Kenya Power

NCB No. KP1/6A.1/OT/9/26/CO9

FOR PROCUREMENT OF DESIGN, SUPPLY, INSTALLATION AND COMMISSIONING OF PRIMARY AND DISTRIBUTION SUBSTATIONS WITH ASSOCIATED LINES AT RONGAI (NAKURU COUNTY), KATHWANA (THARAKA NITHI COUNTY) AND KISERIAN (KAJIADO COUNTY)

VOLUME 2

SECTION VI

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

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

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

1.3 Completeness of Works

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

1.3.2 All materials and skilled labour, whether of temporary or permanent nature, required by the Contractor for the design, manufacture, erection and testing at site of the equipment shall be supplied and paid for by the Contractor. All computer equipment shall be delivered with all software and 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.

1.3.3 Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any equipment shall imply equipment that is complete with all accessories, apparatus and fittings as outlined in **sub clause 1.3.1** and **1.3.2** above.

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

1.4 Space Requirement

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

1.5 Documentation and Drawings

1.5.1 General

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

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

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

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

All text on documents provided by the Contractor shall be in the English language in addition, if necessary, to that of the country of origin. All drawings shall be dimensioned in 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, 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 and external hard disk with a format readable in the latest AutoCAD version or another format to be agreed upon by the project manger in addition to the paper copies.

- All drawings shall be bound in hard covers.

1.5.2 Drawings

The Employer's drawings attached to the Bid Documents are of informative character. These drawings are intended to illustrate the basic requirements to be satisfied. It is the responsibility of the contractor to prepare a detailed layout showing the manner in which the various items of equipment can be accommodated to best advantage within the available area.

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

1.5.3 Progress Plans

The Progress Plans shall at least contain the following milestones:

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

1.5.4 Exchange of Interface Information

The Contractors shall in due time supply interface information to other sub-contractors where needed. The Contractor is in particular required to check that all foundations and fixations of his equipment is sufficiently dimensioned to meet the forces acting upon it. If the Contractor feels that he lacks such information from other contractors, he is obliged to request such from the Project Manager. The

Contractor cannot claim liability exemption for his own contractual responsibilities because of actions performed or omitted by other sub-contractors.

1.5.5 Final Documentation

The Contractor shall 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 done by such personnel.

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

The documents shall be submitted in both hard copies and soft copy in external hard disk and flash drives.

The Project Manager shall approve the documents before the final submission.

1.6 Contractor's Quality Assurance Procedures

The Contractor shall have established a quality assurance system based on ISO 9001 also covering sub-contractors. The Contractor shall provide a documentation of the system with a list of current procedures, an 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 guaranteed 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-contractors do not fulfil the requirements in the specifications and it is obvious that the required quality cannot be achieved by corrective measures, he can request the subcontract to be suspended and the works to be produced elsewhere without extra cost for the Employer.

1.8.2 Inspection and Testing

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

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

Type tests shall be made on one unit of each type of different equipment. Instead of carrying out the type tests the Contractor may submit suitable certificates of tests made on equipment of the same type; however, the Purchaser reserves the right of accepting these certificates or to reject them partially or totally.

On complex systems the Bidder shall propose factory acceptance tests (FAT) to be performed.

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

A test programme shall be submitted to the Project Manager for approval at least one month ahead of the commencement of testing. The program shall include tests to be performed at subcontractor’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 Resident 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 two weeks 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, Testing at Site, Commissioning

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

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

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

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

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

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

1.9.4 Accommodation of Contractor's Personnel

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

1.9.5 Health, environment and safety

The Contractor shall follow all local rules and regulations related to workers’ safety and health as well as regarding protection of the environment.

The Contractor is responsible for employing a health worker to inform the workforce and affected villages about the increased health risks, especially HIV/AIDS and COVID 19.

The Contractor is also responsible for equipping all his workers with necessary safety equipment as helmets, eye protection glasses and safety belts and enforce the use of such.

No toxic material (such as Halon, PCB, Asbestos) shall be utilised neither during construction nor under operation and maintenance.

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

1.10 Time of Delivery and Completion

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

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

1.11 On the Job Training

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

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

1.12 Tools

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

1.13 Spare Parts

Spare parts supplied under the contract shall be packed and preserved for long time storage. before handover to the Employer as per the specifications.

Transportation cost of the spare parts to any store of KPLC as directed by the Project Manager shall be borne by contractor at no additional cost to the Employee.

SECTION VI

2. GENERAL TECHNICAL SPECIFICATIONS

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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 as stated in the specifications. All electrical connections shall be secured by bolts or set screws of ample size, fitted with locknuts or lock washers of approved types.

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

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

2.5.2 Electrical Equipment Materials

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

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

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

Copper and aluminium used as electrical conductors shall be of the electrolytic type and comply with the respective ASTM or DIN Standards.

Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment that is in tension or subject to impact stresses. Exception is made where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

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

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

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

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

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

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

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

2.5.4 Electrical Equipment Panels and Support Structure Surface Treatment and Painting

2.5.4.1 Electrical Equipment Panels

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

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

Structural supports outdoor and in wet or moist rooms and parts that cannot be readily painted, shall be hot-dip zinc 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.

2.5.4.2 Substation Equipment Steel Support Structures

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

2.5.5 Insulating Oil

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

The Contractor shall 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 and Oil

2.6.2 Electrical Sockets

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

2.6.3 Degree of Protection

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

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

Low voltage switchgear and control cabinets:

- Indoor - IP 3x
- Outdoor - IP 54
- With open door - IP 20
- Junction boxes - IP 65

Light fittings

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

2.6.4 Indicators and Instruments

All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools.
In un-manned operation a switch shall be arranged for turning off the indication lights for the substation. A switch for lamp test shall be arranged.

All indicators mounted on control desks and panels shall be flush mounted.

The minimum accuracy tolerance for these indicators shall be 2.5% of span. Indicators shall generally be of the moving coil type but electronic type digital indicators are also acceptable. Where digital indicators are used these shall be provided with at least 4 digit indications.
Indicators mounted on local gauge boards shall be of circular type and shall have a minimum case diameter of 160 mm. All local indicators shall be housed in robust dust and moisture proof cases suitable for open air installation. The read-out window for indicators, recorders and similar equipment shall be non-reflecting, anti-static and minimize parallax errors
All control instruments shall be rectangular or square type, with the exposed metal portions of all cases having the same finish, trim and general appearance. Instrument and meter scales shall be white with black markings. Instrument cases shall be dust- proof.
Each instrument shall have a zero-adjustment device so that the zero position of the pointer can be adjusted without removing the cover. For frequency measurement purposes it is not permissible to use reed type frequency meters except for the synchronizing equipment.

2.6.4.1 Electronic equipment

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

2.6.4.2 Measurement of electrical parameters

Remote indicators for electrical quantities such as power, voltage, current frequency, etc. will be of the milliamp type. The overall dimension of the ammeter, Voltmeter, shall be 96x96mm. All power and energy measurement devices shall be digital type. All indication contacts shall be galvanic isolated and potential free.

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, and shall be used for issuing of commands (Trip and Open). No additional push button for close and open shall be installed.

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2.6.5 Fuses and Miniature Circuit Breakers

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

Where nothing else is specified, LV power fuses above 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.

2.6.6 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.

2.6.7 Motors

2.6.7.1 General

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

DESCRIPTION	**RATING**
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.

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

2.6.7.2 Special Motors

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

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

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

2.6.8 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.

2.6.9 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 inputs 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. Panels for power circuits shall be in accordance IEC 60439 (minimum partly type tested apparatus (PTTA)). All enclosures shall be ventilated so that the temperature inside the enclosure do not raise more than 5 °C above ambient even with possible heaters connected.

Outdoor-cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit collection of moisture. The heater must be

arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.

All major or important compartments containing electrical equipment shall be provided with a single phase 16A square pin socket and internal lighting facilities switched off by a door switch.

Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting.

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

2.7.2 Wiring and Terminal Blocks within Enclosures

All wiring shall be stranded flexible copper conductor, PVC with steel wire armour. Insulated, suitable for operation at voltages below 1000 V and in compliance with the provisions of the applicable IEC Recommendations. Conductors shall not be smaller than 2.5 mm^2 for measurement circuits and all other control circuits. The selection of conductor sizes 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.

All cables shall be steel wire armoured with stranded flexible conductors.

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

Minimum cross sections shall be as follows:

- Measuring cables for current 2.5 mm^2
- Control and other measuring cables 2.5 mm^2
- DC Supply cables 2.5 mm^2
- Telecommunication 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 where 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 relevant Particular Technical Specification **4.1.2.6** Substation Earthing.

SECTION VI

3. PROJECT SPECIFIC DATA

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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”.

3.2 Design Data, High and Medium Voltage

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

Item	Parameters	System Voltage			
		132kV	**66 kV**	**33kV**	**11 kV**
1	System	50 Hz, 3 phase			
2	Neutral point earthing	Solid earthed			
3	Nominal voltage of networks	132 kV	66 kV	33 kV	11 kV
4	Highest system voltage as defined by IEC-60038	145 kV	72.5 kV	36kV	12 kV
5	Short circuit and earth fault current, symmetrical r.m.s. value (min breaking current) not less than 3 seconds	40 kA	31.5 kA	25kA	25 kA
6	Thermal Short-circuit current withstand, not less than 3 seconds	40 kA	31.5 kA	25kA	25kA
7	Dynamic peak current (min making current) not less than	80 kA	80 kA	63kA	63 kA
8	Rated current of busbars and bus coupler if not given in Scope of Works, for each individual substation	2000 A	1250 A	1250A	1250 A
9	Minimum rated current of isolating switches and circuit breakers if not given in Scope of Works	2,000 A	800 A	800A	630 A
10	Insulation level coordination 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 $_{peak}$)	650 kV	325 kV	170kV	95 kV
10c	Power frequency withstand voltage 1 min dry and wet. To earth and between phases (kV $_{RMS}$)	275 kV	140 kV	70kV	28 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]	1 270	700	500	500
11b	Phase to phase [mm]	1 475	790	450	450
11c	Bus bars phase to phase [mm]	3 500	3000	2800	1250
11d	Height to live parts above ground [mm]	5 000	3500	2900	2900
11e	Height to live parts above ground at transformer transport routes [mm]	5000			
11f	Lowest part of insulators above ground [mm]	5000	2 500		

Item	Parameters	System Voltage			
		132kV	66 kV	33kV	11 kV
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	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, permissible short circuit duration shall be at least 3 secs. 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 computed by multiplying the r.m.s. value of the symmetrical short circuit current by the factor 1.8 x √2.

Note 3 - Ref IEC 60071)
All High and Medium Voltage equipment shall be designed for installation at 2200m above sea level. IEC 60071 shall apply with the specified correction factor for the altitude above sea level.

3.2.1 Design Data, Low Voltage Equipment

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

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

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.

3.2.2 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 and Blue (RYB).

3.2.3 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, Yellow, Blue & Black
Current transformers	Red, Yellow, Blue & Black
A.C. Circuit	Brown & Blue
D.C. Circuit	Red & Black
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.

3.2.4 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.

3.2.5 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)

3.3 Auxiliary Power

3.3.1 Electric Service During Construction

The contractor shall ensure the availability of metered electric supply at 415/240V, 3-phase, 50 Hz TN-S at the substation sites. All tools and equipment supplied by the Contractor shall be suitable for this supply system.

