or 40 mm for external un-plastered face.

b) The greater diameter of the bar or 15 mm for internal face.

Shall be inspected by the Project Manager.

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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.

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.

Camber

To formwork shall not be at the expense of the overall depth of the concrete.

Weather

Concrete shall not be placed if temperatures above 30 degrees Celsius or below 0 degrees Celsius are expected during concreting

Batching

Shall

a) Be by mass in accurately calibrated scales or be volume in soundly constructed gauge boxes making due allowance for bulking of the fine aggregate.

b) Be in proportion to whole sacks of cement.

Mixing

Shall

a) Be in a machine in good condition, large enough to carry the whole mix, controlled by a competent experienced operator.

b) Be for sufficient time to ensure complete mixing of the ingredients.

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.

Compaction

a) Shall be by immersion (poker) vibrator in the hands of experienced operators.

b) Concrete shall not be moved by vibrator.

c) Shall be sufficient to remove all air pockets and honey-combing and to ensure complete dense concrete cover to all reinforcement.

Testing

a) Making of concrete cubes by Contractor under Project Manager's supervision. Contractor shall arrange for transport of cubes to approved testing laboratories. Cubes to be in sets of 3.

Curing

a) Shall commence early on the morning following the placing of the concrete.

b) Shall be effected 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.

Stripping of Formwork

a) To soffits shall not be struck until 7 days after placing of concrete (but see below for (props).

b) To vertical faces shall not be struck until 14 days after placing concrete.

c) Props to soffits shall not be struck until 14 days after placing concrete.

d) Shall not be stripped without the Employer's or the Project Manager's approval who has the power to vary the above items.

Patching

a) To defective work shall not be undertaken before the item has been shown to the Project Manager.

b) Is a sign of poor workmanship? 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.

Records

Are to 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.

FOUNDATIONS

Foundations to Transformers and for circuit breakers, switches and insulators pedestals shall be at a depth not less than 1200 mm from the existing ground level.

Cable Ducts and Trenches

The Contractor is responsible for all civil engineering works required for the cable runs between switchgear and buildings, in reinforced concrete cable trenches. 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. Trench covers inside the building will be of 6mm thick Metal Chequer plates reinforced with 25x25x4mm angle iron welded underneath along the edges and across ‘X” formation and with facilities for easy handling on removal, except in areas where heavy traffic is expected where covers will be of concrete finished with terrazzo to match the floor finish. Trench covers outside buildings shall be of reinforced concrete, designed for the maximum likely imposed loads appropriate to their location. The trenches and ducts shall be silt proof to prevent silt and debris from entry. The trenches shall be raised to a level that keeps away storm water from flowing in . 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 slab. Concrete cable trenches shall be adequately drained to soak pits of adequate capacity or shall be connected to the general drainage system such that they will remain as dry as possible. The trench covers will be fitted into grooved sides of the trench walls for a flush top of trench and covers. Where the cable trench is crossing roads the ducts shall be constructed in such way that they will be able to withstand the weight imposed on them.

Power cables and control cables shall be laid on suitable galvanized cable racks or cable trays and in separate trenches. Cable entries into buildings shall be sealed to prevent the entry of dust, vermin water, etc., using suitable materials.

5.1.1.6.3 BUILDER'S WORK

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.

<u>Materials</u>

a) Cement
   Cement shall be as described in concrete Works, Part 6B.

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.

<u>Concrete Blocks</u>

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 20 N/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 metre 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.

Cement Mortar
The cement mortar is to be mixed in the proportions of 1 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.

Building Walling
All blockwork 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.

Blockwork 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 arrisses. The blockwork shall be pointed as the work proceeds with a neat joint. Where blockwork is the be rendered or plastered the joint shall be raked out 10 mm deep as the work proceeds to form an adequate key.

galvanised 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.

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.

Structural Steelworks Switchgear building

Structural steelwork shall be shop-fabricated from structural shapes of medium grade carbon steel in suitable lengths for easy transport and erection. The structural members shall be jointed or fixed on site by bolting or welding. Site welds should be minimised.

All workmanship and fabrication shall be in accordance with the best practice and shall generally comply with the requirements of B.S. 449. 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.

Where required in the Contract, the Contractor shall design the steelwork to comply with the information given on the Contract Drawings. Loading and factors of safety shall comply with relevant codes and regulations. Shop drawings shall be prepared using welding symbols to B.S. 499 where appropriate. design calculations and shop drawings must be submitted to the Project Manager for his approval prior to fabrication of members. The approval of shop drawings and calculations by the Project Manager shall not relieve the Contractor of the full responsibility for any discrepancies, errors, omissions or failure arising therefrom.

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.

Roofing

Materials, accessories and fixings shall be ordered from an approved supplier and the Contractor shall as and when required by the Project Manager, submit and deliver samples of any materials for inspection and testing.

Roof sheeting shall be hot dip galvanised troughed mild steel sheeting and shall be of minimum thickness 0.6 mm. The sheeting shall have approved plastic coating on face side. Type and brand of such sheeting shall be proposed by the Contractor with his Tender together with supporting specifications.

The sheets shall be laid with 200 mm end laps and double corrugation side laps away from the prevailing wind. The sheets shall be fixed to lightgauge steel purlins with galvanised coach screws and seating washers.

Holes for screws shall be carefully drilled in the ridges of the corrugations. 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 purpose made corrugation closers.

Maximum load acting on the building in accordance with local or regional standards.

Switchgear building - ceiling

All rooms included 33 kV switch-gear is assumed to have ceilings consisting of fore-manufactured sheets, mounted on steel or tree grids jointed to roof structures.

Roof Drainage

Gutters and down pipes shall, unless otherwise shown on the drawings, be approved plastic coated steel of diameters 200 mm and 150 mm respectively. One down pipe shall be provided for approximately every 50 m2 roof area.

Joints shall be lapped 150 mm in the direction of the flow and soldered. Slip joints shall be provided to allow for expansion. All hangers, brackets, and fastenings should be of the same metal as the gutter or of compatible materials. Gutters and down pipes 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.

Metalwork

Unless otherwise specified, metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BSI standards.

All steel shall unless otherwise specified, be hot dip galvanised.

Prior to fabrication the Contractor shall submit shop drawings to the Project Manager for approval.

Metal Doors

a) 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 rate shall include all supplies, site works, painting and hardware.

b) Doors

Door frames shall be pressed steel frames made from minimum 2 mm thick steel sheeting and reinforced where door closers are fixed.

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 45-55 mm.

All doors shall have fire rating Class A 30.

Placing of doors in accordance with Switchgear building drawing.

Internal door frames are to be built to walls truly vertical and square with six ties per frame.

External door frames are to be built in to walls truly vertical and square with eight/ten ties per frame.

All door frames are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue.

Door frames are to be complete with 100 mm, loose pin steel hinges welded in position and adjustable striking plate.

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 blockwork 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.

The following type of timber doors shall be used unless otherwise instructed by the Project Manager and shall be of approved manufacture, true to shape and free from twists or warps:

internal doors shall be hollow core doors consisting of skeleton frames covered with 4 mm plywood for painting. They shall be 47 mm thick overall unless otherwise approved.

Aluminium or Steel Windows

Unless otherwise indicated windows shall consist of aluminium sub frame with clear glass. 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.

Frames shall generally be built-in during construction of the walls and securely fixed.

Placing of windows in accordance with Switchgear building drawings. Widows are to be built in to walls truly vertical square with six ties per frame.

All aluminium or steel windows are to the from an approved manufacturer and illustrated in the Manufacturer's Catalogue.

Windows are to be fitted complete with casement fastening, stays etc.
All windows shall have approved burglar bars, and approved means of opening/locking.

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 shall be lockable. External doors shall have approved security locks.

Three keys for each lock, clearly labelled, shall be handled over to the Project Manager and all ironmongery shall be cleaned, oiled, adjusted and left in perfect working order.

MV Switch-gear, 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 these pressure openings, and submit his proposal for approval.

Switchgear building

SCHEDULE OF MATERIALS AND FINISH

ROOM	FLOOR	WALLS	CEILING	REMARKS/NOTES

33 kV Switchgear	plastering/ painting	Plastering/	Sheet/plate painting

NOTES:

Sheets for ceilings = prefabricated/-manufactured colour and type in according with approval of the employer.

Switchgear building: External/internal colour in accordance with approval of the employer.

5.1.1.6.4 PLASTER AND FLOOR COVERINGS

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 can not be made good satisfactorily then the whole surface is to be removed and re-plastered at the Contractor's expense.

5.1.1.6.5 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.

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 arrised 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 a 8 000 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. Hardwall 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 arises 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 grainfill as necessary with filler as described.

NOTE:

a) All paints specified are to be obtained from an approved manufacturer and used in strict accordance with their instructions. Their representative will check the paints being used and the method of application and will advise accordingly.

b) 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.

c) 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.

5.1.1.6.6 SUBSTATION BUILDING SIZES.

Proposed substation control buildings should be in conformity with relevant building codes with regard to room size and safety. The building must meet the requirements described in the scope of work and take into consideration future expansion. Specific requirements of the building are described in clause **6.1.4.1.3**

5.1.1.6.7 IRONMONGERY AND METALWORK

<u>General</u>

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 two 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.

5.1.1.6.8 ELECTRICAL INSTALLATION

Scope of Works
This section of the specification relates to the supply, installation, testing and commissioning of the complete electrical services within the switchgear building, including:

1. LV Switchgear
2. Lighting
3. Small Power

The switchgear building consists of a switchgear room.

A full specification of the electrical equipment proposed by the contractor shall be included in the Bid.

The Employer reserves the right to reject any of the contractor suppliers if he feels the product does not meet with the contract specification.

Electrical Services General Description
The complete electrical installation shall comply with all local standards and rates.

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
a. Luminaries shall be fluorescent lamps except for the toilets and outdoor lighting (except switchyard and perimeter lighting) where GLS lamps can be utilised. In switchgear room: 250 lux is required. In offices 500 lux is required.
b. All luminaries shall be supplied, installed and tested by the electrical sub-contractor.
c. All metal work on the luminaries shall be connected to an insulated earth protective conductor.
d. Lighting Control Switches

e. Outdoor lighting shall be controlled from an automatic photo cell.
f. Lighting control switches shall be flush pattern with white finished plates.
g. Grid switches shall have 5 or 10 amp rating, generally where fluorescent discharge luminaries are controlled switches have 10 amp rating where as with low energy PL lamp, 5 amp switches shall be installed.

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.

AC Installation

The Contractor shall supply and install three number AC units including wiring and insulator for the unit.

Fire Safety Facilities

Portable fire extinguishers shall be provided under this Contract. Portable, wall mounted, hand held extinguishers shall be 5.5kg pressurized control discharge BCF units. The number of units within the Substation shall be a minimum of 4 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 and 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.

6 PARTICULAR TECHNICAL SPECIFICATIONS CABLES

Particular technical specifications – 66 and 33 kV Cables

Cables

General

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

All cables shall be suitable for operation:

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

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

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.

Cable

The conductor shall be covered with:

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

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

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 REA´´. Alternatively the identification may be embossed on the outer PVC sheet together with identification and voltage markings

Armour

All cables shall be armoured according to approved manner

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.

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.

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

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

Heat Shrink Materials

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.

Installation

This extract from KPLC’s “Medium Voltage Underground Distribution Handbook determines the minimum acceptable conditions for installation of medium voltage cables.”

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 3.1: BENDING RADII

Bending radii	Single core	3-core
Recommended	17xD	15xD
Minimum	15xD	12xD
At sealing ends	12xD	10xD

D = cable diameter

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. This information as well as details about the joint (i.e. joint location) will be also recorded on a map.

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.

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.

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 covering the cables 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.

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.

Ducts

Road crossings when necessary will be done with ducts in the following manner

- they will be installed in a level position and concreted where possible to provide mechanical protection through out its length, they will have a depth of 1.2m.
- future expansion will be provided for by providing one or several spare ducts depending on the location of the crossing.
- at all times the cables should be adequately protected.
- road and railway crossings must be planned in full detail.
- 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 e.t.c.

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 150 mm.

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.

Direct Burial

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 can not 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 with out mechanically sharp objects will be adequate enough to backfill the trench.

Cables shall not be buried in areas within the substation boundaries. Necessary cable trenches shall be prepared instead to the satisfaction of the client’s project Manager.

Galleries

When the number of cables justifies 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.

Parallel Separation

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.

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.

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 REA, KPLC and KPTC

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.

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.

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.

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.

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.

Crossing of Roads and Railroad Tracks

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.

Railroad 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.

Crossing Other Services

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.

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.

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.

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.

Gas

The minimum distance in crossings with gas pipelines shall be of 250mm. The crossing shall not be made over gas pipelines joints.

Sewers

In crossing sewage pipes it is recommended that the electric cable should be above the sewer line where possible.

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 metres.

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.

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 ensured 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 (ref: 3.1)

When the cables are being laid the workers must be distributed uniformly along the trench.

The cables should also be laid using cable rollers.

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.

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.

Identification

The cables must bear marks indicating the year of manufacture, manufacturer's name, and cable characteristics (size and voltage level).

Fibre Optic Cable

General Specifications

a. The equipment to be supplied shall conform in all respects to this specification. Unless another standard is specifically mentioned in this specification, all material and practices employed in the works must be in accordance with such other authorised standard appropriate to the country of manufacture, which in the opinion of this company shall ensure an equivalent or higher quality.

   Alternative solutions, which deviate from the specifications required, may be submitted separately in addition to this tender. Such alternatives should be fully detailed and the price indicated, they may be considered for adoption after the comparison of quotation submitted in accordance with this specification.

b. All material used under this Contract shall be new, of the highest quality and of the class most suitable for working under the conditions specified, shall withstand the variations of temperature and atmospheric condition arising under working conditions without distortion or deterioration or setting up of undue stresses on, or impairing the effectiveness of any part.

c. The cable shall be an all dielectric, Single Mode, 24 fibres, Optical Fibre cable Specifically manufactured for underground Installation. The cable is to be laid in the same trench as 33kV 300sq mm s/c XLPE copper power cables. A written confirmation must be obtained from the cable manufacturer giving an assurance that the cable so offered is suitable for underground installation along side the 66kV Power cables and that it will give a reliable communication link suitable for Protection of the 66KV cable, Speech and Data Transmission.

d. The Manufacturer shall also submit a list showing Locations where similar cables have been laid underground along side single core Power cables rated 66kV or above and the duration over which the cables have been in Operation.

Standards

The optical cables herein specified must be in accordance with the following standards.