3.3.2 Power Supply

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

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

3.3.3 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.

3.3.4 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 125/52 VDC.

3.3.5 220 V AC Un-interrupted supply (UPS)

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

3.4 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, signaling and indication shall be included in the Bid and hence the Contract, it being understood so that the enumeration found in Scope of Works, in this respect is indicative but not limiting.

3.5 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 equipment covered by any other lot even if this lot is contracted by separate contractor. The Contractor shall pay special attention to the Power Transformers. All necessary equipment and connections required to form a complete working plant and not mentioned under the Power transformer shall be included in the switchgear contract whether or not specifically mentioned in these Particular Technical Specifications.

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

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

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

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

SECTION VI

4.1.1 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SWITCHGEARS AND AUXILIARY SUPPLIES

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4.1.1 PARTICULAR TECHNICAL SPECIFICATIONS - SWITCHGEAR AND AUXILIARY SUPPLIES.

4.1.1.1 General

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

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

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

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

4.1.1.1.1 General Design Data

Provided no special data are given below, the equipment shall be designed in accordance with the requirements given in “Project Specific Data”
The tentative single-line diagrams, layout plans and sections for the various projects are shown on the drawings enclosed to the Tender Documents. The drawings will be submitted with the bidding documents.

4.1.1.2 Switchgear

4.1.1.2.1 Breakers and Switches

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

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

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

A sufficient number of auxiliary contacts, with at least 10NO and 10NC contacts as spare, for 110 VDC shall be provided for control and interlock purposes.

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

4.1.1.2.2 Circuit Breakers

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

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

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

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

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

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

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

4.1.1.3 Measuring Transformers

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

However, the transformer shall not be loaded less than 60% of rated burden.

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

4.1.1.3.1 Current transformers

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

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

The core(s) for measuring:

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

The core(s) for energy metering:

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

The core(s) for protection:

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

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

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

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

4.1.1.3.2Voltage Transformers

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

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

The core(s) for energy metering:

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

The core(s) for protection:

- Accuracy — class 3P

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

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

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

4.1.1.4 SF6 gas

4.1.1.4.1Low Density Warning

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

4.1.1.4.2Gas Refilling

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

4.1.1.5 High and Medium Voltage Outdoor Switchgear

4.1.1.5.1General

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

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

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

All breakers and switches shall come ready for distribution automation.

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

4.1.1.5.2 Circuit Breakers

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

For 132 kV Voltages and above three-phase rapid auto-reclosing only is required. The circuit breaker mechanism shall be common for all poles (ganged type) in Transformer and Busbar bays, and single pole mechanism for Line bays.

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

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

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

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

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

4.1.1.5.3 Disconnectors / Isolators and Earthing Switches

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

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

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

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

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

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

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

4.1.1.5.4 Measuring Transformers

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

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

4.1.1.6 Lightning Arresters

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

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

	132kV	**66kV**	**33kV**	**11kV**
(1) Continuous operating voltage (rms) (kV)	106	59	28	9
(2) Rated discharge current (8/20ms)(kA)	10	10	10	10
(3) Rated Voltage (kV)	108	54	27	9
(4) Creepage distance (mm)	4092	1800	900	500

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

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

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

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

4.1.1.7 Line Traps (where applicable)

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

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

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

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

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

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

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

4.1.1.7.1 Coupling Capacitors

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

4.1.1.7.2 Line Matching Units

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

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

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

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

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

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

Technical requirements:

Bypass filter:

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

Drain Coil:

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

Earthing Switch:

- Rated current 300 A rms

Lightning Arrester:

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

4.1.1.8 Conductors, Insulators, Accessories

4.1.1.8.1 Conductors

Unless otherwise stated in Scope of Works, the conductors shall be concentrically laid, stranded, flexible conductors made of round aluminium, aluminium alloy or copper wires. The alloy shall be aluminium alloy 6201-T81 in accordance with ASTM Standard B 398-67 (equivalent IEC standard) or aluminium alloys of similar approved composition, as known under the trade name "ALDREY".

The same type of conductor may be used for the overhead earth wires, the cross-sections being at least the equivalent of 95mm^2 copper. Other earth wires shall always be of copper.

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

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

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

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

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

4.1.1.8.2 Tubular Conductors

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

4.1.1.8.3 Insulators

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

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

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

Minimum factors of safety shall be:

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

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

4.1.1.8.4 Accessories

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

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

4.1.1.9 Cable Ducts

All necessary cable ducts from the switchyard to the control building to be included in the tender. The cable ducts are specified in **Section VI : 4.1.4 _ Civil Works**.

4.1.1.10 Cable Marshalling Kiosks

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

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

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

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

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

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

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

Miniature circuit breakers, with alarm contact, shall be provided for the voltage transformer secondary circuits.
All terminals, socket outlets and other parts of the kiosks shall be easily accessible without dismantling any part.

4.1.1.11 Tests

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

4.1.1.11.1 Conductors, Insulators, Accessories

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

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

4.1.1.11.2 Tests on the Switchyard on Site

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

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

4.1.1.12 Autoreclosers

4.1.1.12.1 General

Provided below are general requirements for 33kV & 11kV Auto reclosers and **where these requirements differ with those provided in the attachment for KPLC Specification for Auto reclosers, the data in the attachment *KPLC specifications for Auto reclosers* shall prevail.**

Auto-reclosers are used on remote/semi urban 33/11 kV substations instead of circuit breakers and control systems. The autorecloser shall be designed for pole mounting with the following features:
(i) Ability to distinguish between permanent and transient/temporary faults

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

4.1.1.12.2 Modes of operation

Autoreclosers shall be equipped to provide three phase 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)

4.1.1.12.3 Operating Mechanism

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

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

4.1.1.12.4 Power Supply

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

4.1.1.12.5 Control Cabinet

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

4.1.1.12.6 Control Requirements

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

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

- Local/remote control selection
- Closing/tripping
- Autoreclose in/out (one trip to lockout)
- Protection engaged/disengaged
- Earth fault in/out

- Sensitive earth fault in/out
- Relay status.
- Energy profiles;
- Demand registers

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

4.1.1.12.7 Protection Requirements

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

Dead times and reclaim time shall be selectable in steps.

The protection system shall have facilities for:

- Phase faults
- Earth faults
- Sensitive earth fault.

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

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

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

4.1.1.12.8 Insulating and Interrupting Medium

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

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

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

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

4.1.1.12.9 Ratings

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

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

4.1.1.12.10 Bushing Current Transformers

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

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

4.1.1.13 Alternative Indoor 66 kV Switchgear

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

4.1.1.14 Medium Voltage Indoor Switchgear

4.1.1.14.1 General

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

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

Tests shall be made in accordance with IEC60298. Arc tests, as specified in IEC 60298 Annex AA are required. The arch type test shall be performed by an internationally recognised test institution for the full short circuit current in at least 1 sec.

4.1.1.14.2 Switchboard Panels

The boards shall be complete with bus bars, Withdrawable circuit breakers, cable connection points, earthing switches, measuring transformers, cable relays, instruments and other ancillary equipment, fully wired, but dismantled to individual panels/sections for delivery purposes.

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

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

The rated short circuit current withstand for 11KV indoor switchgear shall be 31.5KA/3sec, whereas for 33KV shall be 40KA/3sec.

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

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

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

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

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

4.1.1.14.3 Circuit Breakers and Disconnectors

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

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

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

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

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

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

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

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

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

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

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

be blocked against operation. SF6 gas refilling equipment mounted on a trolley shall be provided.

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

A sufficient number of auxiliary contacts for 110VDC shall be provided for control and interlock purposes.
Motors shall be designed in accordance with valid IEC publication and shall be effectively protected by miniature circuit breakers, with alarm contacts.

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

4.1.1.14.4 Circuit Isolation and Interlocks

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

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

4.1.1.14.5 Switch-Disconnectors and Fuses

Cabinets for station transformers for local LV supply to be equipped with switch-disconnectors, fuse holders and earthing switches. Such breakers do not need to be erected on trolley but the arch test requirements prevail and the cubicle must be extensible with standard cubicles on both sides.

The disconnector must be so arranged that it is possible to insert an isolating plate between the live and dead contacts when working in the cubicle. Such plate should be part of the supply.

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

4.1.1.14.6 Shutter Mechanism

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

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

4.1.1.14.7 Earthing

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

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

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

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

4.1.1.14.8 Cable Connection

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

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

4.1.1.14.9 Measuring Transformers

4.1.1.14.9.1 *Current Transformers*

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

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

For measuring and instruments, not less than 15 VA, Class 0.2
33kV: Ratio 150-300-600/1-1-1Amp
11 kV: Ratio 200-400-600/1-1-1Amp

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

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

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

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

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

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

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

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

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

4.1.1.14.9.2 *Voltage Transformers*

Three phase voltage transformers shall have the following characteristics

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

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

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

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

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

The transformer shall be resin encapsulated of the electromagnetic type.

4.1.1.15 Protection and Control

4.1.1.15.1 General

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

4.1.1.15.2 Arc Detection

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

The system shall ensure arc flash protection in all compartments of the switch gear board (Control compartment, MV Cable connection, Circuit Breaker and Busbar

compartments). The arc detection system shall automatically carry out regular self-checking of the sensor's integrity and continuity and generate an alarm if a problem is detected.

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

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

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

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

4.1.1.15.3 Optional Equipment and Accessories

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

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

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

4.1.1.16 MV Cables and Accessories

4.1.1.16.1 General

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

All cables shall be suitable for operation:

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

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

4.1.1.16.2 Conductors

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

4.1.1.16.3 Cable

The conductor shall be covered with:

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

4.1.1.16.4 Cable Laying and Routing

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

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

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

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

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

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

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

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

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

- Measuring cables for current 2.5 mm^2

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

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

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

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

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

4.1.1.16.5 Laying-up and Fillers of Three Phase Cables

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

4.1.1.16.6 Manufacturer's Identification

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

4.1.1.16.7 Armour

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

4.1.1.16.8 Testing

Notwithstanding that cables are manufactured to approved standards, all cables, accessories and materials shall be subjected to and withstand satisfactorily the test requirements detailed in this specification. All materials shall withstand such routine tests as are customary in the manufacture of the cables and accessories included in the Contract.

The manufacturer shall have established a quality control system based on regularly accelerated test of production samples according to CENELEC HD605. This system shall be described in the Bid.

4.1.1.16.9 Sealing and drumming

The cable shall be wound on strong drums arranged to take a round spindle of a section adequate to support the loaded cable drum during installation and handling.

The drums shall be lagged with closely fitting battens that shall be securely fixed to prevent damage to the cable. Wooden drums shall be constructed of seasoned timber to prevent shrinkage of drums during shipment and subsequent storage at site. Each drum shall be clearly marked including indication of direction of rolling.

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

4.1.1.16.10 Current carrying Capacity and design Parameters

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

4.1.1.16.11 Terminations

Detailed drawings showing the types of cable sealing ends, terminal arrangements shall be submitted to the Project Manager for approval. Stress cones or other approved means shall be provided for grading the voltage stress on the core insulation of the cables.
The terminations and joints for the cables shall be of an appropriate heat shrink or cold type jointing kits incorporating a suitable arrangement for stress control, and rain sheds for outdoor use.

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

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland.

4.1.1.16.12 Joint and termination material

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

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

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

4.1.1.17 Auxiliary Supply and Substation Lighting

4.1.1.17.1 General

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

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

From the main low voltage switchboard, (AC and DC) feeders shall supply the sub-distribution boards of the plant.
Domestic installations are part of the Civil Works.

4.1.1.17.2 Auxiliary Supply Distribution Boards

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

The distribution boards shall be vermin proof. The boards and panels shall be self-ventilated. No ventilating fans shall be used.
Permissible temperature rise shall not be exceeded even when the free space available for future feeders is mounted with feeder equipment and loaded with rated current.

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

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

All boards and panels shall be designed for easy access to the equipment, cable terminals, etc. during erection, maintenance, disassembly and extensions.
In addition to the required number of outgoing circuits, one more of each rating employed shall be fully equipped ready for connection of future circuits. Furthermore, each board and panel shall have at least 20% free space available for future extensions.

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

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

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

4.1.1.17.2.1 Circuit Breakers and Fuses

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

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

In the design of the distribution systems and in the selection of circuit breakers, MCB's, fuses and protection relays due attention shall be paid to the selectivity of

breaker tripping at overloads and at short circuits. Full selectivity shall be achieved, only the feeder or circuit which has an overload or short circuit shall trip.

Un-delayed MCB's shall be used only as the last breaker of a circuit. Selectivity between MCB's and fuses shall be proved, with ample margin.
The circuit breakers shall be manually operated, except for the breakers in the feeders from the auxiliary transformer which shall be electrically operated.

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

The breakers for DC shall be two-pole, and with thermal overload and magnetic short-circuit protection in both poles. All such circuit breakers, miniature circuit breakers, switches, contactors, fuses, etc., shall be of a type specifically designated for the use on DC, and the dynamic current and the making and breaking capacities shall be ample for the short-circuit power of the batteries.

All DC circuit breakers, miniature circuit breakers, switches and contactors shall have an alarm contact or an under voltage relay with alarm contact shall be provided.
Circuit breakers on the main DC switchboards which are rated 50A and higher shall be withdrawable

4.1.1.17.2.2 Current Transformers

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

Power frequency test voltages, 1 minute:

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

4.1.1.17.2.3 Instruments and Relays

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

Instruments shall be of the three-element type, for unbalanced three-phase load and loaded neutral conductor.
The relays shall preferably be of the solid-state type. The instruments and relays shall, as far as applicable, be of the same make and type as those of the other parts of the plant.

4.1.1.17.2.4 Tests

Tests shall be made in accordance with the applicable standards.

4.1.1.17.3 Auxiliary Transformers

Two (2) 100kVA Auxillary transformers shall be installed in substations with ratings of upto 66kV. Substations rated at 132kV rating and above shall have two (2) auxillary transformers minimum rating of 200kVA. These Auxillary transformers shall be part of the scope of supply.

4.1.1.17.4 AC Distribution Boards

The AC distribution board main and alternative circuit breakers shall have current carrying capacity not less than 250A for upto 66kV rated substations and not less than 400A for 132kV and above rated substations. The two sources shall be switched by a changeover system that will select between the sources and shall be arranged within the main board. This changeover system shall incorporate a manual by-pass switch.

For 7.5MVA Substations and above the changeover system shall be Automatic with 240VAC controls circuits with auto and manual operation selection. Automatic switchover between the sources shall be arranged within the main board.

The main board shall be equipped with instruments for measuring of current and voltage in all phases as well as energy meters for recording of energy consumption. Continuous current rating of the phases and neutral of the busbars in the main switchboard shall not be less than 250A for upto 66kV rated substations and not less than 400A for 132kV and above rated substations The current rating of the feeders shall be ample for the actual load and have at least 50% reserve capacity compared to the actual load.

The figures given in these specifications are indicative only. Only a limited number of different makes, types and ratings shall be used, for the purpose of standardisation and interchangeability.

4.1.1.17.5 Switchyard Lighting

The switchyard lighting shall be by means of floodlights with 400W for bay lighting and 70W for perimeter lighting. The lighting shall be constructed with LED lamps. The housing shall be of high-pressure die-cast aluminium with a non-corrosive finish. Refracting front covers of etched vandal-resistant polycarbonate shall be provided. The enclosure protection shall be min. IP65.
The switch bay and transformer illumination level shall be 50 lux on 0.85m height in the switchyard and for the transformers. The perimeter illumination level shall be 5 lux.
The switchyard lighting shall be controlled by photocells and timer switch. All necessary supports, fixing material and cabling from the distribution board shall be included.

In addition, there shall be five standalone 200W solar lights installed appropriately in the switchyard, subject to the Project Manager's approval.

4.1.1.17.6 DC Emergency Lighting

Emergency lighting is provided for 23MVA and above substation in the control room building as specified under **Section IV: 4.1.4 _ Civil Works.**

4.1.1.17.7 Hand Lamps and Portable Hand Sets

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

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

4.1.1.17.8 Clock

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

4.1.1.18 DC SUPPLY

4.1.1.18.1 General

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

4.1.1.18.2 Distribution Boards

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

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

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

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

All protection and control circuits shall be connected to the DC system. All boards and panels shall be supplied with the necessary internal wiring. Battery connections and cabling in the battery rooms shall also be included.

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

All instruments and protection relays on the rectifiers and on the boards and panels shall be included.
Starters, contactors and protection for motors shall be included whenever such equipment is not provided as part of the motor supply.

4.1.1.18.3 DC Battery Charger and Batteries (Lithium Ion Phosphate)

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

The 110 V batteries shall be loaded with the switchyard load.
The DC System shall have Lithium Ion Phosphate Battery Units, Direct Current (DC) Battery Chargers and accessories to be used in primary substations for DC supply.

The complete battery system shall consist of the following items:

a) Lithium ion phosphate battery units,
b) Battery cabinet
c) Inter cell connectors
d) DC battery chargers
c) Battery management system. BMS
f) Monitoring and communication systems.
g) All accessories and communication devices

Below is the description of Lithium Ion Phosphate DC Cells and Battery Chargers

Cell Tvpe	Description of Cell (Ah)	Description of Charqer
A	20	30V for 20Ah batteries
B	50	30V for 50Ah batteries
C	100	48V for 100Ah batteries
D	165	48V for 165Ah batteries
E	265	110V for 265Ah batteries
F	315	110V for 315Ah batteries
G	800	110V for 800Ah batteries
H	1200	110V for 1200Ah batteries
I	1500	110V for 1500Ah batteries

The size of the required battery cells and battery chargers shall be specified in the Scope of Works section.

4.1.1.18.3.1 Lithium Ion Phosphate Battery Units

The cell shall be rechargeable storage secondary cells of Lithium Ion Phosphate used to form the positive electrode and graphite (synthetic or natural) used for anode, electrolyte made of lithium salt, solvent and additives used to improve stability. Nominal cells voltage shall be as per manufacturers design. These materials are assembled in a multi-layered structure stacked for prismatic cells.

The Lithium Ion Phosphate prismatic secondary single cells shall be of medium rate discharge (M) as per IEC 62620 and enclosed in a rigid aluminium shell to provide structural integrity and protect against damage.

The cells shall hermetically sealed maintenance free units with a design and construction suitable to withstand the harsh service conditions more so, dust and be able to withstand vibrations and shocks in service.

The cell designation covered shall have a nominal voltage per cell as per the manufacturers design; at ampere hour capacity of the 5h (C_5) discharge; to an end voltage at 25 +/-5^{O}C as per IEC 62620 requirements.

The battery shall be designed for standby applications with controlled float/charge voltage via BMS, while being capable of >5000 or fuller discharges with less than 10% loss of capacity.

The battery cell design shall have negligible internal resistance, welded construction, and be at least 97% efficient on recharge. It shall be of high quality cells with maximum capacity and consistent performance.

The cells shall be composed of positive (+), negative (-) electrodes (clearly and permanently marked), separators, cell containers, special vents and electrolyte. The cell shall have non-flammable housing and mechanical shock resistant lid/cover assembly.

The battery cell design, shape and dimensions shall be prismatic (rectangular shape) and shall permit accommodation of all the battery units in the battery cabinet. It shall also conform to relevant IEC standards. The battery cell container shall be of high strength corrosion resistant stainless steel or aluminium alloy to protect internal components. The container shall be engineered to be lightweight yet robust.

The sealing lid (cap) shall be laser welded to the container, creating hermetically sealed, leak resistant enclosure that prevents electrolyte leakage and protects internal components from external moisture and damage. Pressure relief vents shall be embedded in the casing typically between terminals to release pressure if the battery overheats, venting gases hence preventing explosion.

The design characteristics shall be as per table below based on IEC 62619 and other relevant standards.

No	Performance Characteristics	Ratings
1	Design Life	15years
2	Rated Capacity (5 hour rate)	Manufacturer to state
3	Nominal capacity normal charging current — max. $0.2C_5$ A	Manufacturer to state
4	Recommended charging voltage (voltage per cell)	Manufacturer to state
5	Internal Resistance at $25^{O}C$ (md)	Manufacturer to state
6	Ageing coefficient	Manufacturer to state
7	Charge efficiency, min	>97%
8	Operating Temperature Range:	
	Discharge	-20 ~ $60^{O}C$
	Charge	-10 ~ $60^{O}C$
	Storage	-30 ~ $75^{O}C$

The casing of a cell, module, battery pack and battery system shall incorporate a pressure relieve function that will preclude rupture or explosion.

The separator shall consist of layers of polypropylene fibrous membrane acting as separating grid in between two layers acting as current collectors shall also be dimensionally stable and shall not deform or deteriorate at the temperature of use.

The separator shall eliminate the possibility of short circuits due to trapped active material between the layers. They shall provide an optimum balance between performance, reliability and long life. Each cell shall be provided with a suitable guard, adequately secured to prevent damage to separators while inserting thermometers or service apparatus in a cell.

For cells supported by encapsulation within an outer case, the type and method of encapsulation shall neither cause the battery system to overheat during normal operation nor inhibit pressure relief.

Technical specifications for the various types of cells

Cell Type	A	B	C	D	E	F	G	H	I
Rated Capacity C_5 (Ah)	20	50	100	165	265	315	800	1200	1500
Rated end point voltage t discharge (25°C)	25	25	37.5	90	37.5	90	90	90	90

The electrolyte shall conform to IEC 62619, IEC 62620 and other relevant IEC standards. The composition shall be stated by the manufacturer.

4.1.1.18.3.2 Battery Cabinet and Accessories

The cell shall be mounted in a battery cabinet whose design and construction shall ensure safe and reliable operation. The cabinet shall be designed, constructed and certified to the seismic design Category D, with Occupancy Category IV, having a short-period response acceleration given by 0.50g < SDS and a Component Importance Factor, Ip of 1.5 as per 1BC2006, appropriate for use in generator stations.
It shall be constructed of phosphatized steel with coat of powder epoxy acid-resistant end frames and beams with powder-coated polyethylene.
It shall be supplied fully wired and assembled with all the necessary accessories.

4.1.1.18.3.3 Inter Cell Connectors

Nickel-plated copper inter cell connectors and/or suitable insulated copper cables shall be used for connecting adjacent cells and rows. Bolts, nuts and washers shall be nickel-plated steel/stainless steel. All terminals and cell inter-connectors shall be fully insulated or have insulation shrouds.