- IEC 60793 – 1 , Optical Fibres-Part 1 : Generic Specifications.
- IEC 60793 – 2 , Optical Fibres – Part II : Product Specifications.

All cables must conform to ITU G652 and G655

Geometrical characteristics

The fibre cables specified herein will fulfil the following geometrical specifications.

The cable should have	24 fibres
Core diameter	9-10 microns
Cladding diameter	125.0 ±2.0 microns
Mode field concentricity error	≤ 1.0 micron
Cladding non-circularity	≤ 2.0 %
Coating diameter	245 ± 8 microns
Mode field diameter	9 ± 1 Micron

Optical characteristics

The single-mode fibre cable specified herein must fulfil the following optical specifications

Attenuation coefficient:

At 1310 nm.	≤ 0.35 dB/ Km.
At 1550 nm.	≤ 0.22 dB/ Km.

Total chromatic dispersion

For 1280 nm ≤ Labda ≤ 1340 nm	≤ 2.9 ps/(nm*Km)
At 1550 nm.	≤ 18 ps/(nm*Km)

Cable cut-off wavelength: Labda ≤ 1250 nm.

Conditions of operation

All the optical fibres shall be able to work without significantly degradation in its characteristics in the temperature range –20 C to 70 C. The shipping and storage temperature range of the cable shall be –50 C to 70 C.

The installation temperature range of the cable shall be –5 C to 70 C.

NOTE: The cable will be for underground installation alongside 3 No. 33KV Medium voltage single core cables. It should have the pre-requisite Mechanical Protection to prevent damage during installation and due to other Human activities such as excavation. The cable should also be Rodent resistant. The cable must be specifically manufactured for underground installation and must be all dielectric, hence unaffected by Electromagnetic induction from the 66KV Cables. This must be specifically stated in the Tender Offer.

Additional Requirements

The cables shall additionally meet the following standards. Tenderers shall give technical documents on whether they meet these standards.

Standards summary

Test carried on cables

	Cable Test Type	Applicable Standard
1	Water Ingress Test	IEEE 1138
2	Seepage of Flooding Compound	IEEE 1138
3	Short Circuit Test	IEEE 1138
4	Aeolian Vibration Test	IEEE 1138
5	Galloping Test	IEEE 1138
6	Sheave Test	IEEE 1138
7	Crush Test	IEEE 1138
8	Impact Test	IEEE 1138
9	Creep Test	IEEE 1138
10	Fibre Strain Test	IEEE 1138
11	Strain Margin Test	IEEE 1138
12	Stress Strain Test	IEEE 1138
13	Cable Cut-Off Wavelength	IEEE 1138
14	Temperature Cycle Test	IEEE Std 563
15	Cable Self Damping	IEEE Std 4
16	Lightning Test	EIA/TIA-455-16A
17	Salt Spray Corrosion	MCIT 048-200 6508
18	TemperatureCycling/Ageing/ Water Immersion	MCIT 048 200 6508
19	Tension Cycle Sustained Loading	MCIT 048 200 6508
20	Gas Tube Tightness Test	MCIT 048 200 6508
21	Twist Test	MCIT 048 200 6508
22	Bend Test	IEC 794
23	DC Resistance	
24	Generic fibre specifications	IEC 60793, IEC 60794

25	Ageing Test	EN187000

Colour code

The colour coding of fibres and tubes shall be in accordance with table below.

Number	Primary	Secondary
1	Natural	Red
2	Red	Natural
3	Blue	Natural
4	Yellow	Natural
5	Black	Natural
6	Violet	Blue
7	Brown	
8	Green	

E.t.c. for the 48 fibres.
All colour codes must be able to distinguish each fibre strand from all other fibre in the same cable.

7 PARTICULAR TECHNICAL SPECIFICATIONSTELECOMMUNICATIONS

7.1 General requirements

In order to achieve the desired SCADA functionality telecommunication links based on OPGW and Radio shall be established linking the SAS in new substations to respective control centres. Necessary engineering required to transmit data and speech signals to the Regional and National Control Centre(s). Fibre links shall be based on 48 fibre - OPGW while Radios shall be UHF point-to- point or Point-to-Multipoint links

These specifications describe the basic requirements for the 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 certificates, 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 client’s Engineers or her 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 REA 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.

The Tenderers are requested to indicate the shortest possible delivery period of each product.

7.1.1 SCOPE OF WORK

The scope includes 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 project. Scope shall include integration of STM-1and Radio links 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 centres. Survey and necessary preparation works on existing systems, Equipment and substations to achieve specified functionality shall be in the scope of supply. The contractor shall determine the necessary radio towers heights, Line traps, Line matching Units and Blocking line traps where required and their support structures. Contractors shall be required to submit for approval detailed design of system before manufacture.

In addition all substations shall be equipped with a Base Radio capable of communicating with the existing ASTRO trunking radio system for use during switching operations.

All communication equipment supplied under this project shall be type approved by the regulator, Communication Commission of Kenya (CCK) and the Kenya Bureau of Standards (KBS) where applicable. It is the responsibility of the contractor to obtain these necessary approvals.
The employer shall apply for allocation of required frequencies from the CCK once the contractor has finalised detailed Radio propagation analysis.

The type of required communication link shall be detailed in scope of supply for individual stations.
Notwithstanding employers recommendation bidders are required to present a complete solution for communication from substations to Control centres based on preliminary survey during bid preparation.

The links to be established include but not limited the following;

	New Substation	Source station	Proposed communication media	Existing Equipment in Terminal station	Control Centre substation reports to
1	Galana Kulalu	Weru	PLC		Rabai

	Substation	220/66KV Substation			Substation

7.1.2 OPGW

Technical Description

The transmission line earth wire integrating optical fibres shall be of design and construction to ensure long service with high economy and low maintenance costs. It shall be suitable in every respect for continuous operation at nominal parameters as well as in transient operating conditions under the climatic conditions peculiar to the site. Where an existing line without OPGW is used for the fibre to reach terminal station, necessary modification on existing towers/poles shall be done by contractor to enable line carry required OPGW.

- The OPGW shall incorporate at least 48 optical fibres. The OPGW constitution shall be of stranded aluminum-clad steel (ACS) wires or Galvanized steel wires (GS). Other OPGW types are acceptable if the required performance characteristics are met.

- All materials used shall be of the best quality and workmanship, and shall be of the highest class throughout with the designs and dimensions of all parts such that the stresses to which the OPGW are subjected to shall not render them liable to distortion or damage under the most severe conditions encountered during installation as well as in service.
- Special attention shall be paid to the OPGW stranding process to ensure the necessary tightness between different layers in order to avoid slippage or relative movement of strands or cage formation during stringing.

- Stranding tolerances as well as inspection and testing shall be as per IEC 61089 as far as applicable, and to the respective manufacturing standards.

- The OPGW manufacturer shall have ISO 9000 quality assurance system certified and shall prove a minimum experience in successful supply of similar OPGW in the last 5 years.

- The OPGW installation shall include all cable fittings (tension and suspension spirals, vibration dampers, earth connection etc.), joint boxes, termination boxes, fibre connectors and other accessories required for a complete working fibre link.

- Optical fibre parameter and performance

- The OPGW, access cables and underground cables shall have at least 48 (forty-eight) single mode optical fibres with following characteristics:
- Transmission wavelength: 1310 nm and 1550 nm
- Mode field diameter: 9.0 to 11.5 micrometers (μm), including tolerances
- Optical cladding diameter: 125 μm ± 2.4%
- Cable Attenuation: not greater than 0.38 dB/km for every fibre in every drum at optical wavelength of 1310 nm; and not greater than 0.22 dB/km for every fibre in every drum at optical wavelength of 1550 nm

- Joint attenuation: not greater than 0.1 dB at optical wavelength of 1310 nm and not greater than 0.2 dB at 1550 nm for every fibre, measured on the fully installed joint
- Total dispersion: not greater than 3.5 ps/km.nm at optical wavelength of 1310 nm and not greater than 19.0 ps/km.nm at optical wavelength of 1550 nm
- Core numerical aperture: less than 0.23
- Life span: greater than 30 years
- The Contractor is required to supply a graph of attenuation versus wavelength over the range of 1200 nm to 1600 nm
- No joints shall be allowed in any fibre in any drum length.
- Discontinuities will be acceptable if:
- Less than 0.10 dB in magnitude measured at 1310 nm, and
- OTDR traces from both ends of the cable at 1310 and 1550 nm wavelength show a difference of less than 0.05 dB/km for every fibre in every drum.
- Power Meter & Light source. The test shall be used to verify that the measured loss is in average equal or less than the calculated link budget.
- The Contractor shall state the refractive index of the optical fibres at 1310 nm and 1550 nm.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 earthwire 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 earthwire 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 earthwire without damage. The fibre optic earthwire (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:

- 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.

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.

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.

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.

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.

NON – METALLIC UNDERGROUND FIBRE OPTIC CABLE

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. It shall be suitable to withstand harsh environmental conditions.

PROTECTIVE TREATMENT

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.

Ingress of Moisture

The cable shall be capped before shipment to prevent the ingress of water.

Optical Joint boxes

Optical joint boxes (steel exterior) shall be hot dipped galvanised after manufacture to meet the requirements of BS 729.

INSTALLATION

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.

Workmanship

The Contractor shall ensure that the fibre optic cable are not strained or damaged either mechanically or optically during stringing and/ or jointing.

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.

4.1.6.1. Optical Distribution Frames (ODF)

Each Optical Line Terminal Equipment (OLTE) or SDH multiplexer shall include an optical distribution frame, installed inan own wall mounted fixed cubicle.

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 (< 0.3 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

7.1.2.1 FIBRE TERMINAL EQUIPMENT

Specifications

The terminal equipment shall be the type SDH STM-1 optical terminal equipment.

SDH (STM-1) 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). 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, 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 G.703 tributary interfaces.

The SDH equipment shall be wired for the full STM-1 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.

7.1.3 POWER LINE CARRIER

State-of-the-art single side band multipurpose DPLC terminals shall be installed in the network. The modulation shall be single step without use of intermediate frequencies. It shall be possible to operate transmitter and receiver in adjacent frequency bands or in non-adjacent bands

The equipment shall be operated with a channel bandwidth of 8 kHz in each direction in a carrier frequency range of 40 kHz to 500 kHz. The Bidder shall state the range of channel bandwidths > 8 kHz that are available for increasing the data rate. The methods of transmission shall be clearly stated with the offer.

Any limitations in paralleling their own or other manufacturer's equipment shall be stated with details of necessary frequency spacing. The equipment shall be compatible on the line side with any existing equipment, both analogue and digital, i.e. coexistence shall be possible. Where limitations of offered equipment exist, bidders shall in scope of supply links extending to respective Regional Control centre.

The design of the DPLC terminal equipment shall be modular, based on dedicated processors and interfaces for the different services as necessary (data, speech and teleprotection) and shall employ self-monitoring functions.

All DPLC terminals shall be equipped with data transmission interfaces for connection to the RTUs and with telephone interfaces (2/4 wire) for connection to the PAX/PABXs and/or to remote subscriber telephone sets.

The installation of different interface cards in any combination, according to the needs of the different links in the network shall be possible. The Bidder shall describe any restriction regarding combination of interfaces.

The equipment shall be furnished with local failure indication by LEDs and potential free contacts for external alarm annunciation (for higher level supervision and monitoring in a future SCADA system).

Besides a general alarm/warning, single alarms shall at least be generated for:

Transmitter failure,
Receiver failure,
Signal-to-noise ratio too small
DC supply failure.

The terminals shall be equipped with a telephone handset to be used for maintenance purposes or in emergency situations and with a test tone generator.

Provision shall be made for terminating the HF output with an appropriate dummy load for test purposes.

The bidder shall perform calculations in accordance with IEC 60663 detailing coupling equipment, line attenuation and any other losses in order to show that the proposed PLC system will attain a signal-to-noise ratio of not less than 30 dB for full digital operation under fair weather conditions.

Digital Transmission Multiplexing System
The unit shall be a universal service multiplexer, which for a given bandwidth transfers speech and data channels in a multitude compared to traditional technologies. It shall use latest Digital Signal Processor (DSP) technology, permitting the implementation of a transmission system, which is robust, and economical with bandwidth. If the bidder proposes an external MUX, the advantages of the solution shall be explained.

The system shall use Multi Carrier Modulation for converting the digital data to a suitable line signal. Important channel parameters shall be continuously monitored in order to detect and compensate changes in line characteristics resulting in optimal transmission quality at all times.

The systems data rate shall be programmable over the range of 1200 bit/s to 64 kbit/s. The Bidder shall state the range of available system data rates and DPLC transmission bandwidths. An adjustment facility shall permit optimal capacity utilization of the presently available bandwidth.

In case of channel noise ratio changes, the data rate shall be automatically adjusted to new conditions. In case of worse signal-to-noise ratio, the data rate shall be reduced until an adequately low bit error rate in reinstated. When the conditions improve, the transfer rate shall automatically raise accordingly. The step width for this rate adjustment shall be programmable.
The equipment shall be capable of boosting protection-signaling inputs along with suppression of voice/tele-control during transmission of protection trip-signals.

In substations with low traffic volume, a PABX switching system may not be economically viable. In such cases a local subscriber shall access the remote PAX on two-wire basis via a connection to the multiplexing system. The standard performance features shall be available at the subscriber station.

Data Channels

The DPLC equipment shall be capable for data transmission. It is foreseen to operate the data channels for the SCADA data transfer at a rate between 2400 to 9600 bit/s. It shall be possible to utilize the capacity of speech channels, which are not in use for improving of data transmission capacity. The Tenderer shall state with his offer the data rates possible.

Service and Test Functions
It shall be possible to connect a PC with the appropriate software based on an MS-Windows-XP-Professional (latest build) to the DPLC terminal and perform any service and test functions. The change of transmission frequency, change of bandwidth and sideband, the configuration of speech, data and teleprotection channels and the execution of test procedures shall be programmable as a minimum. The PC shall also be used for monitoring of the DPLC equipment.

Power supply
Each DPLC terminal equipment shall be connected individually to one feeder of the DC supply distribution panels. No inter-equipment looping of supply circuits is allowed.

7.1.4 RADIO SYSTEM

7.1.4.1 UHF Point To Point Radio

Description

A solution is sought to connect a remote station to a master station for data and voice communication.

The radio, the data communication Equipment (DCE) is to connect data terminal equipment (DTE) via a standard RS232 serial interface at a data rate of 9600bps.

Standard connectors must be used: DB25 or DB9

The DCE is to be fully transparent to data from DTE at both ends.

For voice communication, One analogue, 2- wire telephone is to be extended to the remote station, hence, an FXO is to be provided at the master station and an FXS (with a ringer) at the remote end.

A **VHF 2-way Base Radio** shall also be provided for each remote site.

The **radio** shall be supplied with a **wall mounted, lockable, 12-U cabinet**, with the interfaces (Data, voice and antennae) extended to a more accessible place.

The vendor shall carry out **site surveys**, to determine **the line of site** and perform RF **path calculations** for optimal performance of the Radio link.

The vendor shall also supply **antennas, feeder cables** and other accessories necessary for installation of the remote Radio, and shall also install and test the **Radio link**.

The minimum performance parameters of the radio link shall be:

- **Fade margin: >30dbm**
- **SNR: >30dB**

The installation shall be **professional** with **standard grounding** of the **feeder cables** and the **equipment,**

The vendor is to decide on how to integrate the solution on condition that, any additional equipment like a multiplexer must meet the network management specifications of the radio.

Specifications for the UHF radio equipment and **VHF 2-way Base Radio** are given below.

UHF point to point radio specifications

General

- Standard: ETSI
- Transmission: Subrate,
- Frequency Band: 300-512 MHz
- Channel size: >25,
- Data rates: 64 kbps with overhead
- Modulation: Digital,

Transmitter

- Output control range: minimum 10 steps of upto 10dB.
- Freq. Stability: < 1.5 ppm.

- Output power: 30dBm
- Residual BER: <1x10^{-6}

Interfaces:

- Data: EIA 530 D25 DCE / G.703
- Oderwire: DTMF capable
- Ethernet NMS: 10 Base-T
- Configuration Port: RS-232, 300 bps – 115.2 Kbps
- Alarms: At least 2 programmable outputs, 2 programmable inputs
- Antenna: 50 Ohms impedance

Network Management

- Local LED Indicators: LED status indicate-Power, general alarm, TX alarm, Rx alarm, I/O alarm
- Element Management: Full management via command line interface, Full IP based management through SNMP and HTML Web Server.
- Remote element management: Able to manage remote radio over the air.

Environment

- Temp:-10 to +60C
- Humidity: <95% non condensing

Electrical

- Power consumption: <80W
- Voltage range: ±48 Vdc

Mechanical

- Rack mounted standard cabinet – 1 U
- Weight: Max 10kgs

Agency Approvals

- Transmission: FCC Part 90, 74, 22, IC RSS-119
- EMC: ETS 300 385, FCC Part 15

System Performance

- Receiver Sensitivity at (10-6 BER) : <-90dbm
- System Gain at (10-6 BER) : >120db

7.1.4.1.1 POINT TO MULTIPOINT RADIOS

Description

A solution is sought to provide **Remote radios** to operate in an existing point to multipoint radio communication system based on the UHF licensed frequency band, to be used for **data acquisition**. For this solution, two Master Radios are already existing at Juja and Ngong and the scope shall only be limited to remote radio and necessary Engineering works at the Radio NMS at the control centre.

The system consists of a **Master station**, with a **master Radio**, and **remote stations** with **remote radios.**

The **radio system** provides a **transparent data channel**, where communication is managed by the **central data acquisition system**.

The remote radios must operate with an existing master radio of type MDS 4790 whose specifications are outlined.

The remote radio shall be supplied with a **wall mounted, lockable, 12-U cabinet**, with the interfaces (Data and antennae) extended to a more accessible place.

The vendor shall carry out **site surveys**, to determine **the line of site** and perform RF **path calculations** for optimal performance of the Radio link.

The vendor shall also supply **antennas, feeder cables** and other accessories necessary for installation of the remote Radio, and shall also install and test the **Radio link**.

The minimum performance parameters of the radio link shall be:

- **Fade margin: >30dbm**
- **SNR: >30dB**

The installation shall be **professional** with **standard grounding** of the **feeder cables** and the **equipment,** with **lightning protection**.

Voice communication at the remote stations to be realized through one **VHF, Two- way base radio** for each station, compatible with an existing, **APCO, Project 25(P25)** based **VHF digital trunking Radio system**.

The specifications for the VHF base radio shall be outlined.

MASTER RADIO SPECIFICATIONS

General

- Make: MDS 4790

- Actual operating frequency: TX 360MHZ, RX 370MHZ
- Data Rate (Data): 110 bps - 38.4 Kbps
- Frequency programmability: 6.25 kHz increments to any MAS channel pair
- Operational modes: asynchronous - half-duplex, full-duplex, protected.
- Modulation: digital
- Latency (Rx-Tx-Rx): <10 ms including RTS/ CTS delay
- CTS Delay: 0-255 msec programmable in 1 msec increments
- Range: Up to 50 miles
- RF Data Rate: upto 19,200 bps
- Frequency Bands: 330 - 512 MHz
- Network wide diagnostics: Management software managing the master and remote radios. The software used is Insite 6.

REMOTE RADIO SPECIFICATIONS

General

- Data Rate (Data): 110 bps – 19.2 Kbps
- Modulation: digital
- Range: Up to 50 miles
- RF Data Rate: 19200 @ 25 kHz
- Frequency Bands: 330 - 512 MHz

Transmitter

- Frequency Stability: +/- 1.5 ppm
- Carrier power: 0.1 to 5 Watts Programmable
- Carrier power Accuracy: Normal +/- 1.5 dB
- Duty Cycle: Continuous
- Output Impedance: 50 Ohms

Receiver

- Type: Double Conversion Super heterodyne
- Selectivity: >70dB
- Bit Error rate: <1x10-6 @ -110 dBm typical

Interfaces

- Data interface: EIA/RS-232, DB25 Female
- Data Rates: 1200–19200 bps, asynchronous
- Diagnostic: RS232, DCE, 300 bps – 115.2 Kbps

Management

- Local: Via -Diagnostic port
  -Front panel display: DCD, RX activity LED, TX activity LED.
- Network wide management

Environmental

- Temperature: -30°C to +60°C
- Humidity: Min 95% at 40C (104°F) non condensing

Mechanical

- Rack mounted standard cabinet – Max 1 U

- Weight: Max 5kgs

Electrical

- Primary power ±48 Vdc
- Power required < 30 Watts nominal

Agency Approvals

- Transmission: FCC Part 90, 74, 22, IC RSS-119
- EMC: ETS 300 113, EN 300, 279

7.1.4.2 **SPECIFICATIONS FOR VHF 2-WAY BASE RADIO**

General

- APCO. PROJECT 25 compatible for trunking system
- Frequency range: 136-174 MHz
- Modulation: C4FM of QPSK-C family
- Protocol: Project 25-CAI (4.4 kbps IMBE, 2.8 kbs Error Correction Coding, 2.4 kbps Embedded Signaling)

Channel Bandwidth

- **Analogue**: 12.5/25/30 kHz (136-174 MHz)
- **Digital:** 12.5 kHz

Voice coder

- Voice Coding Method IMBE (CAI): Improved Multi Band Excitation (IMBE)
- Frame Re-sync Interval: 180 mSec (Clear Digital Mode)
- Forward Error Correction: Golay code

Signaling

- Signaling Rate:9.6kbps
- Error Correction Techniques: Golay, BCH, Reed-Solomon codes

Transmitter

- RF Power:10-50W
- Max Freq Separation: Full Bandsplit
- Freq Stability Operating Freq Accuracy<2ppm

Electrical

- Power Supply: 13.8V DC ±20% Negative ground
- Standby at 13.8V DC ±20%: 0.85A
- Transmit current at rated power 13.8V DC ±20%:13A (50W)
- Receive at 13.8V DC ±20%: 3.2A

Environmental

- Operating Temperature: –30ºC / +60ºC
- Ingress Protection: IP54 certified

SPARE PARTS

The bidder shall include any special tools and test
The Contractor shall furnish a list of recommended spare parts and test equipment for the fibre and OLTEs. The spare parts list shall be subdivided into:

- 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.
- long-term spare parts that are necessary for ten (10) years of operation.

TOOLS AND TEST EQUIPMENT

The bidder shall include special tools and test equipment needed to maintain the fibre (including OTDR and splicing Kit), PLC, Radios and OLTEs over their expected lifetime. Bidder shall provide relevant technical data/pamphlets for all the items. The test kit shall include necessary laptops and all equipment applications and their licences.

- The test equipment and other special tools proposed shall be of the same type as used by the contractor for erection and commissioning. The test equipment shall not however be available to the contractor during erection and commissioning.

DOCUMENTATION:

a. 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.

b. The following documentation should be provided for the system in the course of the project. It shall be consistent, CAD supported and of similar look/feel:

c. Control Room Layout
d. Single-Line Diagram
e. Block Diagram
f. Circuit Diagram
g. List of Apparatus/ Equipment
h. List of Labels
i. Functional Design Specification (FDS)
j. Test Specification for Factory Acceptance Test (FAT)
k. Logic Diagram
l. List of Signals
m. Operator’s Manual

n. Product Manuals
o. Calculation for uninterrupted power supply (UPS) dimensioning
p. Concept and contract for maintenance
q. It is necessary to present the technical description and the technical data for the whole system and for any equipment and function
r. Time plan for the project realization.

TRAINING:

- The Contractor shall provide 2 weeks and 1 week training for four REA staff at the supplier's factory premises on SCMS and OLTE and on site during installation works. The scope of each service shall be given.
- On completion of the training, REA staff shall be able to modify and make changes to the configuration of the SCMS and OLTEs including the HMI and signal list mapping to accommodate any future changes as well as interfacing & data transmission to the RCC.

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 shall be carried out for fibre, SCSMS and OLTE
- Site Acceptance Tests (SAT) Systems shall pass these tests before they may be put into operation and before they are Taken Over

SYSTEM ACCEPTANCE

- The System will be accepted by REA 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 REA.

- If either of these conditions has not been complied with, then the necessary corrective action shall be agreed between the Contractor and REA.

8 SCOPE OF WORK - SUBSTATIONS

8.1 SCOPE OF WORK - SUBSTATIONS

8.1.1 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 CIP site, of all equipment as specified in the preceding chapters.

For substations contracted on turnkey basis the substation contractor shall be responsible for design, material supply, transport, erection 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 and fire damper consisting of crushed stones laying on a galvanised steel grating.

Loose equipment for the Employer's rehabilitation shall be complete with documentation and ancillaries like programs, licences 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 is to be taken over by the Employer at these sites.

OVERVIEW OF KPLC SCADA SYSTEM

KPLC has a SCADA (Supervisory, Control & Data Acquisition) system that is controlled from the Regional Control Centres & the National Control Centre. The National Control Centre (NCC) is at Juja Rd and controls the entire transmission network & substations (ie some 66kV, all 132kV, all 220kV & soon to be introduced 400kV stations.)

There are 4 regional control centres in total, at Juja Rd (Nairobi region), Rabai (Coast region), Lessos (West Kenya region) & Kiganjo (Mt Kenya region). These Regional Control Centres monitor & control the 11KV, 33kV & 66kV Distribution networks & stations in their specific regions.

The Control Centres all run ABB's Network Manager WS500 which is the software used for monitoring & Control of all the incorporated substations. The Communication protocols currently supported by KPLCs front end servers (ABBsPCU 400) for data telegram exchange with Remote Terminal Units (RTUs) & Station Control Management Systems (SCMS) in the substations in its SCADA system are **IEC 60870-5-101&IEC 60870-5-104**.

The automated 33/11kV Distribution substation will be required to communicate with the front end server (ABB's PCU400) via the communication protocols outlined above. The automated Distribution Station must communicate with the Regional Control Centre under which it shall be monitored &controlled.

The interconnected KPLC's telecommunications system is based a backbone of SDH STM1 terminal equipment, FOX 515 from ABB and includes Power Line Carrier and Radio. A network management system (NMS) for the telecommunication system has been installed at NCC.

8.1.2 Standard Substation

This section defines the standard substation components. The actual quantities to be included in the price schedules are found for each substation in the subsequent sections.

8.1.3 66KV and 33 kV Switchgear Outdoor Type

8.1.3.1 66KV Switchgear Outdoor Type

8.1.3.2 66 kV Feeder Bay

2 (two) complete bay shall be equipped with:

(a) 3 (three) autorecloser
(b) 4 (Four) earthing switch
(c) 2 (two) set of busbars
(d) 2 (two) set of current transformers
(e) 2 (two) bay control unit with display and measuring functions
(f) 2 (two) 3-phase over current relay function with auto re-close function. The auto-reclose function must be selectable with an external switch
(g) 2 (two) Earth fault relay function
(h) 2 (two) sensitive Earthfault function
(i) 2 (two) restricted fault relay function (if not provided on the HV transformer bay panel)
(j) 2 (two) 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.

Note: 66KV Power Factor Correction Equipment (LC Circuit) switchgear shall be equipped with the necessary protection and control relays for Capacitor banks. .

8.1.3.3 **Transformer Bay**

2 Bays, 1 (one) complete bay shall be equipped with:

(a) 1 (one) circuit breaker
(b) 2 (two) isolator with motor operation
(c) 1 (one) earthing switch
(d) 1 (one) set of busbars
(e) 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.
(f) 1 (one) set of current transformers
(g) 1 (one) set of steel structures for support
(h) 1 (one) bay control unit with proper display, for measurements (V,I,MVAR,MW)
(i) Tapchanger voltage regulating relay (AVR)
(j) 1 (one) multifunctional protection unit as per 4.1.2.4.2.2 Section VI Particular Technical specifications substations control, and Protection
(k) HV overcurrent protection relay.
(l) 1 (one) lock-out trip relay with electrical/hand reset facilities
(m) 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

8.1.3.4 **66KV Feeder Bay**

1 (one) complete bay shall be equipped with:

(n) 1 (one) circuit breaker
(o) 2 (two) isolator with motor operation

(p) 1 (one) earthing switch
(q) 1 (one) set of busbars
(r) 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.
(s) 1 (one) set of current transformers
(t) 1 (one) set of voltage transformers
(u) 1 (one) set of steel structures for support
(v) 1 (one) set of control/protection panel
(w) 1 (one) bay control unit with display and measuring functions
(x) 1 (one) multifunctional protection unit.
(y) 1 (one) lock-out trip relay with electrical/hand reset facilities
(z) 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.

8.1.3.5 **Bus Bar Protection**

1 (one) bus bar protection unit included in the control panel for all 66 and 33 kV bus bars.