The connector covers shall be made of hard PVC plastic, insulating the positive and negative terminals against the short circuit from any metallic object falling on the battery. Similarly, cables shall be adequately insulated.

All inter cell connectors/cables and inter-row connector lead cables shall be sized for the maximum current draw of the charger. All connectors and leads shall be suitable for carrying 30-minute discharge current continuously and rated for short circuit duty of 4kA for l second.

4.1.1.18.4 DC Battery Charger

The battery charger shall be supplied completely wired and fully assembled with all interconnections cable sockets, earth bar and earth terminal in a well-ventilated vermin proof cubicle, fabricated from steel sheets. The cubicles shall be painted to give a dark admiralty grey colour, shade no. 632 of BS 381C. The coating thickness shall not be less than 80µm.

The cubicle for chargers above 30V shall be for floor mounting and supplied with holding down bolts. The chargers for 30V shall be for wall mounting with supplied brackets and bolts.

The charging equipment shall operate from an AC mains supply of 415 V AC three-phase or 240 V AC single-phase with voltage variations of 10% and frequency variations of +/-10%. The DC output voltage regulation under extreme conditions of AC input and between 0-100% of battery loading shall be within +/-1% at float voltage.

The charger shall be capable of automatically trickle charging the battery and loads and boost charge the battery employing the constant current charging method.

In case of automatic boost charging, the charger shall have a temperature cut off input from batteries that shall stop the boost charging in case the temperature exceeds the cells maximum rating.

The charger shall employ temperature cut off, settable timer and drop of voltage (-6V) as means of detecting fully charged batteries and hence reducing the charging current. The charger shall be protected against reverse polarity and overloads by appropriate means.

The power transformer shall be of double wound, air cooled type with primary and secondary winds and an earth shield between the windings or a suitable equivalent.

The charger shall have a local alarm annunciator with an LED or LCD display of alarms. The alarms shall be reset manually.

The following alarms shall be provided for local and SCADA:

a) Charger failure
b) Positive and negative earth fault alarm (Not applicable for 48V)
c) Battery low voltage
d) Battery high voltage
e) Mains failure
f) Boost charge failure
g) Battery temperature cut off alarm

The following indicating instruments shall be provided:

a) Ammeter to indicate the net charge output
b) Voltmeter to indicate battery voltage
c) Center zero ammeter connected on the positive lead to indicate the rate of charge or discharge
d) Voltmeter to indicate the mains voltage
c) Ammeter to indicate mains current

The following isolation switches and MCBs shall be provided:

a) A switch to disconnect charger from the A.C supply
b) A switch to disconnect charger from battery
c) A switch to disconnect battery from outgoing loads
d) MCBs to protect battery front short circuit
e) DC MCBs to protect the battery from a fault on the charger and outgoing loads
f) MCBs to protect charger from short circuit

Technical Specifications for the Battery Charger

Charger Type		A	B	C	D	E	F	G	H	I
Charger for batteries (Ah)		20	50	100	165	265	315	800	1200	1500
DC output voltage(V)	Nominal	30	30	48	48	110	110	110	110	110
	Float range	34 - 36	34 - 36	52- 56	52- 56	120-129	120-129	120-129	120-129	120-129
	Boost range	<42	<42	<64	<64	<147	<147	<147	<147	<147
Rated DC output Current (A)		*To be stated based on battery charge characteristic*								
Trickle current range (A)		*To be stated based on battery charge characteristic*								
Boost Current range(A)		*To be stated based on battery charge characteristic*								
Mains type (no of Phases)		1	1	1	3	3	3	3	3	3
Mains A.C voltage(V)		242	242	242	420	420	420	420	420	420
Frequency		50	50	50	50	50	50	50	50	50

4.1.1.18.5 Battery Management System (BMS)

A Battery Management System (BMS) shall be provided to monitor and protect the bank from failure. The BMS shall be responsible for the safe operation of the battery bank assembly through the following functions:

(i) Monitor voltage, current, temperature and state of charge
(ii) Prevent cell under voltage by timely disconnection of the load.
(iii)Prevent cell overvoltage by reducing charge current or stopping charge process.
(iv) Shutdown the system/battery cut-off in case of over temperature.
(v) Break connection to charger and load in case of short circuit (internal or external).
(vi) Ensure active or passive cell balancing.
(vii) Battery internal resistance monitoring.
(viii) LCD to view the voltage of each battery cell, state of charge, temperature, alarms and other data.
(ix) GPS function to achieve battery positioning and tracking.
(x) Communication interface to substation automation.
(xi) Built in high capacity memory chip to store key operating data and SD Card to store battery history data. At least 10,000 run logs can be stored. Stored content shall be exported through the monitoring port based on first in first out principle.
(xii) Protection against: under/over voltage, overcurrent, short-circuit, over temperature.
(xiii) Ensure active and passive battery cell balancing.

The system shall have alarm and data logging facility. The remote monitoring facility shall be provided through SNMP and LAN based for remote supervision and

integration into network management systems. The communication shall be achieved through RS 485, CANBUS/Modbus.
It shall support parallel battery bank operation with inter module communication and coordinated control.

4.1.1.18.6 Inspection and Testing

The battery unit, chargers and accessories shall be inspected and tested in accordance with the requirements of IEC 62619, IEC 62620, other relevant standards and the provisions of this specification.

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

SECTION VI

4.1.2 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

SUBSTATION AUTOMATION, CONTROL AND PROTECTION

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4.1.2 SUBSTATION AUTOMATION, CONTROL AND PROTECTION.

4.1.2.1 Substation Automation and Control

4.1.2.1.1 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.

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

4.1.2.1.2 Overview of Substation Automation SAS

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

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

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

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

The substation must communicate with the Regional Control Centre, from where it shall be monitored &controlled.

4.1.2.1.3 Design

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

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

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

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

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

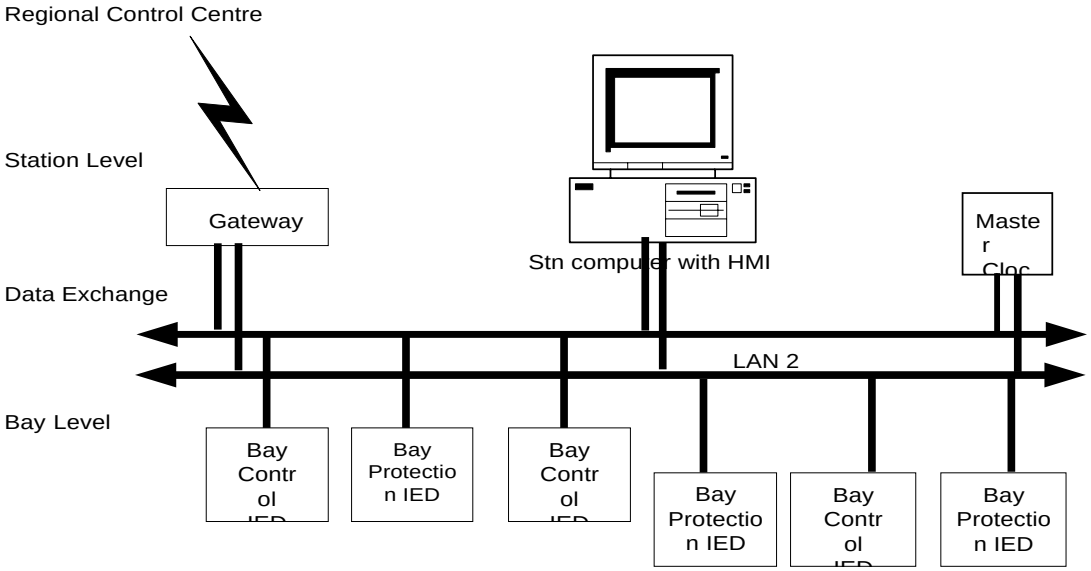
For safety and availability reasons the Substation Automation System shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

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

4.1.2.1.4 Typical SAS Architecture for Substation

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

System Architecture of Substation Automation



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

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

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

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

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

To provide highest reliability the station HMI and the gateways shall work completely independent meaning retrieving the process data directly from the bay level devices.
Additionally, the gateway and the station HMI shall be configured fully redundant to ensure full functionality in case of single point of failure.

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

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

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

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

The gateway/RTU shall be used, to collect, store and map signals of relays, measurement units, control units and other IEDs in the substation to The National Or Regional Control Center

The following protocols shall be supported by the gateway/RTU towards the process/substation end: IEC 61850, IEC 60870-5-101/104, IEC 60870-5-103, Modbus Serial, Modbus TCP/IP and DNP3.0.

The RTU/gateway shall be able to support hardwired signals where required.

The following protocols shall be supported by the gateway/RTU towards the control center: IEC60870-5-101/104

There are different types of switchgear and equipment in Sub Stations.
In automating an existing substation, which has old switchgear & auxiliary equipment (i.e. non IED) installed, the RTU can be connected directly to auxiliary contacts & transducers of the process via a Marshalling Cubicle with interposing relays& local transducers.

In substations with relays/IEDs, modern measuring and control units, it shall be possible to use compatible and supported, non- proprietary communication protocols, as listed above.

4.1.2.1.5 Scope of Work:

The following equipment and adaptation works are required at the station level for supervisory control and data acquisition:

- New Remote Terminal Units (RTUs)
- Interfacing Marshalling Cubicles,
- Interface terminal blocks at the existing station control and protection panels or at the station equipment itself.
- Cabling between RTUs and the points where the required data are available (either marshalling cubicles or interface terminal blocks in existing control and relay panels at the stations)
- Wiring modifications and additional de-coupling relays
- Analogue and digital transducers

The contractor shall provide the following:

- Provision of all hardware and software necessary to control and monitor the substation equipment both locally and remotely.

- Interface substation equipment to local control panels.
- Incorporate new and modified substation equipment into the SCADA/EMS System at the Central Control Centre
- At all substation sites, the Contractor shall undertake a complete survey of existing facilities to ensure that any additional control equipment provided under the scope of this package, provides at least the same level of control and functionality as similar existing equipment on site and provides a seamless interface to all the substation control points.
- The status, alarms and analogues from the new and modified circuits shall be presented to the Regional Control Centre RTU either by provision of additional transducers (Amps, Volts, MW, MVAR) or by an additional direct input CT/VT card in the RCC RTU.

4.1.2.1.6 SAS Equipment

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

4.1.2.1.6.1 The RTU Technical Specifications:

The RTU shall be programmable, with real time clock, synchronized by an external source, process Input and Output (I/O) modules, CPU, memory and data transmission equipment.