8.1.4 33 kV Switchgear Outdoor Type

8.1.4.1 **33 kV Feeder Bay**

1 (one) complete bay shall be equipped with:

(k) 2 (two) autorecloser
(l) 2 (two) earthing switch
(m) 2 (two) set of busbars
(n) 2 (two) set of current transformers
(o) 2 (two) bay control unit with display and measuring functions
(p) 2 (one) 3-phase over current relay function with auto re-close function. The auto-reclose function must be selectable with an external switch
(q) 2 (two) Earth fault relay function
(r) 2 (two) sensitive Earthfault function
(s) 2 (two) restricted fault relay function (if not provided on the HV transformer bay panel)
(t) 2 (two) 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.

8.1.4.2 **Switch Board Panel for 33 kV Feeder Indoor panel**

1 (one) complete bay shall be equipped with:

(u) 2 (two) circuit breaker
(v) 2 (two) earthing switch
(w) 2 (two) set of busbars
(x) 2 (two) set of current transformers
(y) 1 (two) bay control unit with display and measuring functions
(z) 1 (two) 3-phase over current relay function with auto re-close function. The auto-reclose function must be selectable with an external switch
(aa) 2 (two) Earth fault relay function
(bb) 2 (two) sensitive Earthfault function
(cc) 2 (two) restricted fault relay function (if not provided on the HV transformer bay panel)
(dd) 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.

8.1.4.3 **Switch Board Panel for Indoor Bus- Sectionaliser**

1 (one) complete bay shall be equipped with:

(a) 1 (one) circuit breaker
(b) 1 (one) set of protection 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)
(f) 1 (one) bay control unit with display
(g) 1 (one) overcurrent function and 1 (one) relay function
(h) 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 remote operation.

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8.1.4.4 **Current Transformers for Neutral current measurements**

(a) 1 (one) current transformers for neutral current measurements one on each winding

8.1.4.5 **Lightning Arresters**

(a) 66kV lightning arrestors erected close to HV side of power Transformer
(b) 3 (three) 33 kV lightning arresters erected close to LV side of power transformer

8.1.5 Auxiliary transformer

(a) 1 (one) 33/0.433 kV auxiliary transformer, 50 kVA, Dyn11 with built on low voltage fuses. The transformers shall be installed outdoor

8.1.6 MV Power Cables from Transformer to Indoor Switchgear

(a) 1 (one) lot of 33 kV cable from main transformers to 33 kV switchgear, rated for 120 % of nominal transformer rating

(b) 1 (one) lot of 33 kV cable terminations for transformer and switchgear connection
(c) 1 (one) lot of support structures for lightning arresters and transformer connection
(d) 1 (one) lot of 33 kV cable from switchgear to auxiliary transformer
(e) 1 (one) lot of 33 kV cable terminations for auxiliary transformer and switchgear connection
(f) 1 (one) lot of support structures for auxiliary transformer.

8.1.7 MV Power Cables from Indoor Switchgear to line termination tower

(g) 1 (one) lot of 33 kV cable from indoor 33 kV switchgear to terminal tower
(h) 1 (one) lot of 33 kV cable terminations for switchgear connection and line connection
(i) 1 (one) lot of support structures for cable terminations in terminal tower

8.1.8 Control, Protection, Metering and Signalling

8.1.8.1 Substation Automation System

General

1 (one) lot complete 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 signalling. 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, signalling, 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.

8.1.8.1.1 Scope.

The system design shall be sub divided into 2 sub-groups, depending on the type of substation automation system (SAS);

I. 66-33kV Distribution Stations with SCMS (Substation Control and Monitoring Systems) and shall be controllable from the RCC
II. 66-33kV Distribution Stations with SCMS (Substation Control and Monitoring Systems) which shall not be controllable by the interconnected SCADA system but shall be prepared for future connection.

Stations in the first category are:

a) GALANA KULALU
Stations in Category 2

a) None

The supply and services to be performed by the Contractor 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 works.

The proposed SA system for the above work should offer at least the following functionality: -

- Full operational control, reporting, alarm and indication facilities for the substation from the RCC's (Supervisory level).
- Full operational control, alarm and indication facilities for the substation from the Human Machine interface (HMI) workstations in the substation control room (Substation Level).
- Operational control of each new circuit/bay from the protection relay panel using the bay control unit LCD display (Bay level).
- Control of each item of plant from the Local Control Cubicle (LCC) (Local Level)
- The control facilities from each control point are to be interlocked (hardwired) to prevent operation of any device simultaneously from more than one control point.
- At least one fully operational control point shall remain available in the event of a single equipment or communications failure.

- Complete facilities must exist for the proper lockout and maintenance tagging of circuits and plant items to ensure the safety of personnel and the security of the system
- The SA system shall use open communication protocols and be readily interfaced with third part devices operating on open protocols. The Tenderer shall describe such interfaces and provide an experience list of devices with which the offered control system has previously been interfaced.

The SCMS shall typically include:

- Station Level:
- 2 independent Gateways (Main and Hot-standby) for communications to the SCADA system.
- 1 Operator Workstation/HMI, and the complete workplace (desk, chair).
- color printer. To print screen shots
- Operator log printer
- Satellite clock, complete with GPS Receiver, Antenna and necessary time synchronization ports.
- Interface for laptop computer for maintenance, information transfer and emergencyHMI
- Laptop Computer for maintenance, information transfer and emergency HMI
- UPS system for SCMS.
- Communication network equipment [station (system) LAN, Field Communication Network, Various optical couplers, etc.].
- interface for control and monitoring of the circuit/bay
- Interface for protection devices that cannot directly interface with the substation LAN

Approved communication link & its terminal equipment from the Substation to the Regional Control Centre.

8.1.8.2 **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.

For a point-to-point communication link the IEC 60870-5-101 protocol shall be implemented.
As part of the supply necessary engineering of the substation signal list (I/O list) shall be included. The engineering shall be carried out on the format prescribed by KPLC.

8.1.8.3 **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.

8.1.8.4 **Telecommunications**

a) In order for the SCADA data to be transferred to the Regional control centre at Juja Road substation, the bidder shall design and commission an appropriate communication system based on Radio or other communication media for data and speech requirement.

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

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

b) It is the responsibility of the contractor to interconnect with existing SCADA and Telecommunications system. However use of existing infrastructure where possible shall be encouraged.
c) 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 is necessary, the Tenderer shall supply drawings for the proposed installation. The tenderer 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.
d) All communications equipment installed in the country must be type approved by the Communications Commission of Kenya (CCK). The Contractor will obtain the type approval.
   The CCK 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.
   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.
e) 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.
f) The contractor shall offer training for four (4) technical appointees of the employer for 2 weeks at manufacturer’s premises. Terms and conditions similar to 4.2.15
g) The contractor shall provide necessary configuration software pre-installed on a maintenance laptop with a one time software license.

8.1.9 Auxiliary AC Supply Equipment

8.1.9.1 Main AC Distribution Board

1 (one) main distribution board designed for minimum 200 A with the necessary number of panels for:

(a) 1 (one) circuit breaker, manual operated, minimum 200 A, for the feeder from the station supply transformer.
(b) 2 (two) current transformers 200/1/1 A with two cores, one core for measuring and one for protection.
(c) 1 (one) constant time overcurrent relay.
(d) 1 (one) earth fault relay.
(e) 1 (one) A-meter function with selector switch.
(f) 1 (one) V-meter function with selector switch.
(g) 1 (one) lot of feeder circuit breakers with electro-magnetic and thermal releases. The breaker ratings shall be chosen to suit the different consumers to be connected. 20% of the breakers of each size shall be spare and readily mounted.

8.1.9.2 Sub-distribution Boards and Panels

(a) 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.

8.1.9.3 Cables

(a) 1 (one) lot of all necessary armoured power and control cables for supply to the main distribution board and to the sub-distribution boards, panels and equipment except for the cables for lighting and small power which are included in the civil Goods under separate contract.

8.1.10 DC Supply System

8.1.10.1 Battery

i. (1 (one) 110 V battery. Capacity at least 200 Ah/10h for substations with more than 10 MVA installation of transformer capacity

ii. The 48V batteries shall be included in the bid for communication equipment and the RTU. The battery shall be at least 100A/10Ah

The capacities to be recommended by the Bidder, based upon the calculated consumption considering a fully developed substation.
Batteries shall be installed in separate room with EX proof ventilation fan (for 110 V batteries only).

8.1.10.2 **Charger**

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

The chargers shall be complete with instruments, breakers on AC and DC side, and protection.

8.1.10.3 **Switchboard**

1 (one) switchboard 110 V DC.

The board shall have:

(a) 1 (one) circuit breaker with magnetic and thermal release for the feeder from earache charger and battery.
(b) 1 (one) A-meter with shunt for each battery.
(c) 1 (one) V-meter with selector switch for the voltage between the poles and between poles and earth for each battery.
(d) 1 (one) set of contacts on the front for banana jacks for the battery voltage and earth.
(e) 1 (one) battery monitoring devices with alarm contacts.
(f) 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.

8.1.10.4 **Battery Conductors and Fuses**

(a) 1 (one) set of conductors for the battery in the battery room.
(b) 2 (two) single pole fuse boxes with main fuses for the battery, placed on the wall outside of the battery room, and two fuses for the battery monitoring device.

8.1.10.5 **Sub-distribution Boards and Panels**

(a) 1 (one) lot of all necessary sub-distribution boards and panels.

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 whenever needed.

8.1.10.6 **Cables**

(a) 1 (one) lot of all necessary DC power supply cables, including wiring to the apparatus in the switchyard.

8.1.11 Earthing System

An earthing network shall be installed comprising the following:

(a) 1 (one) lot of underground earthing system covering the platform 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.

8.1.12 Ancillary Equipment

8.1.12.1 Station Equipment

(a) 2 (two) self-contained, rechargeable, portable hand-held lights.
(b) 1 (one) audible alarm system with the necessary wiring.

8.1.12.2 Earthing Devices

(a) 1 (one) set of three phase portable earthing devices for outdoor 33 kV with operating rods suitable for earthing of the bay conductors and busbars.
(b) 1 (one) set of voltage indicator for 33 kV and 11KV with audible and visual indication for voltage

8.1.12.3 Cable Accessories

(a) 1 (one) lot of all connecting material, cable boxes and material for fixing the cables.

Terminals and terminal labels to the extent that this is not included in other sections.

8.1.12.4 Racks, Conduits, Ducts, etc

(a) 1 (one) lot of all cables, racks and trays to the extent necessary for the proper distribution of cables.

All the conduits and protection tubes, wherever cables may deteriorate or where cable laying may otherwise present difficulties.

8.1.13 Power transformers

To be supplied as specified for each sub station, and in accordance with below data.

8.1.13.1 Type of transformers

Main data for the transformers that shall be supplied:

Pos.	Rating MVA (ONAN	Voltage kV	Tapping range	OLTC	Vector group
1	23	66/33	±8 x 1.67%	yes	Dyn11

8.1.13.2 **CT's for Power Transformers**

Transformer Ratings		CT Ratios - Amps Phase Bushings		Neutral Bushings	Protection
(KV)	(MVA)				
		HV	LV		
66/33	23	200/1	400/1	400/200/1	Biased Differential Restricted/ Standby. HV over current

Note: Each function on separate core

8.1.13.3 **Civil Works**

8.1.13.4 **Platform works**

Platform with fence roads and ditches shall be constructed as specified in particular specifications and in scope of work.

8.1.13.5 **Switchgear buildings**

Switchgear buildings shall be constructed as specified in particular specifications and in scope of work.
Control Panels and medium voltage indoor switchgears of different Voltage levels shall be installed in separate rooms

8.1.13.6 **Transformer foundations**

Transformer foundations shall be constructed as specified particular specifications and in scope of work.

8.1.13.7 **Cable Trenches**

Cable trenches shall be constructed as specified in particular specifications and in scope of work.

8.1.14 Training in control and protection system (LS-008a, 008b)

The training includes travel, accommodation and per diem for the 4 (four) REREC/KPLC engineers as well as all course material and other expenses acquired by the Contractor. The training shall be held at the manufacturers. 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.

8.1.15 Factory Acceptance Test (LS – 001,002,003,004,005,006,007)

The FAT shall include shall be done by 5 participants from REREC/KPLC and the Project Manager for the following major equipment:

- **66 and 33KV Circuit breakers**
- **Protection and control system**
- **Transformers**
- **Indoor switchgear**
- **Power Cables**
- **Instrument transformer**
- **Disconnectors/ Isolators**
-

FAT shall be carried out as prescribed in the particular technical specifications of the equipment. The following costs associated to carrying out the above FATs shall be borne by the Contractor. This shall include but not limited to

I. Return flight ticket on economy class for nominated employer representatives above.

II. Per Diem at the approved REREC Rates for the travelling Employees

III. Visa application and processing fee and Local transport expense at the manufacturer's country.

8.1.16 Test Equipment (TS –001)

- Lap top computers: One unit, set up with comprehensive software. The pc shall be supplied with all the necessary accessories and ports and loaded with latest operating system. The Lap top must be able to run all the relay and equipment software's supplied under the contract.

8.1.17 Final documentation

As built drawings:	5 paper copies delivered in binders
	3 CD-ROM copy (all drawings in auto card)
	1 set of transparencies

Operation and maintenance manuals: 1 copy

8.1.18 GULANA KULANA SUBSTATION EQUIPMENT.

New substation, Two transformers shall be installed at **Gulana Kulana 2x23MVA, 66/33 kV.**

Item No.	Description	Unit	Qty
1.5.	Supply 23MVA, 66/33KV Power Transformer with MR-Germany/China OLTC & RTCC Panel	NO	
2.	SF6,Circuit breakers 66kV, 1250/2000 A, 31.5/40 kA	No.	
3.	Vacuum, Circuit breakers 33kV, 1250A, 25/20 KA	No.	
4.	Switching disconnectors 66 Kv, 1250 A, 31.5KA with earthing switch	Set	
5.	Switching disconnectors 33 kV,800 A, 25KA with earthing switch	Set	
6.	66 kV, 10 kA, Station Class Surge Arrester	No.	
7.	33 kV, 10 kA, Station Class Surge Arrester	No.	
8.	66KV, 200-100/1-1-1-1, CT	No.	
9.	33KV, 400-200/1-1-1-1, CT	No.	
10.	66KV, 66KV/√3/110V/√3, VT	No.	
11.	33KV, 33KV/√3/110V/√3, VT	No.	
12.	66 KV C & R Panel for SF6 CB With TVM & Protection Relays	Set	
13.	33 KV C & R Panel for SF6 CB With TVM & Protection Relays	Set	

14.	Bay Marshalling Kiosk (Outdoor)	No.	
15.	300mm sq. ACSR Overhead Conductor on 66KV Side	Mtr.	
16.	300mm sq. ACSR Overhead Conductor on 33KV Side	Mtr.	
17.	66 kV Bus Post Insulator	Nos	
18.	33 kV Bus Post Insulator	Nos	
19.	66 kV Suspension & Tension Polymer Insulator	Nos	
20.	33 kV Suspension & Tension Polymer Insulator	Nos	
21.	Insulator Hardware's	Lot	
22.	Clamps & Connectors for all the above equipments	Lot	
23.	5 C x 2.5 Sq.mm Control Cables	Mtr.	
24.	5 C x 4 Sq.mm Control Cables	Mtr.	
25.	10 C x 2.5 Sq.mm Control Cables	Mtr.	
26.	10 C x 4 Sq.mm Control Cables	Mtr.	
27.	15 C x 2.5 Sq.mm Control Cables	Mtr.	
28.	40 mm dia, GI Pipe Earth Electrode	Nos	
29.	20 mm dia, GI Spike Earth Electrode	Nos	
30.	75 x 12 mm MS Flat	MT	
31.	15 x 6 mm MS Flat for Equipment Raiser	MT	
32.	32 mm dia MS Round for Earth Mat	MT	
33.	Foundation Bolts & Structures for 132KV Structure & Gantry	MT	

34.	Foundation Bolts & Structures for CB,CT,BPI, ISOLATOR, LA,	MT	
35.	110V Battery, 165AH, VRLA Type	Set	
36.	110V, 50A Battery Charger with DCDB for above battery	No	
37.	66KV, Outdoor Power Factor Banks with C&R Panel	SET	
38.	48V DC Charger/Batteries for Telecommunication Systems Costs	SET	
39.	Substation Automation Systems Costs	Lot	
40.	Telecommunication (PLCC based system) Costs	Lot	
41.	66KV Line Wave Traps for PLCC Systems Costs	Lot	
42.	66KV Coupling Capacitors for above PLCC	Lot	
43.	50KVA, 33/0.433KV, Substation Transformer	Lot	
44.	33KV, Drop Out Fuse for above Substation Transformer	No	
45.	Lightning Mast - Tubular Structure	No	
46.	AC Distribution Board	No	

8.1.19 Mandatory Spare Parts and Tools

All spares and tools specified below are to be of makes and types that match with the equipment in the scope of works, to the extent possible. Spares and Tools are to be delivered to KPLC's central stores in Nairobi.

8.1.19.1 For Transformers

The following spares and tools are to be provided *<u>for each type</u>* of transformer offered:

Item no.	Item	Code[1]	Unit	Qty (1)
	Mandatory Spares and tools			
	Spares for transformers			
	Spares			
1.	Auxiliary relay of each type.		Sets	
2.	Switches each type		Sets	
3.	Lamps each type		Sets	
4.	Contactor each type		Sets	
5.	Valve each type		Sets	
6.	Gaskets complete set		Sets	
7.	Silica gel (complete filling)		Sets	
8.	Dial type thermometer		Sets	
9.	Mercury (or similar) thermometer		Sets	
10.	Oil gauge each type		Sets	
11.	Gauge glass each type		Sets	
12.	Glass cylinder for silica gel breather		Sets	
14.	Bushing of each type		Sets	
	Tools for Transformers			
15.	Complete set of slings for lifting		Sets	
	Spares			
16.	66kV disconnector		Sets	
17.	33kV Fuses for Fuse Switches		Sets	
18.	Assorted MCB's for AC and DC distribution boards		Sets	
19.	Trip coils for each type of Circuit Breaker		Sets	
20.	Close coils for each type of Circuit Breaker		Sets	
	Tools			
21.	Lap tops		Sets	

8.1.20 Recommended Spare Parts and Tools

The Bidder shall recommend additional spares and tools suitable for the offered equipment. The prices are to be entered in Price schedule No. 6, which shall not be added to the Grand Summary Prices. The recommended spares and tools are to be specifically discussed and agreed on during contract negotiations

TECHNICAL SCHEDULES

8.2 *TECHNICAL SCHEDULES*

8.2.1 PREAMBLE

1.1 The Technical Schedules shall be filled in and completed by the Bidder, and submitted with the Bid. The type test reports and the relevant manufacturer's technical documents shall be provided for reference.

1.2 All documentation necessary to evaluate whether the equipment offered is in accordance with this Specification shall be submitted with the Bid.

1.3 All data entered in the Schedules of Technical Guarantees are guaranteed values by the Bidder and cannot be departed from whatsoever.

1.4 All data entered in the Schedules of Informative. Data are also guaranteed values by the Bidder. These data may only be altered following the Project Manager's written consent.

8.3 TECHNICAL SCHEDULES SUBSTATIONS

8.3.1 SCHEDULE VI-1a TECHNICAL GUARANTEES, OUTDOOR SWITCHGEAR

Sheet 1 of 4

OUTDOOR SWITCHGEAR			33kV		Reference Doc
	Particulars	Unit	Guar. Fig	Guar. Fig	
	Circuit Breakers (Type __________)		State		
	Breaking Medium	SF_6/Vacuum			
	Manufacturer				
	- Rated voltage	kV			
	- Maximum service voltage	kV			
	- Rated frequency	Hz			
	- Rated continuous current	A			
	- One minute power frequency withstand voltage, dry and wet				
	- to earth	kV rms			
	- across open breaker pole	kV rms			
	- Impulse withstand voltage 1.2/50 ms				
	- to earth	kV peak			
	- across open breaker				
	- Breaking capacity at rated voltage				
	- symmetrical	kA rms			
	- asymmetrical	kA rms			
	- Making capacity	kA peak			
	- Breaking capacity of capacitive current	A			

OUTDOOR SWITCHGEAR			33 kV		
	Particulars	Unit	Guar. Fig		Reference Doc
	8.3.1.1.1.1 Circuit breakers continued				
	- Overvoltage factor for disconnection of unloaded transformers (without voltage limitation by lightning arresters)				
	- Rated inductive current switching capacity	A			
	- Permissible 1 second short-time current	kA rms			
	- Dynamic short-time current	kA peak			
	- Opening time, interval of time between the instant of application of tripping impulse to the instant when the main contacts have separated in all poles	m.sec.			
	- Make time, interval of time between the initiation of closing operation and the instant when the current begins to flow in the main circuit	m.sec.			
	- Total break time, interval of time between the instant of application of tripping impulse to the instant of final arc extinction in all poles				
	- at 100% breaking capacity	m.sec.			
	- under phase opposition	m.sec.			
	- Rate of rise of recovery voltage (RRRV) at 100% short circuit current				
	- 3-phase	kV/msec			
	- 1-phase				
	- RRRV out of phase duty	kV/msec			

	- Minimum temperature rise at rated current of main contact	°C			
	Earthing Switches				
	- Rated short-time current 1 sec.	kA rms			
	- Rated dynamic short-circuit current				
	- Making Capacity				

OUTDOOR SWITCHGEAR			33 kV		
	Particulars	Unit	Guar. Fig	Guar. Fig	Reference Doc

	8.3.1.1.1.2 Current Transformers
	
	Manufacturer
	- Rated voltage
	- Maximum service voltage
	- Rated frequency
	- One-minute power frequency test voltage of
	  - primary winding
	  - secondary winding
	- Lightning impulse withstand voltage
	- Rated primary currents
	- Rated secondary current
	- Short-time thermal rating
	  - 1 second
	- Short-time dynamic rating
	- Burden and accuracy class of
	  - measuring core
	  - protection core
	- Instrument security factor of the measuring core
	- Accuracy limit factor of the
	  - protection core
		
		kV
		kV
		Hz
		
		kV rms
		kV rms
		kV peak
		A
		A
		
		kA rms
		kA peak			

	Voltage Transformers, Type ___________ Manufacturer - Rated voltage - Maximum service voltage	 kV kV rms			

	- One-minute power frequency test voltage - primary winding - secondary winding - Lightning impulse withstand voltage - Burden and accuracy class of a. measuring winding protection winding - Ratio	 kV rms kV rms kV peak kV			
	Country of Manufacture - Cubicles - Circuit breakers - Current transformers - Voltage transformers				

SCHEDULE VI-1b INFORMATIVE DATA OUTDOOR SWITCHGEAR

Sheet 1 of 3

	Particulars	Unit	33 kV	
	8.3.1.1.1.2.1 Circuit Breakers			
	- Reference standard			
	- Type of breaker and designation			
	- Voltage drop across main contacts at rated current	mV		
	- Type of main contact	mm		
	- Type of arch control device	m/s		
	- Method of closing			
	- Method of tripping			
	- Max. percentage of recovery voltage across any break	%		
	- Minimum clearance between live parts and earth, in SF6 or vacuum	mm		
	- Min distances between phases			

	Particulars	Unit	33 kV	Reference Doc
	- Number of opening operations permissible before inspection and maintenance of contacts, gas treatment etc.			
	- at rated current			
	- at maximum short circuit current			
	For SF_6 breakers			
	- Normal gas density for SF6 circuit breaker (represented by gas pressure)			
	- at 20°C	Bar		
	- at 40°C	Bar		
	- Minimum gas density for safe operation			
	- at 20°C	Bar		
	- at 40°C	Bar		
	- Quantity of gas required per 3-pole breaker	kg		
	- Operating pressure of relief device	Bar		
	- Method of monitoring pressure and temperature compensation			
	- Max. permissible dew point temp.	°C		
	- Max. permissible acidity level			
	- Max. permissible leak rate	%/year		
	For vacuum breakers			
	- Vacuum in break chamber	torr		
	- Max. permissible leak rate	%		
	For all breakers			
	- Control voltage	V DC		
	- Type of operating device			
	- Motor voltage			
	- AC of DC			
	- Max. permissible service voltage	V		
	- Min. service voltage	V		
	- Starting current of motor			

	- Power consumption of motor - When starting - When running - Power consumption of - Closing coil - Trip coil - Heater	 W W W W W		

	Particulars	Unit	33 kV	Reference Doc
	- Auxiliary switch - Rupturing current at 110 V DC - Number of free NO contacts - Number of free NC contacts - Test voltage 50Hz, 1 min. Manufacturer's of: - Support insulators - Breaker insulators - Operating mechanism 8.3.1.1.1.2.2 NOTE - In addition to the characteristics listed above, the following information shall be given for all switchgear: - Layout and overall dimensions drawings - descriptions	 A V		
	8.3.1.1.1.2.3 Earthing Switches - Reference standard - Type of isolating switch - Min. creepage distance (live parts to earth) - Min. isolating distance (clearance between open contacts) - Material of contact surface - Total contact pressure - Type of operating device - weight of earthing switch	 mm mm		
	Current Transformers			

	- Reference standard - Type designation - Overall dimensions - Total weight of one current transformer - Type of insulation	kg		
	Voltage transformers - Reference standard - Type designation - Overall dimensions - Total weight of one current transformer - Type of insulation - Type of insulation	kg		

8.3.2 SCHEDULE VI-2a TECHNICAL GUARANTEES, INDOOR MV INDOOR SWITCHGEAR

Sheet 1 of 6

MV INDOOR SWITCHGEAR				66 kV	
	Particulars	Unit		Guar. Fig.	Reference Doc
	Cubicles				
	Manufacturer				
	Metal Clad type				
	- Rated Voltage	kV			
	- Maximum service voltage	kV			
	- Rated frequency	Hz			
	- Rated continuous busbar current	A			
	- One minute power frequency withstand voltage, dry and wet				
	- to earth	kV rms			
	- Impulse withstand voltage 1.2/50 ms				
	- to earth	kV peak			
	- Permissible 1 second short-time current	kA rms			
	- Dynamic short-time current	kA peak			
	Arch tested in accordance with IEC 60280 amendment 2	Yes/no			
	Circuit Breakers (Type ___________)				
	Breaking Medium	SF_6/Vacuum			
	Manufacturer				
	- Rated voltage	kV			
	- Maximum service voltage	kV			
	- Rated frequency	Hz			
	- Rated continuous current	A			
	- One minute power frequency withstand voltage, dry and wet				

	- to earth	kV rms				
	- across open breaker pole	kV rms				
	- Impulse withstand voltage 1.2/50 ms					
	- to earth	kV peak				
	- across open breaker					
	- Breaking capacity at rated voltage					
	- symmetrical	kA rms				
	- asymmetrical	kA rms				
	- Making capacity	kA peak				
	- Breaking capacity of capacitive current	A				

MV INDOOR SWITCHGEAR				66 kV	
	Particulars	Unit		Guar. Fig	Reference Doc
	8.3.2.1.1.1 Circuit breakers continued				
	- Overvoltage factor for disconnection of unloaded transformers (without voltage limitation by lightning arresters)				
	- Rated inductive current switching capacity	A			
	- Permissible 1 second short-time current	kA rms			
	- Dynamic short-time current	kA peak			
	- Opening time, interval of time between the instant of application of tripping impulse to the instant when the main contacts have separated in all poles	m.sec.			
	- Make time, interval of time between the initiation of closing operation and the instant when the current begins to flow in the main circuit	m.sec.			
	- Total break time, interval of time between the instant of application of tripping impulse to the instant of final arc extinction in all poles				
	- at 100% breaking capacity	m.sec.			
	- under phase opposition	m.sec.			
	- Rate of rise of recovery voltage (RRRV) at 100% short circuit current				
	- 3-phase	kV/msec			
	- 1-phase				
	- RRRV out of phase duty	kV/msec			
	- Minimum temperature rise at rated current of main contact	°C			

	Earthing Switches - Rated short-time current 1 sec. - Rated dynamic short-circuit current - Making Capacity	kA rms			

MV INDOOR SWITCHGEAR				66 kV	
	Particulars	Unit		Guar. Fig	Reference Doc
	8.3.2.1.1.2 Current Transformers				
	Manufacturer				
	- Rated voltage	kV			
	- Maximum service voltage	kV			
	- Rated frequency	Hz			
	- One-minute power frequency test voltage of				
	- primary winding	kV rms			
	- secondary winding	kV rms			
	- Lightning impulse withstand voltage	kV peak			
	- Rated primary currents	A			
	- Rated secondary current	A			
	- Short-time thermal rating				
	- 1 second	kA rms			
	- Short-time dynamic rating	kA peak			
	- Burden and accuracy class of				
	- measuring core				
	- protection core				
	- Instrument security factor of the measuring core				
	- Accuracy limit factor of the				
	- protection core				
	Voltage Transformers, Type ___________				
	Manufacturer				
	- Rated voltage	kV			
	- Maximum service voltage	kV rms			