The new RTU to be supplied and installed under the project shall provide at least the following functions:

- Single command outputs, double command outputs
- Regulation command outputs e.g. Raise/lower command outputs for transformer tap changer control
- Analog set-point transmission and output
- Single, double and multiple state digital inputs
- Analogue measured inputs
- Metering pulse inputs for acquisition of energy meter values
- Sequential event recording (SER) with time stamping of events at the RTU
- RTU time synchronization
- Self-testing and diagnostic functions for detection and reporting of any error
- Automatic re-starting function
- Database and parameter setting by menu-controlled dialogues from a local pc and remotely from the corresponding control centre with downloading function.
- Shall be designed to operate in aggressive industrial environments, complying with the highest standards, such as Electromagnetic compatibility (EMC).
- Shall support data calculation and synthesis
- For each station, a manual key type selector switch shall be provided to locally disable all control outputs at a station. The key-type selector switch shall be installed at the RTU such that it can be operated without opening the RTU panel.
- The outputs from the RTU shall be disabled by breaking the power supply connection to the control output. An auxiliary contact on this switch shall be wired to a contact input in the RTU to report the control disable switch's status to the SCADA system.
- All connections between the RTU's termination facilities and signal wiring shall be through barrier-terminal blocks with knife-switch isolation, mounted in the RTU panel or an adjacent marshalling cabinet, if not already existing in the Substation. Terminal blocks shall be screw-type, with full depth insulating barriers.

- The RTU shall report tele-indications by exception but shall also allow the SCADA system to demand - scan status data even if the data has not changed.

4.1.2.1.6.2 Signal List

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

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

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

The design of the SAS system shall include the following ;

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

4.1.2.1.6.3 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.

4.1.2.1.6.4 Station HMI

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

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

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
SAS shall include the following displays &functions:

- Control of all switching devices
- Real time indication of status, alarms and devices
- Display of measured values, high/low limit checking.

- Indication of real and historical values
- Data Archiving
- Disturbance Monitoring and analysis
- Trend display facilities
- Protection device information
- Remote access to SAS from the Central Control Centre via the SCADA system
- Remote communications
- Indication of automatic tap changer relay status
- Manual local and remote setting of tap changer relay
- Self-check & diagnostic: These functions are essential for system operation
- Safety and easy maintenance.
- SAS Management software
- The substation master control shall be capable of automatic restart in the event of power failure
- Without loss of functionality or local database. It shall be readily possible to update the substation
- Computer software to alter or extend the SAS functionality.

Manual data setting (can be performed by the operator) using the following functions:

- Device status setting
- Analogue data setting
- Control inhibit setting
- Alarm inhibit setting
- Maintenance tag setting
- High/Low limit setting
- Protection relay parameter setting, etc.
- Also, all required signals related to the control, status indications and monitoring of the switchgear and other relevant equipment shall be provided to the SAS.
- Time Tagging

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

4.1.2.1.6.5 Substation Local Area Network

Local substation communications shall use Ethernet LAN to connect the components of the SAS using open international IEC 61850 GOOSE protocol. 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 protocol.

4.1.2.1.6.6 Printers

- Two high performance printers shall be provided, each capable of connection to the substation LAN.

- 1 off Matrix printer Logger, for events and for operator log.
- 1 off Color Printer to print screen shots or other information

4.1.2.1.6.7 Satellite Clock

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

4.1.2.1.6.8 Audible Alarm

One common sounder should be provided to give at least two distinct audible alarms in case of alarms/faults or events.
The sounder shall be configurable according to the event type and to the control status of the SAS (Local/Remote). An auto-silencing scheme shall be provided for the alarm and the sounder shall be controlled by distinctly labeled “Audible alarm ON/OFF” control switch.
The complete unit may be mounted in suitable relay/control panel.

4.1.2.1.6.9 Common Bay Unit

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

4.1.2.1.6.10 Data Transmission

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

4.1.2.1.6.11 Cyber Security

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

4.1.2.2 Substation Control

4.1.2.2.1 Bay Control Units

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

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

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

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

All commands from the remote and supervisory control can be given to bay control unit, which execute the commands. Conventional interlocks should be retained.

All microprocessor based control equipment such as bay control units shall be galvanically isolated from the environments outside panels, using opto couplers or interposing relays for signals, galvanic isolated measuring transducers for measurements and relays or contactors for commands.

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

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

4.1.2.2.2 Interface with Supervisory Control and Data Facilities

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

The following SCADA facilities shall be available from the substation.

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

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

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

- Sequential event recording with time stamping of events (time stamp 10ms, resolution 1 ms)
- Selectable priority levels for data acquisition to speed up the acquisition of circuit breaker status changes and important measurements.

4.1.2.2.3 Automatic Voltage Regulator

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

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

4.1.2.2.4 Indicating and Metering Instruments, and Transducers

Remote indication of measurands shall take place on the station controller's VDU. Where local instruments are used, they shall be of the dial type which is easily legible, with black graduations and numerals on a white background.

The instruments shall have a dimension of 96x96 mm. The error of the instruments shall be maximum 1.5% reckoned on the total length of the scale. All instruments shall be of a narrow frame type.

Preferably the measurements shall be performed directly in the SAS or in the protection relays. However, if needed, the metering transducers (converters) shall be installed in the boards and shall be suitable for connection to the potential and current transformers. The cases shall be hermetically sealed against moisture and dust. Transducer output shall be an impressed DC current of 0-10 mA output. The maximum meter reading at the receiving end shall be equivalent to 30% overload of the source value. The permitted resistive load shall be at least 1000 Ohms. The accuracy class shall be minimum 1%. The auxiliary voltage, if required (preferably not) shall be 48VDC.

The W and VAr measurements shall be of the three-element (three-wattmeter) type when connected to primary systems with grounded neutral.

W and VAr measurements for transmission lines, shall be such that the direction of the power flow is indicated by negative direction towards the substation and positive direction out of the substation. The voltage shall be measured phase-phase voltage, one reading is sufficient.

The scale on the different types of instruments shall be proposed by the Contractor and be subject to approval by the Project Manager.

4.1.2.2.5 Enclosures

The Contractor shall provide enclosures meeting the following requirements:

- Swing racks supported by heavy gauge hinges shall be provided so that only front access to components and wiring is required for routine maintenance and troubleshooting.

- Provisions for top and bottom cable entry. Cable entries shall be provided with protection against insect and rodents entry and sealed to prevent dust and sand contamination.

- Protection class of the enclosures shall be
  - ❖ for indoor cabinets IP52 minimum
  - ❖ for outdoor cabinets IP64 minimum.

- Suitable signal and safety ground networks within the enclosure.
- Convenience outlets at 230VAC, shall be provided. Sockets shall be 15A British type.

4.1.2.2.6 Power Supply

At all stations where no adequate power supply exists and new RTUs and telecommunication equipment shall be installed, the Contractor shall supply, install and wire a new and complete 48V DC power supply system including a 48V DC battery, charger(s), low voltage disconnect switch,
All DC distribution equipment and cabling required for the uninterruptable supply of 48V DC power to the RTU as well as the communications equipment provided under the Contract.

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

The rectifier output shall be k x S
Where k = 1.5
S = sum of the following:
- input power in kVA of the largest tendered RTU
- input power to the new telecommunication equipment provided under the contract.

The battery capacity shall be $C = 1.5 \times C_n$,
where C_n is the capacity to feed the above total load for eight (8) hours.

The battery chargers shall provide normal system power and shall be capable of recharging a fully discharged battery in twelve hours while supplying normal system power. The chargers shall have 240 volt, 1 phase input power. Where duplicated chargers are to be provided, both chargers shall have an output diode in the positive pole to prevent back-feeding a failed charger.

The Contractor shall supply any hardware required to convert the 48 V battery voltage to the required internal voltages for the RTU hardware. The RTUs shall be capable of operating with ungrounded or grounded (either polarity) input power.

In RTU DC distribution, Miniature Circuit Breakers (MCBS) with alarm contact shall be used, i.e. fuses are not accepted.

4.1.2.2.7 Spare Parts

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

- Mandatory spare parts that are necessary for two (2) years of operation. These spare parts shall be included in the contract.
- Recommended spare parts that are necessary for ten (10) years of operation.

4.1.2.2.8 Documentation

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals. All manuals and AS-Built-Drawings shall be provided in 3 No. hardcopies and a softcopy.
The following documentation to be provided for the system in the course of the project. It shall be consistent, CAD supported and of similar look/feel:

- Control Room Layout
- Single-Line Diagram
- Block Diagram
- Circuit Diagram
- List of Apparatus
- List of Labels
- Functional Design Specification (FDS)
- Test Specification for Factory Acceptance Test (FAT)
- Logic Diagram
- List of Signals
- Operator's Manual
- Product Manuals
- Calculation for uninterrupted power supply (UPS) dimensioning (or Charger and batteries).
- Concept and contract for maintenance
- It is necessary to present the technical description and the technical data for the whole system and for any equipment and function
- Time plan for the project realization.

4.1.2.2.9 RTU Configuration & Maintenance

The RTU shall perform continuous self-diagnostics to monitor its own operational capability. Any detected fault or abnormality, which could affect its performance or operational capability, shall be indicated to the Regional Control Centre.

- A laptop computer based configuration and maintenance facility shall be provided along with all database and software interfaces required for the maintenance and configuration of the RTU,
- The laptop computer shall also be used to monitor and test the RTU's operation and communication interfaces and shall be capable of emulating the RCC.
- All equipment software licenses shall be in employer's name but acquired by contractor and one time licenses (i.e. no periodic license renewal required)
- Upon completion of tests and commissioning, the following shall be provided in CDs and portable hard drives:
    - Operating system recovery disk (drivers and manuals) and installation disks
    - All installed software drivers and manuals
    - As built backup installation files, configuration files and reading software for the substation protection, metering and SCADA systems

- 2 No. Laptops (at least core i8 8th generation), each with all substation backups

4.1.2.2.10 Testing

The Control system with Station Control Unit and Field Units shall undergo the following tests:-

a) Factory Acceptance Tests (FAT)
Systems shall pass these tests before they may be shipped to site. FATs shall be witnessed by the employer.

b) Site Acceptance Tests (SAT)
Systems shall pass these tests before they may be put into operation and before they are Taken Over

4.1.2.2.11 Training

The Contractor shall provide 2 weeks training for 4 (four) KPLC staff at the supplier's factory premises and on site during installation works and the scope of each service shall be given.
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 Contractor
- Communication protocols, IEC 60870-103/104, IEC 61850-3-2013
- Protection device settings and configurations

On completion of the training, KPLC staff shall be able to modify and make changes to the configuration of the RTU to accommodate any future changes as well as interfacing & data transmission to the RCC.

4.1.2.2.12 Spare Parts and Tools

The Contractor shall furnish a list of recommended spare parts and test equipment for the purchased SAS system to maintain reliable operation. The spare parts list shall be short-term spare parts that are necessary for two (2) years of operation. These spare parts shall be included in the contract and shall comprise at least one spare module for supplied equipment and basic tools for system maintenance.

4.1.2.2.13 System Maintenance

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

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

4.1.2.3 System Protection

4.1.2.3.1 General Requirements

The protection relays to be installed for the protection of 132kV, 66kV, 33kV and 11kV distribution lines, transformers and other HV/MV equipment shall be **Numerical type** and support Communication protocols including but not limited to IEC 60870-5-103/104, Modbus serial, Modbus TCP/IP, IEC 60870-5-101/104 and DNP3. Shall also support IEC 61850-9-2 GOOSE messaging. Relays shall be 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 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.

4.1.2.3.1.1 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:

  i. Separated DC power supply,
  ii. separated boards,
  iii. separate current transformer cores,
  iv. separate voltage circuits,
  v. separated tripping devices,
  vi. separate tripping coils,
  vii. separated cables,
  viii. Separated relay protection channels.

- The restricted earth fault and differential functions for the transformers shall also follow the same principle for separation as outlined above.