	- One-minute power frequency test voltage				
	- primary winding	kV rms			
	- secondary winding	kV rms			
	- Lightning impulse withstand voltage	kV peak			
	- Burden and accuracy class of				
	a. measuring winding protection winding				
	- Ratio	kV			
	Country of Manufacture				
	- Cubicles - Circuit breakers - Current transformers - Voltage transformers				

SCHEDULE VI-2a TECHNICAL GUARANTEES, MV INDOOR SWITCHGEAR

MV INDOOR SWITCHGEAR			66 kV		
	Particulars	Unit	Guar. Fig	Guar. Fig.	Reference Doc
	Cubicles				
	Manufacturer				
	- Rated Voltage	kV			
	- Maximum service voltage	kV			
	- Rated frequency	Hz			
	- Rated continuous busbar current	A			
	- One minute power frequency withstand voltage, dry and wet				
	- to earth	kV rms			
	- Impulse withstand voltage 1.2/50 ms				
	- to earth	kV peak			
	- Permissible 1 second short-time current	kA rms			
	- Dynamic short-time current	kA peak			
	Arch tested in accordance with IEC 60280 amendment 2	Yes/no			
	Country of Manufacture				
	- Cubicles				

8.3.3 SCHEDULE VI-2b INFORMATIVE DATA MV INDOOR VOLTAGE SWITCHGEAR

Sheet 1 of 6

MV INDOOR SWITCHGEAR					
	Particulars	Unit		66 kV	Reference Doc
	Cubicles				
	- Reference standard				
	- Type of conductors				
	- Conductor material				
	- Cross-section of busbars	mm^2			
	Cross section of branch off	mm^2			
	- Temperature rise of busbars at rated current	^oC			
-	Distances between				
-	- Busbar phases	mm			
-	- branch offs	mm			
-	- Live parts and earth	mm			
-	Are busbars insulated? If so state insulation material				
	- Class of protection	IP			
	- Short circuit test certificate designation				
-	Overall dimensions of the complete cubicle				
-	- length	mm			
-	- height	mm			
-	- width	mm			
	- Thickness of plates	mm			
-	Movement in isolator function	Hor./vert.			
-	Isolation distance	mm			
-	shutters when isolated or withdrawn?	Yes/no			
-	Weight of complete cubicle with circuit breaker etc.				

	8.3.3.1.1.1.1 Circuit Breakers				
	- Reference standard				
	- Type of breaker and designation				
	- Voltage drop across main contacts at rated current	mV			
	- Type of main contact	mm			
	- Type of arch control device	m/s			
	- Method of closing				
	- Method of tripping				
	- Max. percentage of recovery voltage across any break	%			
	- Minimum clearance between live parts and earth, in SF6 or vacuum	mm			
	- Min distances between phases				

MV INDOOR SWITCHGEAR

	Particulars	Unit		66 kV	Reference Doc
	- Number of opening operations permissible before inspection and maintenance of contacts, gas treatment etc.				
	- at rated current				
	- at maximum short circuit current				
	For SF_6 breakers				
	- Normal gas density for SF6 circuit breaker (represented by gas pressure)				
	- at 20°C	Bar			
	- at 40°C	Bar			
	- Minimum gas density for safe operation				
	- at 20°C	Bar			
	- at 40°C	Bar			
	- Quantity of gas required per 3-pole breaker	kg			
	- Operating pressure of relief device	Bar			
	- Method of monitoring pressure and temperature compensation				
	- Max. permissible dew point temp.	°C			
	- Max. permissible acidity level				
	- Max. permissible leak rate	%/year			
	For vacuum breakers				
	- Vacuum in break chamber	torr			
	- Max. permissible leak rate	%			
	For all breakers				
	- Control voltage	V DC			
	- Type of operating device				
	- Motor voltage				
	- AC of DC				
	- Max. permissible service voltage	V			
	- Min. service voltage	V			

	- Starting current of motor				
	- Power consumption of motor				
	- When starting	W			
	- When running	W			
	- Power consumption of				
	- Closing coil	W			
	- Trip coil	W			
	- Heater	W			

MV INDOOR SWITCHGEAR

	Particulars	Unit		66 kV	Reference Doc
	- Auxiliary switch - Rupturing current at 110 V DC - Number of free NO contacts - Number of free NC contacts - Test voltage 50Hz, 1 min. Manufacturer's of: - Support insulators - Breaker insulators - Operating mechanism 8.3.3.1.1.1.2 NOTE - In addition to the characteristics listed above, the following information shall be given for all switchgear: - Layout and overall dimensions drawings - descriptions	 A V			
	8.3.3.1.1.1.3 Earthing Switches - Reference standard - Type of isolating switch - Min. creepage distance (live parts to earth) - Min. isolating distance (clearance between open contacts) - Material of contact surface - Total contact pressure - Type of operating device - weight of earthing switch	 mm mm			
	Current Transformers - Reference standard				

	-	Type designation				
	-	Overall dimensions				
	-	Total weight of one current transformer	kg			
	-	Type of insulation				
		Voltage transformers				
	-	Reference standard				
	-	Type designation				
	-	Overall dimensions				
	-	Total weight of one current transformer	kg			
	-	Type of insulation				
	-	Type of insulation				

8.3.4 SCHEDULE VI 3a TECHNICAL GUARANTEES, CONTROL SYSTEM

8.3.4.1.1.1.1.1 Sheet 1 of 1

SUBSTATION CONTROL SYSTEM (SCS)			
	Particulars	Unit	Guar. Fig
	Control system response and update time under "moderate load" conditions		
	The control system shall be designed to yield the following response and update times under "moderate load" conditions		
	- Time taken to completely refresh data held with the SCS:	s	
	a. maximum	s	
	b. average		
	- Time taken to carry out a complete status check of all indications and alarms		
	a. maximum	s	
	b. average	s	
	- The time between selection and display of a VDU diagram fully updated from the existing main computer data base shall not exceed	s	
	- The time between selection of a control function and check back shall not exceed	s	
	- The time between execution of a control function and successful completion being displayed at the Operation Workshop shall not exceed for		
	a. Circuit breaker (operating time = 250 ms)	s	
	b. Isolator (operating time = 10s)	s	
	- The time between the occurrence of the first change of state/alarm and display at the Operator Workstation shall not exceed	s	
	- The time between selecting display of analogue measurements and the corresponding value in the database being displayed shall not exceed	s	
	- The time between successive updates of the data base with analogue measurements shall not exceed	s	
	a. Network MW measurements	s	
	b. Other analogue measurements	s	

	Equipment Reliability		
	Mean time between failure shall be not less that:		
	- Each computer	h	
	- VDU	h	
	- Logging printer	h	
	- System console	h	
	- Communication system	h	

8.3.5 SCHEDULE VI 3b INFORMATIVE DATA, CONTROL SYSTEM

Sheet 1 of 1

SUBSTATION CONTROL SYSTEM (SCS)			
	Description	Unit	Data
	General System Considerations		
-	Software		
	- Package		
	- Which RTU communication protocols are supported		
-	Real-time database		
	- Package		
	- Is an SQL interface supported		
-	Database Management Tool		
	- Package		
	- Is an SQL interface supported?		
-	Man-machine Interface		
	- Package		
	- State type of man-machine interface software		
	Operator Workstation		
-	Reference standard		
-	Type designation		
-	Weight	kg	
-	Mounting arrangement		
	VDU		
-	Reference standard		
-	Type designation		
-	Diagonal screen size	mm	
-	Usable display area	max. mm	
-	Weight	kg	
-	Mounting arrangement		

	Alphanumeric Keyboard - Reference standard - Type designation - Mounting arrangement			

8.3.6 SCHEDULE VI 4a TECHNICAL GUARANTEES, PROTECTION ETC.

Sheet 1 of 3

CONTROL, PROTECTION, METERING, SIGNALLING				
	Particulars	Unit		Reference Doc
	Indicating Instruments - To be filled in for each AC and DC Ampere meter and Voltmeter and for each Wattmeter, VAr-meter, Frequency-meter and other indicating instruments: - Instrument for: (A, V (AC), V (DC), W, etc.) - Error - Max. admissible current - Max. admissible voltage	 % $\%.I_N$ $\%.I_N$		
	Meters - To be filled in for each meter - Meter for (MWh, MVArh): - Error with 5% load - Error with 10% load - Error with 20% load - Error with 100% load - Max. admissible current	 % % % % $\%.I_N$		
	Metering Converters (Transducers) - Converter for (MW, MVAr, A, etc): - Error - Linearity	 % %		

		- Max. admissible current for 0.5 seconds - Max. admissible current continuously - Max. admissible voltage for 0.5 seconds - Max. admissible voltage continuously	%.I_N %.I_N %.I_N %.I_N		

CONTROL, PROTECTION, METERING, SIGNALLING

	Particulars	Unit		Reference Doc
	Protection Relays			
	- To be **copied** and filled in for each type of relay as applicable			
	Relay for ______________________:			
	- Accuracy of the adjustable tripping time	sec.		
	- Min. possible tripping time	ms		
	- Drop out ratio	%		
	- Directional sensitivity (dist. relay only)	$\%.U_N$		
	- Max. admissible current during 0.5 sec.	$\%.I_N$		
	- Max. admissible current continuously	$\%.I_N$		
	- Relation between tripping coil current and holding coil current (diff. relay only)	%		
	- Limit value of the adjustable tripping current (O.C.R.)	$\%.I_N$		
	- Limit value of the instantaneous tripping current (O.C.R.)	$\%.I_N$		
	- Limit value of the adjustable tripping voltage (O.V.R.)	$\%.I_N$		
	- Limit value of the instantaneous tripping voltage (O.V.R.)	$\%.I_N$		
	<u>Distance Protection</u> Shall incorporate the			

		following features: • Ratings: AC Inputs: 110V, 1Amp (three phase). • Power Supply Voltage: 110VDC. (Universal power supply of 30-300VDC is preferred). • The relays shall be of Numeric design. • 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. • IDMT Three Phase/Over current & Earth fault Protection. • Fuse failure supervision. • Auto- reclose logic 1 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.	Shall incorporate all the features as listed Shall incorporate all the features as listed		

		• Clear faulted phase indication. • Clear fault identification even for boundary conditions. • Software necessary for all above functions shall be provided. • Three sets of Installation, Commissioning and maintenance manuals shall be provided. <u>Three phase numeric directional over current and earth fault relay</u> Shall incorporate the following features: • Relay must be of Numerical design. • 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 BS 142 or IEC 60255 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 • Highset 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. • Must provide all technical and operations manuals and configurations and settings software.			
		Protection Relays			
	-	To be **copied** and filled in for each type of relay as applicable			
		Relay for ______________________:			
	-	Accuracy of the adjustable tripping time	sec.		
	-	Min. possible tripping time	ms		
	-	Drop out ratio	%		
	-	Directional sensitivity (dist.	%.U_N		

	relay only)			
	- Max. admissible current during 0.5 sec.	%.I_N		
	- Max. admissible current continuously	%.I_N		
	- Relation between tripping coil current and holding coil current (diff. relay only)	%		
	- Limit value of the adjustable tripping current (O.C.R.)	%.I_N		
	- Limit value of the instantaneous tripping current (O.C.R.)	%.I_N		
	- Limit value of the adjustable tripping voltage (O.V.R.)	%.I_N		
	- Limit value of the instantaneous tripping voltage (O.V.R.)	%.I_N		
	<u>Biased differential protection for a two winding transformer</u>. • Relay Must be of Numerical design • Pick up setting range, 0.1 to 0.5In • Should incorporate a high-set Element with a setting range of up to 20In. • Magnetising 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. • Overfluxing restraint • Overfluxing protection	Shall incorporate all the features as listed		

		with Alarm and Trip functions • 5th harmonic restraint feature on the differential Element. • Appropriate Dual Bias characteristic to ensure relay stability for heavy through faults • 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.	Shall incorporate all the features as listed		
		<u>Three phase numeric IDMTL over current and earth fault relay</u> Should incorporate the following Features; • Relay must be of Numerical Type • 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 • Highset Element for both	Shall incorporate all the features as listed		

		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% <u>Restricted Earth fault relay</u> • Relay must be of Numerical type • Relay should reject harmonics produced by C.T saturation • The offer should include the associated stabilising resistor and voltage dependent resistor (metrosil) • Current setting range 0.05-0.8In • Operating time < 25ms at 5 times the setting			

CONTROL, PROTECTION, METERING, SIGNALLING

	Particulars	Unit		Reference Doc
	Auxiliary Circuit Breakers			
	- To be filled in for each type of AC and DC breaker:			
	- Min. operating voltage	$\%.U_N$		
	- Max. operating voltage	$\%.U_N$		
	- Drop out voltage	V		
	- Service life (min. number of contact operation)			
	Manufacturer's Name			
	- Control room boards			
	- Local relay boards			
	- Protection relays			
	- Auxiliary contactors			
	Country of Manufacture			
	- Control room boards			
	- Local relay boards			
	- Protection relays			
	- Auxiliary contactors			

8.3.7 **SCHEDULE VI 4b INFORMATIVE DATA, PROTECTION ETC.**

Sheet 1 of 2

CONTROL, PROTECTION, METERING, SIGNALLING					
		Particulars	Unit		Reference Doc
		Indicating Instruments			
		To be filled in for each type of instrument:			
	-	Reference standard			
	-	Type (moving coil, iron type, etc.)			
	-	Consumption of internal resistance	VA/ohm		
	-	Size	mm		
		Meters			
		To be filled in for each type of meter:			
	-	Reference standard			
	-	Type			
	-	Consumption of internal resistance	VA/ohm		
	-	Size	mm		
		Metering Converters (Transducers)			
		To be filled in for each type for converter:			
	-	Reference standard			
	-	Type			
	-	Consumption, current	VA		
	-	Consumption, voltage	VA		
	-	Time constant	ms		
	-	Size	mm		
		Alarm Annunciators			
		To be filled in for each annunciator panel:			

	- Reference standard - Type - Number of annunciators - Size of each annunciator (area of the cap) - Total size of panel	 mm mm		

	Control Room Board
	
	- Height
	- Width
	- Length
	- Relay boards
	  - Height
	  - Width
	  - Length
		
		m
		mm
		mm		

CONTROL, PROTECTION, METERING, SIGNALLING

	Particulars	Unit		Reference Doc
	Protection Relays To be **copied** and filled in for each relay with the applicable items of the data below: Relay for ____________________:			
-	Reference standard			
-	Consumption	VA		
-	Limit values of the adjustable tripping time	sec.		
-	Limit values of the adjustable sensitivity	%		
-	Limit values of the adjustable operating quantity (current, voltage, frequency, etc.) in % of normal	%		
-	Limit values of the instantaneous operating quintet in % of nominal value	%		
-	Size	mm		
	For distance relay only:			
-	Starting impedance adjustable between	ohm/ph		
-	Earth fault tripping current adjustable between	$x.I_N$		
	Protection Relays To be filled in for each relay with the applicable items of the data below: Relay for ____________________:			
-	Reference standard			
-	Consumption	VA		
-	Limit values of the adjustable tripping time	sec.		
-	Limit values of the adjustable	%		

	sensitivity			
	- Limit values of the adjustable operating quantity (current, voltage, frequency, etc.) in % of normal	%		
	- Limit values of the instantaneous operating quintet in % of nominal value	%		
	- Size	m		
	For distance relay only:			
	- Starting impedance adjustable between	ohm/ph		
	- Earth fault tripping current adjustable between	$x.I_N$		

8.3.8

8.3.9 SCHEDULE VI 5b INFORMATIVE DATA, CABLES

Sheet 1 of 2

POWER CABLES, CONTROL CABLES, CABLE RACKS				
	Particulars	Unit		Reference Doc
	Low Voltage Cables			
	- Conductor material			
	- Insulation material			
	- Armouring/screen			
	- Protective coating			
	- Overall diameter of cable of biggest cable	m		
	- Weight of heaviest reel, including cable	kg		
	- Size of biggest reel, diameter/width	mm/mm		
	Control and Measuring Cables			
	- Conductor material			
	- Insulation material			
	- Armouring/screen			
	- Protective coating			
	- Overall diameter of cable of biggest cable	mm		
	- Weight of heaviest reel, including cable	kg		
	- Size of biggest reel, diameter/width	mm/mm		
	Special Cables			
	To be used for:			
	- Relevant informative data			

8.3.10

8.3.11 SCHEDULE VI 5b INFORMATIVE DATA, CABLES

Sheet 2 of 2

POWER CABLES, CONTROL CABLES, CABLE RACKS				
	Particulars	Unit		Reference Doc
	11 kV Voltage Cables - Conductor material - Insulation material - Armouring/screen - Protective coating - Overall diameter of cable of biggest cable - Weight of heaviest reel, including cable - Size of biggest reel, diameter/width	 mm kg mm/mm		
	33 kV Voltage Cables - Conductor material - Insulation material - Armouring/screen - Protective coating - Overall diameter of cable of biggest cable - Weight of heaviest reel, including cable - Size of biggest reel, diameter/width	 mm kg mm/mm		
	33 kV Voltage Cables - Conductor material - Insulation material - Armouring/screen - Protective coating - Overall diameter of cable of biggest cable - Weight of heaviest reel, including cable - Size of biggest reel, diameter/width	 mm kg mm/mm		
	Special Cables, Optical fibre			

	- Relevant informative data			

8.3.12 SCHEDULE VI 6a TECHNICAL GUARANTEES, EARTHING

Sheet 1 of 1

EARTHING SYSTEM				
	Particulars	Unit		Reference Doc
	Resistance to Earth of Earthing Electrode System (for each substation)			
	- Under the control building max.	ohms		
	- Under the switchyard max.	ohms		
	- Complete earthing system	ohms		

8.3.13 SCHEDULE VI 6b INFORMATIVE DATA, EARTHING

Sheet 1 of 1

EARTHING SYSTEM				
	Particulars	Unit		Reference Doc
	- Reference standard - Material of earth conductor - Max. temp of any earth conductor during 1 sec. rated phase - ground fault - Method of interconnecting earth grid conductors			

8.4 TECHNICAL SCHEDULES TRANSFORMERS

8.4.1 SCHEDULE VI 7a - TECHNICAL GUARANTEES, POWER TRANSFORMERS

Sheet 1 of 7

HV POWER TRANSFORMERS			Guaranteed Data		
	Description		**23MVA 66/33KV**		
	Continuous maximum rating on any tapping when operation under the ambient conditions specified in Section VI, Clause 4.1.3.2.1 Design criteria:				
	With ONAN cooling; HV winding				
	LV winding				
	TV winding		-		
	With ONAF cooling; HV winding				
	LV winding				
	TV winding		-		
	Rated frequency				
	Rated no-load voltage at rated frequency on:				

		HV, principal tapping HV, extreme plus tapping HV, extreme minus tapping LV, TV, Tapping ranges from principal tapping: HV, no of plus tappings HV, no of minus tappings HV, steps in % of rated voltage No-load losses at rated voltage and frequency No-load current at rated voltage and frequency		-		

HV POWER TRANSFORMERS			Guaranteed Data		
	Description		**23MVA 66/33KV**		
	Load losses at 75^{o}C at rated currents, the third winding being open:				
	HV - LV, ONAN		-		
	HV - TV, ONAN		-		
	LV - TV, ONAN		-		
	HV - LV, ONAF		-		
	HV - TV, ONAF		-		
	LV - TV, ONAF		-		
	Cooling plant power consumption				
	Total losses at 75^{o}C on principal tapping and unity power factor and rated currents:				
	ONAN				
	ONAF including input to cooling plant				
	Impedance voltages at 75^o referred to mutual capacities at rated frequency and 100% rating:				
	Principal tapping:				
	HV - LV, ONAN				

	HV - TV, ONAN		-		
	LV - TV, ONAN		-		
	HV - LV, ONAF		-		
	HV - TV, ONAF		-		
	LV - TV, ONAF		-		

HV POWER TRANSFORMERS			Guaranteed Data		
	Description		**23MVA 66/33KV**		
	Extreme plus tapping:				
	HV - LV, ONAN				
	HV - TV, ONAN		-		
	LV - TV, ONAN		-		
	HV - LV, ONAF				
	HV - TV, ONAF		-		
	LV - TV, ONAF		-		
	Extreme minus tapping:				
	HV - LV, ONAN				
	HV - TV, ONAN		-		
	LV - TV, ONAN		-		
	HV - LV, ONAF				
	HV - TV, ONAF		-		
	LV - TV, ONAF		-		
	Temperature rise after continuous operation with rated MVA, under the ambient conditions specified in Section VI, Clause 4.1.3.2.1 and the rated conditions giving the highest losses:				
	Top oil (by thermometer)				
	Windings (by resistance)				
	Efficiency on principal tapping max. temperature of winding and unity power factor and TV winding open:				
	- 120% load, ONAN				
	- 100% load, ONAN				

	- 50% load, ONAN - 120% load, ONAF - 100% load, ONAF - 50% load, ONAF					

SCHEDULE VI-7a - TECHNICAL GUARANTEES, POWER TRANSFORMERS

Sheet 4 of 7

HV POWER TRANSFORMERS			Guaranteed Data		
	Description		**23MVA 66/33KV**		
	Inherent voltage regulation on principal tapping, 75^oC and unity power factor:				
	-				
	- 80% of full load on LV winding and 20% on TV winding				
	Inherent voltage regulation on principal tapping, 75^oC and 0.8 power factor lagging:				
	- TV winding open				
	- 80% of full load on LV winding and 20% on TV winding				
	Vector group				
	No. of phases per transformer				
	Type of cooling				
	Whether star connected windings shall be fully insulated or graded				
	- HV winding				
	- LV winding				

		Insulation levels of star points - HV winding - LV winding Method of system earthing: - HV system - LV system				

SCHEDULE VI-7a - TECHNICAL GUARANTEES, POWER TRANSFORMERS
Sheet 5 of 7

HV POWER TRANSFORMERS				Guaranteed Data	
	Description		**23MVA 66/33KV**		
	Method of transformer earthing: - - - Whether TV windings are to be brought out to separate bushing insulators Indoor or outdoor installation System highest voltage according to IEC: - - - Maximum flux density at rated voltage on principal tapping and rated frequency: - -				

		Maximum flux density at most onerous voltage and frequency conditions: - - Specific core loss				

SCHEDULE VI-7a - TECHNICAL GUARANTEES, POWER TRANSFORMERS
Sheet 6 of 7

HV POWER TRANSFORMERS			**Guaranteed Data**		
	Description		**23MVA 66/33KV**		
	Maximum current density in windings at rated output:				
	HV, higher voltage, ONAN				
	HV, lower voltage, ONAF				
	LV, ONAN				
	LV, ONAF				
	TV, ONAN				
	TV, ONAF				

	Magnetising current at rated nominal voltage on principal tapping Maximum hot spot temperature of winding Equivalent resistance referred to HV side Equivalent reactance referred to HV side Maximum current carrying capacity of bushings: HV LV TV Rated service voltage of bushings: HV LV TV HV, neutral LV, neutral				

SCHEDULE VI-7a - TECHNICAL GUARANTEES, POWER TRANSFORMERS
Sheet 7 of 7

HV POWER TRANSFORMERS			**Guaranteed Data**		
Item	**Description**		**23MVA 66/33KV**		
35.	1 minute, 50 Hz dry withstand voltage: HV bushing LV bushing TV bushing HV, LV neutral bushings				
36.	1 minute, 50 Hz wet withstand voltage: HV bushing LV bushing TV bushing HV, LV neutral bushings				
37.	Impulse withstand voltage: HV bushing LV bushing				
38.	Maximum noise level				

	- Transformer and tap changing equipment energised and at no-load with ONAN cooling - Same as above but with ONAF cooling (fans running)				

8.4.2 SCHEDULE VI-7b - INFORMATIVE DATA, POWER TRANSFORMERS

HV POWER TRANSFORMERS					
Item	**Description**		**23MVA 66/33KV**		
1.	Type of transformer (core or shell type)				
2.	Number of core legs				
3.	Type of windings: HV LV TV				
4.	Type of insulation: HV, winding LV, winding TV, winding Tappings Tapping connection Core bolts (if any) Core bolt washers (if any) Core lamination designation Specific core loss				
5.	Type of axial coil supports: HV winding LV winding				

		TV winding				
	6.	Winding conductor material HV LV				
	7.	Type of joints in the magnetic core (butt type, interleaved etc.)				
	8.	Calculated thermal time constant: ONAN ONAF				

HV POWER TRANSFORMERS						
	Description		**23MVA 66/33KV**		
	Type of bushings: HV LV TV HV, LV neutral Principal bushing insulator materials: HV LV TV HV, LV neutral Total creepage distance over porcelain externally: HV bushing LV bushing Protected leakage distance over porcelain externally (90^{o} shadow) HV bushing LV bushing Thickness of transformer tank:				

		Sides Bottom Top Thickness of radiator plates Number of radiators per transformer				

HV POWER TRANSFORMERS					
	Description		**23MVA** **66/33KV**		
	On-load tap changer: Type (resistor type, reactor type, etc.) Total number of tappings including principal Rated currents of: - - - Maximum overcurrent of: - - - Driving motor input Type of driving motor (3-phase etc.) Monitoring contact: - Closing time in advance of parting of diverter switch - Opening time after diverter switch contacts have fully opened				

	Diverter switch opening time Time from "point of no return" to parting of diverter switch contacts Whether outdoor cabinets/kiosks are provided with heaters				

HV POWER TRANSFORMERS					
	Description		**23MVA 66/33KV**		
	Forced air cooling system:				
	State if fans are blowing directly on radiators				
	Total number of fan units per transformer				
	Cooling capacity of each complete cooling system				
	Total oil quantity in completely filled transformer				
	Total weight of oil in completely filled transformer				
	Total oil quantity in conservator				
	Total quantity of oil in conservator between highest and lowest level				
	Volume of conservator tank				
	Weight of copper in windings				
	Weight of core/winding assembly				

		Weight of each radiator: Filled with oil Empty Total weight of bushings: HV LV				

HV POWER TRANSFORMERS					
	Description		**23MVA 66/33KV**		
	Total weight of complete transformer erected at site				
	Weight of transformer as arranged for transport				
	Filling medium during transport				
	Overall dimensions of transformer completely erected at site, including bushings, radiators:				
	Length				
	Width				
	Height				
	Overall dimensions of transformer arranged for transport:				
	Length				
	Width				

		Height Maximum lift of core/winding assembly incl. lifting beam, slings, etc. for untanking Rated output per fan unit Speed of fan motors Continuous rating of fan motors Starting current of fan motors				

HV POWER TRANSFORMERS						
	Description		**23MVA 66/33KV**			
	Efficiency of fan motors					
	Power factor of fan motors at rated output					
	Material in rating and diagram plates					
	Are on-load tap changing equipment prepared for fully automatic operation					
	Are on-load tap changing equipment prepared for local, remote control (control room) and supervisory (NCC) operation and indication					
	Are on-load tap changing equipment prepared for fully automatic parallel operation with similar transformers					
	Whether first filling of oil is included					
	Whether tap changer cubicle and wiring cabinet are provided					

		Whether winding, and top oil indicators are provided Whether cooling fans are automatically operated from the winding temperature indicators Whether pressure relief device is to be fitted Whether Buchholz relay is fitted				

HV POWER TRANSFORMERS					
	Description				
	Whether all internal cabling/wiring on transformer is supplied to form a complete self contained unit				
	Are the following alarms/trip signals provided:				
	Tap changer not operating, alarm				
	Tap changers out of step, alarm				
	Voltage transformer failure				
	Fan failure, alarm				
	Oil/gas flow transformer, alarm				
	Oil/gas flow transformer, trip				
	On load tap changer protective relay operated, trip				
	Oil gauge low level, alarm				
	Oil gauge low level, trip				
	Tap changer oil gauge level low, alarm				
	Tap changer oil gauge level critical, trip				
	Top oil temp. high, alarm				
	Top oil temp. critical, trip				
	Winding temp. high, alarm				
	Winding temp. critical, trip				
	Are the following temperature indicators provided:				

	HV winding LV or common winding TV winding					

HV POWER TRANSFORMERS					
	Description				
	Are the following oil level gauges provided: - - Tap change indicator provided Tap change in progress indicator Tap changer out of step indicator Potentiometer switch for remote/supervisory on-load tap changer position indicator Will the tests specified in Section 3-II - Clause 10 be adhered to? If deviations, please state underneath				

HV POWER TRANSFORMERS					
	Description				
	State all Standards applied underneath: State identity of transformer manufacturer and all sub-manufacturers including the parts manufactured below: Transformer: Cooling equipment On-load tap changer Current transformers Bushings Core steel Oil Buchholz relay Breather Thermometer Other equipment to be listed by the Bidder: - - - - -				