- The Auxiliary relays for protection trip shall have operating speed of less than 7 milliseconds.
- Strict requirements shall be given on selectivity in isolation. Only the minimum possible part of the plant shall be tripped to isolate the fault or clear the abnormal conditions.

- The Contractor shall for each substation carry out the protection plan for relay settings. The plan shall be submitted to the Project Manager for approval.

- All necessary intermediate current and voltage transformers, converters and auxiliary power supply units shall form part of the supply.

- The user manuals must be user-friendly and divided into one general hardware and software description and one setting manual describing only the specified functions and necessary settings for the different types of relays

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

4.1.2.3.1.3 Fault Clearing Time

The protection system plus the circuit breakers shall have fault clearing time of not more than 60ms.

4.1.2.3.1.4 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.

4.1.2.3.1.5 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.

4.1.2.3.1.6 Supervision

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

The protection relays shall also communicate with the bay control units over the open protocol IEC 61850.

4.1.2.3.2 Protection Schemes and IEDs

4.1.2.3.2.1 132kV, 66kV & 33kV Line Protection Schemes

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

The line protection schemes shall contain the following functions:

a) Line Distance Protection (Main A)
b) Line Differential Protection (Main B - for 132kV and above)
c) Bay Control and Protection Unit (BCPU)
d) Three phase unidirectional Over Current and Earth fault function (Backup)
e) Sensitive Earth fault function
f) Auto reclose relay function
g) Trip circuit supervision
h) Auto reclose IN/OUT Switch
i) SEF IN/OUT Switch
j) Breaker failure function

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

Protection functions (c, d, e and f) shall be incorporated in BCPU as one IED for the 66kV and 33kV Line protection.

4.1.2.3.2.2 11kV Line Protection Schemes

The main protection for 11kV lines shall be three phase Overcurrent & Earth fault, Sensitive earth fault and auto reclose function combined in one IED/BCPU.
The facilities shall include duplicate breaker trip coils, separately MCBs DC circuits and the use of separate CT and VT windings. The protection relays shall be arranged to initiate a single set of auto-reclosing equipment. The protection relays / IEDs shall be visible from the front of the panel without having to open the panel door.

The line protection schemes shall contain the following functions:

a) Bay Control and Protection Unit (BCPU)
b) Three phase unidirectional over current and Earth fault function (Backup)
c) Sensitive Earth fault (SEF) function
d) Auto reclose relay function
e) Trip circuit supervision
f) Auto reclose IN/OUT Switch
g) SEF IN/OUT Switch

All the protection functions (a. b, c and d) shall be incorporated in BCPU as one IED.

4.1.2.3.2.3 Power Transformer Protection Schemes

The main protection for transformers shall be the Transformer Differential function and Restricted Earth Fault (REF) functions. Backup protection shall be the Three Phase Overcurrent & Earth fault and Standby Earth Fault (SBEF).

The facilities shall include duplicate breaker trip coils, separately MCBs DC circuits and the use of separate CT and VT windings. The protection relays / IEDs shall be visible from the front of the panel without having to open the panel door.

The transformer protection schemes shall incorporate the following protection functions:

(i) Biased differential protection relay for two winding Transformer.
(ii) HV & MV Restricted Earth Fault relay. This should include stabilising resistor and voltage dependent resistor (metrosil) incase of High Impedence REF
(iii) HV Three-Phase Directional/Unidirectional Over Current & Earth fault Protection
(iv) MV Three-Phase Directional/Unidirectional Over Current & Earth fault Protection
(v) Auxiliary relays with annunciator for the following transformer mechanical protection functions
- Tx Buchholz gas Alarm
- Tx Buchholz surge Trip
- OLTC Oil Surge Trip
- Pressure Relief Valve Trip
- Winding temperature Alarm
- Winding temperature trip
- Oil temperature alarm
- Oil temperature trip
- Tx oil level low Alarm
- OLTC oil level low Alarm

(vi) Standby Earth Fault Protection.
(vii) HV & MV Master trip
(viii) Trip circuit supervision relay for HV & MV breaker visible from front of panel without opening relay compartment door.
(ix) Breaker Fail Protection function
(x) Bay Control Function

The Transformer differential and Restricted Earth Fault protection functions shall be in separate relays/IEDs.

4.1.2.3.2.4 Protection IEDs

a) <u>Line Distance Protection IED</u>

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

i. Ratings: AC Inputs: 110VAC, 1Amp (three phase).

ii. Power Supply Voltage shall be universal 24-240VDC

iii. The relays shall be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850

iv. The relay shall also have auto reclose function.

v. Impedance criteria.
vi. Three zones phase –phase Protection.
vii. Three zones phase –earth Protection
viii. Additional Zone 4 Protection
ix. Automatic Switch on to fault.
x. Independent settings for each zone.
xi. Distance to fault measurement.
xii. Display: On operation, the relay should display the faulted phase(s), time and zone of operation and distance to fault.
xiii. Power Swing detection: Blocking/non-blocking selectable by user.
xiv. Scheme communication logic and residual current compensating.
xv. IDMT Three Phase/Over current & Earth fault Protection.
xvi. Fuse failure supervision.
xvii. Auto- reclose logic 1phase and/or 3 phases.
xviii. Three pole tripping logic.
xix. Disturbance and event records including software for disturbanceanalysis.
xx. Fault record should be incorporated.
xxi. At least six (6) Binary inputs.
xxii. Mho/Quadrilateral characteristics.
xxiii. Stability against Switching inrush currents and Reverse faults.
xxiv. Clear faulted phase indication.
xxv. Clear fault identification even for boundary conditions.
xxvi. Software necessary for all above functions shall be provided.

All these functions must be integrated in a compact package and a user-friendly menu driven interface should be available to enable the setting and testing of the relays.

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

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

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

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

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

Further the device includes a disturbance recorder and arc supervision unit. The manage communicates with other systems using common protocols, such as the Modbus RTU, Modbus TCP, Profibus DP, IEC 60870-5-103, SPA bus and DNP 3.0.

In addition, each relay is expected to interface directly with a single mode optical fibre.

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

c) Biased Differential Protection IED for Power 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 transformer protection.

This should incorporate the following features:

i. Ratings: AC Inputs: 1Amp
ii. Power Supply Voltage shall be 24-240VDC universal.
iii. Relay Must be of Numerical design and supports communication protocols IEC 60870- 5-103a-104 and IEC 61850-9-2
iv. Pick up setting range, 0.1 to 0.5In
v. Should incorporate a high-set Element with a setting range of up to 20In.
vi. Magnetising current inrush restraint
vii. Integral CT ratio compensation (0.1-2) and vector group compensation
viii. Measurement and indication on the MMI, of phase, differential and bias currents
ix. Storage of Fault records and Event records; the Fault flags should be accessible on the relay LCD screen without opening the relay cover.
x. Over fluxing restraint
xi. Over fluxing protection with Alarm and Trip functions
xii. 5th harmonic restraint feature on the differential Element.
xiii. Appropriate Dual Bias characteristic to ensure relay stability for heavy through faults
xiv. Should incorporate a disturbance recorder feature.
xv. Red L.E.D to indicate Tripping
xvi. Relay Self diagnostic and Alarm feature
xvii. Ability to Latch output contacts to prevent TX re-energizing before carrying out investigations.

d) Restricted Earth Fault IED

The relay shall be used for protection of one winding of a power transformer and shall have following minimum functions and features: -

i. Relay must be of Numerical type and supports communication protocols IEC 60870-5- 103-104 and IEC 61850-9-2
ii. Ratings: AC Inputs: 1Amp
iii. Power Supply Voltage shall be 110vdv or 24-240VDC universal supply
iv. The Relay shall have both high and low impedance principle.
v. The relay shall be suitable for flush mounting on panel front.
vi. The relay shall be of an independent relay and not a function in the differential relay.
vii. Relay shall reject harmonics produced by the system particularly third harmonics.

viii. Stabilizing resistor and voltage dependent resistor (metrosil) of suitable rating shall be offered with the Relay based on maximum through Fault of 40kA.
ix. The relay current setting range shall be 0.05- 0.8 x rated current (In) as a minimum and an operating time < 25ms at 5 times the setting.
x. The relay shall have at least four (4) LEDs for relay status indication and for trip and alarms annunciation as a minimum and two (2) binary inputs as a minimum
xi. The relay shall have four (4) Binary Outputs as a minimum with LCD screen where the settings and measurands can be read
xii. The relay's REF operate current shall be displayed on the LCD screen and keypad for manual programming of settings and data access
xiii. The relay shall have serial RS232, USB or Ethernet Front Port for relay configuration and programming of parameter settings and data download using a laptop computer.
xiv. The relay shall have an event recorder with capacity to store the last fifty (50) events
xv. The relay shall have fault recorder with capacity to store the last ten (10) fault records
xvi. The relay shall have a disturbance record with capacity to store the last four (4) disturbance records
xvii. The relay terminals shall be screw type terminals large enough to accommodate at least 4mm2 cable and shall be located at the back of the relay
xviii. Relay must be of Numerical type
xix. Relay should reject harmonics produced by C.T saturation
xx. The offer should include the associated stabilising resistor and voltage dependent resistor (metrosil)
xxi. Current setting range 0.05-0.8In
xxii. Operating time < 25ms at 5 times the setting

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

e) Stabilizing resistor

Each REF relay shall be supplied with an adjustable stabilizing resistor. For dimensioning of the stabilizing resistor consider maximum through fault phase–earth current of 25kA.
Restricted earth fault and differential protection functions shall be provided in separate units

f) Voltage dependent Resistor (Metrosil)

Each REF relay shall be supplied with a voltage dependent resistor (VDR) or Metrosil to limit voltage across the REF high impedance circuit.
The basis for the rated voltage of the VDR is the maximum phase-earth through fault of 25 kA.
Note: The Stabilizing resistor and the Voltage dependent resistor shall preferably be housed in a box with terminals that allow connection of the REF relay to the resistor and VDR in the box. Several terminals will be provided to allow selection of required stabilizing resistor. The single box will be suitable for panel mounting.
The Protection Functions Offered shall satisfy the detailed specifications as included elsewhere in this specification for each of the protection and control functions.

g) Bay Control Protection Unit (BCPU)

The relay shall have the following functions and features: -

i. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
ii. Power Supply Voltage shall be Universal power supply of 24- 240VDC is

preferred.

iii. The relay shall be suitable for flush mounting

iv. The relay will have a large LCD screen measuring at least 7cm x 7cm where a mimic of the switchgear arrangement and status of the switchgear for the bay shall be displayed.

v. The position of the switchgear i.e. Circuit Breaker and Disconnectors shall be indicated.

vi. The switchgear close and open push key buttons with symbols and colour codes as per the IEC standards shall be provided on the relay as well as switchgear selection key.

vii. A Local/Remote key selector switch shall be provided on the relay and the selected status of the selector switch indicated by means of an LED.

viii. The Relay offered shall have at least the following protection functions; -

- Three Phase Overcurrent & Earth Fault
- Sensitive Earth fault
- Broken Conductor detection
- Auto reclose function
- Circuit breaker maintenance
- Circuit breaker Failure protection
- Under and over frequency protection as well as rate of change of frequency protection
- Over/under voltage protection
- Synch Check Function

ix. The Relay shall measure and display (Metering) on the LCD screen following power system parameters; Current (I), Voltage (V), Active Power (P), Reactive Power (Q), Frequency (HZ) and power factor (P.F).

x. The relay shall store at least twenty (20) fault records, Fifty (50) events and ten

xi. (10) disturbance records. The disturbance record shall have capacity to monitor Eight (8) analogue and ten (10) digital channels.

xii. It shall be possible to display instantaneous measurands on the screen alongside the bay mimic.

xiii. The unit shall have an L.E.D to indicate relay healthy status (green colour) and relay faulty status (red colour). A separate Red L.E.D to indicate operation (Trip) of the protection functions.

xiv. The relay shall have at least Eight (8) programmable LEDs for displaying Protection function operations and other alarms.

xv. The template for writing the alarm labels shall be provided with the relay

xvi. The relay shall have at least twelve (12) binary inputs

xvii. The Relay shall have at least six (6) output relays

xviii. The relay shall be provided with IEC 61850-8-1 Communication protocol, and the corresponding communication port.

xix. The Relay terminals shall be of screw type terminals large enough to accommodate at least 2x2.5mm2 cable and shall be located at the back of the relay.

xx. Front Serial RS232 or USB or Ethernet Port for relay communication with a laptop computer for relay configuration and parameter settings and download of fault records, events records and disturbance record for analysis.

Note:

- *All the protection functions shall meet the requirements of each function as included in this specification.*

- *Earth Fault and Sensitive Earth Fault Protection elements shall be separate to allow independent settings to be applied.*
- *Earth Fault and Sensitive earth fault shall have separate CT inputs.*
- *Detailed specifications for three phase overcurrent, earth fault and sensitive earth fault functions are included elsewhere in these specifications.*

h) <u>Three Phase Directional/Unidirectional Over Current & Earth Fault IED</u>

Should incorporate the following functions:

i. Ratings: AC Inputs: 110VAC, 1Amp (Three phase).
ii. Power Supply Voltage shall be universal 24-240VDC
iii. In addition of Overcurrent and Earth fault, the relay shall also have auto reclose function
iv. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
v. Current setting range for over current relay 0.5In-2.4In
vi. Current setting range for earth fault relay 0.05In-0.8In
vii. Quadrature connection for polarising voltage (Vn=110)
viii. High set Element, with a setting range of 1-32In
ix. The phase and earth directional elements should be individually selectable.
x. I.D.M.T characteristics according to BS142 or IEC60255 and Definite time characteristic
xi. 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.
xii. Time setting multiplier 0.05 - 1.0
xiii. Broken conductor protection feature
xiv. Negative sequence Protection Feature
xv. High set Element for both over current and earth fault Protection, with a setting range of 1-30In.
xvi. Thermal Protection.
xvii. Dedicated Breaker Fail Protection.
xviii. Circuit Breaker Maintenance
xix. Incorporate Fault records, Event Records and disturbance records.
xx. Configurable output relays with ability to output starting elements to control Tripping of other upstream Protection relays.
xxi. Drop off /pickup ratio >90%
xxii. Low transient overreach < 10%

i) <u>Sensitive Earth Fault IED.</u>

Should incorporate the following Features;

i. Ratings: AC Inputs: 1Amp
ii. Power Supply Voltage shall be Universal power supply of 24- 240VDC
iii. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
iv. Current setting range for earth fault relay 0.005In-0.8In
v. I.D.M.T characteristics according to BS142 or IEC60255 and Definite time delay characteristic; setting range, 0- 30 Seconds.
vi. Circuit Breaker Maintenance
vii. Fault records, Event Records and disturbance records.

viii. Drop off /pickup ratio >90%
ix. Low transient overreach < 10%

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

j) Auto reclose function

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

For 11kV and 33kV lines, the Three Phase Overcurrent, Earth fault & Autoreclose functions shall be combined in one IEDs (BCPU)

k) Under Frequency relay

Where required, on the 11kV and 33kV bus bar, each Bus bar shall be equipped with a separate under frequency relay for load shedding of all outgoing feeders. Each feeder trip circuit from the under frequency relay shall be equipped with a clearly marked isolating link.
The relay shall be numerical type having two independently time delayed settings in the range 50- 47Hz with a resolution of 0.1Hz. The rate of change of frequency function shall be included.

l) Busbar Protection relay for 66kV and above Voltages

Bus bar protection schemes shall be provided on bus bars for voltages from 66kV and above. Low impedance schemes will be acceptable provided full bus bar protection coverage to include single phase and phase to phase faults can be achieved. The type of tripping criteria has to be fully described and preference will be given to systems with at least two (2) criteria checks before tripping.
Bus bar Protection relay shall have the following minimum and functional features:

i. Power Supply Voltage shall be 24-240VDC universal.
ii. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
iii. AC Inputs of 110VAC and 1Amps (In) 50Hz three phase per circuit.
iv. It should be able to carry 4xIn current continuously
v. Shall have extensive self-supervision and diagnostic facilities.
vi. Incorporate a check feature
vii. Incorporate continuous supervision for CT secondary circuits against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate alarm
viii. Be of phase segregated and triple pole type and provide independent zones of protection for each bus
ix. Provide 100% stability up to 50kA fault level and shall have immunity against system transients.
x. Be of high impedance, biased differential type and have operate and restraint characteristics with typical tripping time: 10 to 20ms

xi. The HMI should graphically display the bus bar configuration and the bus bar image and shall permit read out of a minimum of the following information:
xii. Phase currents (and optionally, phase voltages) in each bay
xiii. Differential currents in each Bus bar zone and each phase on line as well as at the time of fault.
xiv. Alarm conditions and Trip conditions
xv. State of all the inputs and outputs setting values
xvi. Positions of the breakers in each bay
xvii. Resetting of output relays
xviii. Shall include Protection Enable / Disable feature
xix. It shall have sufficient number of programmable opto coupler binary inputs (Min of 10 No. per bay) and output relays with heavy duty & signaling contacts (Min of 10 No. per bay)
xx. It shall include a Disturbance Recorder function
xxi. It shall include an Event Recorder function
xxii. The Disturbance Recorder and Event Recorder buffer memory shall be of non-volatile type and shall not require the use of batteries.
xxiii. Programmable LED indications.
xxiv. The relay shall have front and rear communication ports for settings/configuration and integrating with the local station automation or to a station monitoring system.
xxv. One of the protocols offered for the communication port shall include IEC 61850.
xxvi. Time synchronization via IRIG-B and SNTP.
xxvii. Be supplied along with all suitable Original Customized licensed software & communication cable for local and remote communications, analysis of fault etc.
xxviii. The bus bar protection relay shall have built-in Breaker Failure feature.
xxix. The relay shall have CT supervision function.
xxx. There shall be trip command lockout with manual reset (local and remote by binary input.)

m) <u>Breaker Fail Protection relay for 66kV and above Voltages</u>

Where an independent Circuit Breaker fail (CBF) protection relay is required shall be of the numerical design and shall have following minimum features and functions: -

i. Power Supply Voltage shall be 24-240VDC universal
ii. Relay must be of Numerical design and supports communication protocols IEC 60870-5-103 and IEC 61850-9-2
iii. AC Inputs of 1-Amps (In) 50Hz three phase per circuit.
iv. Relay should be able to carry 4xIn continuously.
v. Shall have extensive self-supervision and diagnostic facilities.
vi. Detection shall incorporate current check feature and a timing element.
vii. The current check function shall comply with IEC 60255-151 and timing element IEC 60810-1.
viii. The relay shall have programmable initiating inputs and tripping outputs.
ix. It shall have sufficient number of programmable opt-coupler binary inputs (Min of 10 No.) and output relays with high speed heavy duty & signaling contacts (Min of 10 No.)
x. The HMI should permit read out of a minimum of the following information:
xi. Phase currents
xii. Alarm conditions and Trip conditions

xiii. State of all the inputs and outputs setting values
xiv. Resetting of output relays
xv. Shall include Protection Enable / Disable feature
xvi. It shall include a Disturbance Records, event record function
xvii. The Disturbance Recorder and Event Recorder buffer memory shall be of non-volatile type and shall not require the use of batteries.
xviii. Programmable LED indications.
xix. The relay shall have front and rear communication ports for settings/configuration and integrating with the local station automation or to a station monitoring system. One of the protocols offered for the communication port shall include international standard protocol IEC 61850. Time synchronization via IRIG-B and SNTP.
xx. Be supplied along with all suitable Original Customized licensed software & communication cable for local and remote communications, analysis of fault etc.

The breaker fail protection shall only isolate the bus bar to which the faulty breaker is connected
i.e. the station shall, as far as possible, remain in operation after a breaker failure.
The bus bar protection can be used for selection of breakers to be tripped.

n) <u>Other Functions</u>

The line protection shall also incorporate;

i. Auxiliary relay to indicate/lockout circuit breaker for low SF6 gas pressure
ii. Trip circuit supervision relay that is visible from front of panel without having to open any panel compartment door.
iii. Front panel mounted **Auto reclose IN/OUT** switch.
iv. Front panel mounted **Sensitive Earth Fault ENABLE/DISABLE** switch.

4.1.2.3.2.5 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 pre-set ranges. Permitted phase angle difference shall be adjustable in the range of 5 to 100 degrees, the slip shall be adjustable in the range of 0.05 to 0.5% and the voltage difference shall be adjustable from 2 to 20%.

4.1.2.3.2.6 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 1ms. It shall be possible to connect the unit to a personal computer and necessary software for data recording and data handling shall be included.

4.1.2.3.2.7 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.

4.1.2.4 Metering

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

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

4.1.2.4.1 Meters for Outgoing 33kV 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 61850 protocol.
The energy meters for all the circuits shall be housed in one modular metering panel whose front door is a transparent glass.

4.1.2.5 LV cables and Cable Racks

4.1.2.5.1 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 Contractor 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.

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.

4.1.2.5.2 Technical Requirements

4.1.2.5.2.1 *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°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.

All cables shall be steel wire armoured.

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

4.1.2.5.3 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.

4.1.2.5.4 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 Contractor shall give detailed information about the different types of cables proposed.

4.1.2.5.5 Tests

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

Type test certificates shall be submitted on request.

4.1.2.6 Earthing (Grounding) System

4.1.2.6.1 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 Bidding 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.

4.1.2.6.2 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 of 10 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 underground surface. Connections above earth shall be screwed and shall be easily accessible for control. All connections shall be protected against corrosion.

4.1.2.6.3 Earthing System under the Control Building

The conductors shall be of electrolytic copper with dimensions at least 30 x 3 mm for flat bar or at least 95mm^2 stranded wire. Copper-weld with approximately the same conductivity may be used.

Risers shall be copper stranded wire at least 95 mm^2.

The conductors shall be placed on the ground after the excavation is completed and just before the concreting starts. Care must be taken that the earth wire is in good contact with the soil and preferably embedded into it.

Under the building the grid of conductors shall be placed with an average distance between conductors of not more than 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.

4.1.2.6.4 Earthing 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 120mm^2 stranded wire. Copper-weld with approximately the same conductivity may be used.

The risers shall be of at least 95mm^2 stranded copper wire or equivalent copper-weld.

The conductors shall be placed forming a grid covering the whole switchyard area. The average distance between the conductors shall not be more than 20 m.