8.5 **SCHEDULE VI 8a - TECHNICAL GUARANTEES, DISTRIBUTION TRANSFORMERS**

Sheet 1 of 2

DISTRIBUTION TRANSFORMER			Guaranteed Data	
	Particulars		**50KVA**	**33/0.433 kV**
	Continuous Maximum Rating C.M.R. Normal voltage between phases at no load a) H.V. b) L.V. Tappings a) Plus b) Minus Performance Data at Sea Level, corrected at 75% a) No load loss at normal primary voltage b) No load loss at 10% primary over voltage			

	c) Load loss at C.M.R. d) Impedance volts at C.M.R. and normal ratio e) Regulation at C.M.R. and unity power factor f) Regulation at C.M.R. and 0.8 power factor g) Max temperature rise at C.M.R.: i) Top oil by thermometer ii) Average winding by resistance iii) "Hot Spot" corresponding to (ii)			

DISTRIBUTION TRANSFORMER			**Guaranteed Data**	
	Particulars		**50KVA**	**33/0.433 kV**
	Type of insulation used on windings a) H.V. b) L.V. Lightning Impulse Insulation level of: a) b) c) Are test certificates supplied supporting the level stated in Clause 6 Silica gel Breather a)			

	b)				

8.6 **SCHEDULE VI-8b - INFORMATIVE DATA, DISTRIBUTION TRANSFORMER**

Sheet 1 of 2

DISTRIBUTION TRANSFORMER					
	Particulars		**50KVA**	**33/0.433 kV**
	Transformer type (sealed or breathing) Type of windings HV LV Type of insulation HV winding LV winding Type of tap changer Tap changer designation Type of axial coil supports HV winding LV winding Winding conductor material HV winding LV winding Core laminations designation Specific core loss			

	Type of bushings HV LV				

8.7 SCHEDULE VI-8b - INFORMATIVE DATA DISTRIBUTION TRANSFORMERS Sheet 2 of 2

DISTRIBUTION TRANSFORMER				
	Particulars		**50KVA**	**33/0.433 kV**
	Bushing insulator material HV LV Creepage distance across bushings HV LV Type of cooling system Total oil quantity Total weight Volume of conservator tank Overall dimensions Length			

	Width Height State all standards applied underneath: State identity of manufacturer underneath:				

8.8 SCHEDULE VI-9a- GAURANTEE DATA TELECOMMUNICATION SYSTEM

UHF Link Radios

Type: _______________-_______________

Item	Particulars	Unit	Employer's requirement	Tender Valu
1	Output Power	W	1 - 25	
2	Sensitivity (12dB SINAD)	µV	0.35	
3	Frequency Range	M Hz	403 - 420	
4	Frequency Stability	pp m	± 2	
5	Channel Spacing	kH z	12.5/20/2 5	
6	Channel capacity			
7	Signaling standards		CCIR, ZVEI and EEA	
8	Mode of Operation		Simplex/s emi-duplex/du plex	
9	Antenna connectors		N-female	
10	Antenna impedance	Ω	50	
11	Temperature range	^{O}C	-30 to + 60	
12	Voltage (nominal)	V DC	13.2	
13	Designed for continuous-duty cycle operation	Y/ N		
14	Power consumption @ full power	W		
15	Power consumption, standby mode	W		
16	Mounting		Rack or wall-mounting bracket	

8.9 SCHEDULE VI-9b- GAURANTEE DATA TELECOMMUNICATION SYSTEM

UHF Link Antenna

Type: -

Item	Particulars	Unit	Employer's requirement	Tender value
1	Antenna Type			
2	Frequency band (minimum)	MHz	400 - 420	
3	Impedance	Ω	50	
4	Polarization		Vertical or horizontal	
5	Gain	dBi	> 10	
6	Front to back ratio	db	> 20	
7	Half-power Beam Width, vertical	deg.	< 40	
8	Half-power Beam Width, Horizontal	deg.	< 50	
9	Bandwidth	MHz	> 10	
10	SWR		< 1.5:1	
11	Max. power	W	150	
12	Connection		N-female	
13	Mounting		On 30-58 mm tube	
14	Wind survival rating	m/s		
15	Wind surface	m^2		
16	Wind load @ 40 m/s	N		
17	Weight	kg		
18	Dimensions	mm		

	Feature	Minimum requirement	Tendered offer
	Maximum Operating Load	9000 N	
	Minimum Bending Radius Installation Long Term	20xO.D. 10xO.D.	
	Max. Compressive Loading	4000 N / 10 cm	
	Impact Resistance	4.4 J, 3 x 2 times	
	Twist (Torsion)	10 turns of 180° on 125xO.D.sample, both ways.	
	Storage Temperature Range	-50° C to +70° C	
	Operating Temperature Range	- 40° C to +70° C	
	Core Fluid Penetration	1 m sample, 1 m water head for 24 Hrs	
	Distance Between Poles	Up to 100M	
	Warranty	15 years	
	UV Resistance		
	Outer Cable Markings	Property of Kenya Power & Lightening Company	
	Packing	Rolls for various sections to be determined by distance between section poles but not less than 1000M	
	Length marking	Every meter	
	Color	Grey (to make it unique)	
	Performance	Allowed attenuation per Km for the 9/125 micron single mode fiber optic cable 1310 0.4 db 1550 0.3 db	
	Fusion splice loss	Maximum allowed loss 0.1db	

8.10 SCHEDULE VI-9c- Guaranteed Technical specifications for fig-8 Particular technical specifications Telecommunication) fibre optic cable

SCHEDULE VI-9d- **Guaranteed Technical specifications for ADSS specified in particular technical specification -Guaranteed General specifications for Approach cable**

item	Feature	Description	Tendered offer
1	Maximum Operating Load	9000 N	
2	Minimum Bending Radius Installation Long Term	20xO.D. 10xO.D.	
	Max. Compressive Loading	4000 N / 10 cm	
3	Impact Resistance	4.4 J, 3 x 2 times	
4	Twist (Torsion)	10 turns of 180° on 125xO.D.sample, both ways.	
5	Storage Temperature Range	- 50° C to +70° C	
6	Operating Temperature Range	- 40° C to +70° C	
7	Core Fluid Penetration	1 m sample, 1 m water head for 24 Hrs	
8	Warranty	15 years	
9	Manufacturer Factory Location		
10	UV Resistance		
11	Outer Cable Markings	Property of Kenya Power & Lightening Company	
12	packing	Rolls of 1000M per drum	
13	Length marking	Every meter	
14	Color	Grey (to make it unique)	
15	Performance	Loss per Km for single mode 9/125 1310 < 0.4db 1550 <0.3db	
16	Splice loss	< 0.1 db	

SCHEDULE VI-9e- **Guaranteed Technical specifications for ADSS specified in particular technical specification - Guaranteed General specifications for Optical Distribution frame (ODF)**

	Feature	Minimum requirement	Tendered offer
	Fiber optic ODF	Fiber optic patch panel 48 ports SM wall mounted with enclosure	
		splice tray cassette,	
		pigtails terminated on SC connectors	

SPECIFICATION FOR WATER TREATMENT PLANT/ REVERSE OSMOSIS PLANT

Reverse Osmosis plant to remove dissolved solids in water to provide reliability with the highest treated water quality.

Systems should be frame mounted with all components conveniently accessible and are designed to provide low energy consumption and long life. Shall have the following features:-

- High efficiency 8" RO membranes specified to suit the water quality housed in strong, corrosion proof GRP pressure vessels.
- High treatment performance with up to 98% salts rejection
- High pressure in line multi stage stainless steel feed pump
- System monitoring accessories including inlet and outlet flow meters, pressure gauges and conductivity meter
- Electronic controller for fully automated plant operation including startup, periodic flush cycle and shut down as well as providing various system alarms
- Sediment removal and Carbon cartridge pre-filters
- Skid mounted for simple installation
- Corrosion resistant stainless steel high pressure and plastic low pressure pipes and pipe fittings.

OPERATING PARAMETERS

Normal Rejection: 95%-98%
Water Temperature: 5-35°C,
Minimum Inlet Pressure: 3bar
Operating Pressure: Ranges between 4 bar and 20 bar
Recovery Range: 35% - 75%

EQUIPMENT SPECIFICATIONS

Description		
Flow (m^3/hr)	Permeate	8
	Feed	12
Membrane	Quantity	8
	Stages	1-1
High Pressure	kW	11

Pump (2000ppm TDS)		
High Pressure Pump (5000ppm TDS)	kW	15
Dimensions (mm)	L-Provide	
	W-Provide	
	H-Provide	

OPEN LOOP SOLAR WATER HEATER

Open Loop Flatplate solar hot water designed for long life operation in extreme conditions. Shoul have the following features and equipment specifications;

- Heavy duty tank which includes a steel powder coated outside casing, steel storage tank internally coated with glazed enamel and fitted with a magnesium sacrificial anode for exceptional corrosion protection, steel powder coated end caps and a 3kW heating element with thermostat.
- Flatplate solar collectors that incorporate full area selective copper plates laser welded to copper circulation tubes, high specification insulation and tempered security glass to provide energy absorption of up to 95%.
- Low thermal conductivity high specification flexible stainless steel circulation piping with PVC coated elastomeric rubber foam insulation jackets.
- Connection piping that includes an incoming non-return valve, pressure release valve rated at 6bar and drain cock.
- Galvanized mounting frame for either flat or inclined installation that insures high durability in all weather conditions.

Description	**Qty**	**Tenderers offer**
System Tank Size (Litres)	160	
Collector Area (m^2)	2.3	
Max Heat Output/Day (kWhrs	13	

Min Heat Output/Day (kWhrs	9	

NOTE

Average irradiation levels of 6000W/m^2/day prevailing in September- March and minimum. Heating output to be based on average irradiation levels of 4000W/m^2/day prevailing in June/July and are for purpose of design.

SPECIFICATIONS OF MATERIALS AND WORKMANSHIP FOR SOLAR POWERED STREETLIGHTS

Installation hardware

Mounting structures should be stainless steel or Aluminium, strong enough to withstand windstorms of 100km/hr and be painted to reduce corrosion where necessary.

Fasteners and other installation accessories (screws, bolts, etc) should be galvanized or stainless steel

PV Modules/ Arrays

- Modules or arrays have to be firmly fixed onto mounting structure to avoid rip off by strong winds.
- The module or array mounting structure should be corrosion resistance and the bolts and nuts used in mounting the module or array on to the structure should be stainless steel or galvanized.
- The siting of the module or array should be such that no object or objects will cast any shadows on it at any time of the day between 0900 and 1600 hours.
- The module or array siting should be such the cable run to the battery is kept to a minimum.
- Modules or arrays should be tilted at an angel of between 10 and 20 degrees from horizontal plane facing the Equator.

Electrical Installation

- The electrical installation should be carried out to comply with Kenya Wiring Regulations (KS 662) for Electrical Installation in Buildings.

User Training

A person shall be identified from the county who shall carry out routine maintenance of the systems. This person shall be provided with user training covering the following:

- System performance expectations and limitations
- Purpose of each component of the system
- How to operate and use the systems including safety

- How to deal with breakdowns
- Performance monitoring and data recording
- User manuals

GTPs FOR ALL IN ONE INTEGRATED SOLAR PV STREET LIGHTING

	SPECIFICATION FOR ALL IN ONE INTEGRATED STREET LIGHTS		**SPECIFICATION AS SUPPLIED**
1	Name of manufacturer, Brand Name,		
2	Module Type	Dual (Split Type) or Single Mono-crystalline PV	
3	Module Rating	130W + 130W for Dual 260Wp for Single	
4	Battery	LiFePO4/NiMH	
5	Battery Capacity	600Wh + 600Wh for Split	
6	Battery Management System Capabilities	Temperature, DoD/SoH, Charging Protocol	
7	Motion Sensor	Embedded	
8	Working Mode	20% brightness with no motion detected, 100% with motion detected Dusk to Dawn	
9	Light Photosensitivity (lx)	30	
10	Weight of assembly	<65kg	
11	Dimensions of product (mm) (max)	1500 x 1500 x 1600	
12	Charge Temperature	0ºC - 50ºC	
13	Discharge Temperature	0ºC - 50ºC	
14	Wind Load Rate (kph)	200	
	LED MODULE SPECIFICATIONS		
15	Light Output (W) (min)	100	
	Colour Temperature	5000	
17	Luminous Flux (lm)	20,000	
18	Weight of LED Module (max)	6kg	
19	Installation height	8m	
20	Light Distribution	Type 1/Type 2/Type 3	
	CHARGING CONTROLLER SPECIFICATIONS		
21	Protection	Over current	
		Over voltage	
		Over heating	
22	Communication	USB (at least Type B)	

	Protocol		
23	Protection Class (min)	IP65	

<u>GTPs FOR 10M CONCRETE POLE</u>

	SPECIFICATIONS	**BIDDER'S OFFER**
a) Pole Size (Metres)	10	
b) Spiral diameter wire(mm)	3	
c) Ring bar diameter(mm)	6	
d) H.S diameter (mm)	5	
e) No of H.S bar	14	
f) Spacing of ring bar (tip to bottom (mm)	500	
g) Butt diameter (mm)	330	
h) Average thickness of butt	55	

Specifications for laptop-Minimum

OPERATING SYSTEM	Genuine Preinstalled: Windows 11 Pro, Version 21H2
PROCESSOR	11th Gen Intel(R) Core(TM) i7-1165G7 @ 2.80GHz 2.80 GHz
INTERNAL STORAGE	1TB 5400 rpm Hard Drive
MEMORY	12 GB DDR3L - 1 DIMM
REMOVABLE STORAGE	External Optical Disk Drive
DISPLAY	13.3-inch diagonal Full HD WLED-backlit IPS Display (1920x1080)
GRAPHICS	Intel® HD Graphics 5500
AUDIO/VISUAL	DTS Sound+, stereo speakers, integrated dual array microphone with 720p HD9 Webcam
WIRELESS SUPPORT	Broadcom 802.11 a/b/g/n, Realtek 802.11 b/g/n, Bluetooth v.4.0 combo
COMMUNICATIONS	NIC 10/100/1000 Ethernet Controller
PORTS	2 USB 3.0 ports 1 USB 2.0 port (power port 1 VGA I HDMI 1.4a, I Stereo microphone input, I Headphone line out, 45 (Ethernet), 1 power connector
WEIGHT	3.31 lb (1.50 kg)
POWER	3-cell 48WHr Lithium-ion Battery, 45 W AC power adapter
WARRANTY	1 year
CARRY CASE	Carry Case