A conductor shall also be placed outside the fence along the whole length of the fence at a distance and at a depth suitable for the potential gradation needed to avoid dangerous touch voltage between the fence and the ground.

Trenches for the earthing grid shall be excavated in the ground to reach soil of good conductivity and a layer of at least 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.

4.1.2.6.5 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 95 mm² for 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.

4.1.2.7 Site and Commissioning Tests

4.1.2.7.1 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.

4.1.2.7.2 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.

4.1.2.7.3 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.

b. Secondary injection shall be carried out on all a.c. relays, using voltage and current of sinusoidal waveform and rated power frequency. For circulating current protection employing high impedance voltage setting test shall be across the relay and 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.

4.1.2.7.4 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.

4.1.2.7.5 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.

4.1.2.7.6 Tests on Conductors, Insulators and Accessories

None required.

4.1.2.7.7 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.

4.1.2.7.8 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.

SECTION VI

4.1.3 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

TRANSFORMERS

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4.1.3 PARTICULAR TECHNICAL SPECIFICATIONS - TRANSFORMERS

4.1.3.1 General

This Specification provides for the manufacture, supply, testing before shipment, delivery, erection and commissioning of the transformers detailed in Scope of Works. Particular reference is also made to General Specification, General Technical Specification, Project Specific Data and IEC60076.

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

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

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

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

4.1.3.2 Power Transformers

4.1.3.2.1 Design Criteria

4.1.3.2.1.1 Service Conditions

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

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

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

4.1.3.2.1.2 Rating

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

4.1.3.2.1.3 Tapping

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

4.1.3.2.1.4 Noise

The transformer, tap-changing equipment and supplementary cooling equipment shall operate without undue noise and every care shall be taken in the design and manufacture to reduce noise to the level of that obtained in good modern practice. The noise level of the transformer shall not exceed 78dB(A) when tested in accordance with IEC60076.

4.1.3.2.1.5 Radio Interference

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

4.1.3.2.1.6 Interchangeability and Parallel Operation

All transformer of any one type shall be identical and interchangeable with one another. No alteration to control circuits shall be permissible for this purpose except by means of built-in terminal boards fitted with links for effecting the alteration. All parts are to be made accurately to dimensions so that any corresponding parts will be interchangeable and any spare parts will fit into place without need of adjustments. Where similar equipment has previously been supplied, components shall interchange with those on previous contracts, unless otherwise approved.

The transformer shall be suitable for parallel master-follower operation with each other and with previously supplied transformer of similar rating which shall remain in service on the substations covered by this contract, both in respect of transformer characteristics and control circuits on all relevant taps. The new and old transformers shall share the load subject to the tolerances of impedance and voltage laid down in, IEC60076.

4.1.3.2.1.7 Insulation Levels

When assembled complete with connections as in service, electrical clearances in air shall be adequate to withstand the required impulse withstand voltage given in Project Specific Data. The Bidder shall propose in his Bid details of bushings with drawings showing air clearances and creepage distances. The creepage distance shall not be less than 31mm/kV line voltage in Coast and industrial area and 25mm/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.

4.1.3.2.1.8 Short Circuit Performance

The transformer shall be capable of withstanding, without damage, the effects of a symmetrical three-phase short circuit and a phase to earth short circuit under conditions specified in IEC 60076.

It can be assumed that during a short circuit, nominal voltage will be maintained on one side of the transformer with a short on the other, the external impedance being zero. It can also be assumed that up to four transformers may be connected in parallel between HV and MV busbars.

4.1.3.2.1.9 Frequency

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

4.1.3.2.1.10 Flux Density

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

4.1.3.2.2 Construction

4.1.3.2.2.1 General

Transformers shall be of the oil immersed “core” type (i.e. not “shell” type) suitable for outdoor use, they shall be dried out at the 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.

4.1.3.2.2.2 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 2kV, 50Hz during 1minute. The core shall be designed and built up in such a manner as to avoid accidental or slow development of short circuit paths through the iron and framework.

The core, framework, clamping arrangements and general structure of the transformer shall be of robust design, capable of withstanding any shock to which they may be subjected during transport, installation or service.

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

Lifting lugs or other similar means shall be provided for conveniently lifting the complete assembly (with windings).

Provision shall be made for efficient arrangement of guides to prevent movement of the core and windings during transport, installation or service.

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

4.1.3.2.2.3 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.

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

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

None of the materials used shall shrink, disintegrate, 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.

4.1.3.2.2.4 Internal Earthing

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

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

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

Where oil ducts or insulation parallel to the plane of the laminations divide the magnetic circuit into two or more electrically separate parts, the ducts or barriers

shall be bridged and the magnetic circuit shall not be regarded as being of sectional construction.

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

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

4.1.3.2.2.5 Transformer Tank

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

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

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

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

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

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

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

Four jacking lugs shall be fitted 500mm above ground level and four holes with a diameter of not less than 50,8mm shall be provided on the jacking lugs in order to permit the transformer to be slewed in any direction.

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

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

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

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

The tank and cooling equipment shall be designed to permit vacuum treatment on site. The maximum safe permissible vacuum (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 30seconds the full lower voltage current of the transformer, shall be provided. Provision shall be made at positions close to each of the four bottom corners of the tank for bolting the earth terminals to the tank structure to suit local conditions.

4.1.3.2.2.6 Gaskets

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

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

4.1.3.2.2.7 Current Transformer

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

Accuracy Class 3 shall be used for temperature indication.

Current transformers for protection and measurement, as indicated in scope of works, shall be mounted in the bushing turrets.

4.1.3.2.2.8 Bushings

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

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

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

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

4.1.3.2.3 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 shall be 0.16mm.

The radiator external surfaces shall only be hot-dip galvanized with a zinc deposit on average not less than 400g/m2.

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 of transformer tank 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 0.1mm. Bolts and nuts associated with galvanised parts shall be hot-dip galvanised.

4.1.3.2.4 Fittings

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

4.1.3.2.4.1 Conservator

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

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

The pipe connecting the conservator to the tank shall extend at least 50mm 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 -5ºC ambient air temperature to full load at 45ºC 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 (*Clause 4.1.3.2.4.5*) shall be fitted in this pipe in such a position that inspection, testing and dismantling is possible with the transformer in operation. A step valve shall be provided between the conservator and the relay.

The conservator shall be equipped with the following fittings:

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

4.1.3.2.4.2 Dial-type Oil Gauges

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

4.1.3.2.4.3 Silica-Gel Breathers

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

The weight of the dehydrating agent shall be not less than 0,5kg per 1500litres of oil in the transformer and cooler.

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

4.1.3.2.4.4 Explosion-Vents

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

The explosion-vent shall be provided of sufficient size for the rapid release of any pressure which may be generated within the tank and which might result in damage

to the equipment. The device if used shall be so placed that any discharge from it will not be deposited on any part of the transformer or its associated equipment.

4.1.3.2.4.5 Buchholz Relays

Buchholz relays shall be of the double-float type with separate floats for alarm and shut-down at low and high-speed gas development and shall be of approved manufacture suitable for operation in transformer oil as specified over the temperature range -10^{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 steelwork. 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.

4.1.3.2.4.6 Temperature Indicators

The local temperature indicators shall be of the dial-type graded in degrees centigrade (^{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, MV 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.

4.1.3.2.5 Cooling

4.1.3.2.5.1 Definition

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

a. Natural Air Circulation (ONAN)
   By radiators directly attached to the tank.

b. Forced Air Circulation (ONAF)
   By fans cooling the radiators.

4.1.3.2.5.2 Declaration of Ratings

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

4.1.3.2.5.3 Radiators

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

Radiators shall only 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.

4.1.3.2.5.4 Forced-Air Cooling ONAN/ONAF

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

4.1.3.2.5.5 Cooler Capacity

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

4.1.3.2.5.6 Cooler Control Equipment

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

The cooler control equipment shall include:

- An isolating switch rated to carry and break full-load current for each group of fan and pump motors.
- 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.

4.1.3.2.6 Off-load Tap Changer

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

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

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

4.1.3.2.7 Drain, Filter and Sampling Valves

4.1.3.2.7.1 General

All valves shall be attached by bolted-on flanges and shall not be screwed or welded to the tank. Drain valves or isolating valves larger than 101,6 mm (4"B.S.P.) and of the double-flanged gate-type construction may have bodies of cast iron or cast steel. All valves shall be opened by turning counter clockwise when facing the hand wheel.

Every valve shall be provided with an indicator to show clearly the position of the valve.

Means shall be provided for padlocking the valves in their open and closed position.

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

4.1.3.2.7.2 Drain Valves

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

4.1.3.2.7.3 Oil Sampling Valves

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

4.1.3.2.7.4 Filtration Connections

Filtration connections, which shall have flanges drilled to BS4504 Table 6, for 50,8mm (2") valves, or screwed 50,8mm (2"B.S.P.) female, shall be as follows:

- A valve at the top and bottom of the main tank. The drain valve of the main tank may be used for this purpose if of the size described above.
- The oil conservator drain valve located within easy reach of the ground, by means of a pipe extension if necessary shall be suitable for a filter connection.

4.1.3.2.7.5 Valve Entries

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

4.1.3.2.7.6 Rating and Diagram Plates

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

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

4.1.3.2.8 Oil

The oil shall be of the uninhibited mineral type and comply with BS148, IEC60296 or equivalent standard.

Oil shall preferably be supplied in bulk from within Kenya and dried and cleaned on site. If oil is provided in drums, these shall have a volume of approximately 200 liters and be full. A separate price shall be quoted for transformer oil.

4.1.3.2.9 On-Load Tap Changers

4.1.3.2.9.1 General

The transformer's voltage control equipment shall, if specified in Scope of Work, be of the tap changing type for varying its effective transformation ratio whilst the transformer is on load and without producing phase displacement. The on-load tap changing equipment shall comply with IEC60214. The tappings shall be arranged in the electrical center of the higher winding.

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

inside the transformer, whilst lower capacity transformers may have conventional oil type.

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

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

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

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

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

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

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

4.1.3.2.9.2 Construction

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

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

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

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

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

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

Approved means shall be provided to protect the motor and control circuits.

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

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

4.1.3.2.9.3 Operation

The tap changer shall be operated in the following modes:

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

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

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

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

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

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

4.1.3.2.9.4 Tapping Switches

The switch shall be mechanically robust and provided with a device between the handle and the switch to permit operation without strain in the event of imperfect alignment between switch and handle; the switch operating shaft shall be fully

insulated as between tank and switch and shall be provided with a suitable oil and vacuum tight gland where it passes through the tank.

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

4.1.3.2.9.5 Alarm and Trip Signals

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

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

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

4.1.3.2.10 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 95mm diameter if circular or, if rectangular have no side less than95 mm.

An indelible chart showing lubrication points and specifying recommended lubricants and frequency of application shall be provided in all mechanism cubicles.

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

4.1.3.2.11 Online Monitoring System

4.1.3.2.11.1 General Design and Construction

The power transformers with HV rating of 132kV and above, shall have the Online Monitoring System installed which will be housed in a single IP56 acquisition box, wall or stand mounted, to be placed near the transformer.

The Online Monitoring system for Power Transformer shall combine in a single system and measure the following:

- Partial Discharge (PD) in the transformer main tank and bushings;
- Relative variations of capacitance and power factor of each bushing;
- Three Gas contents (Hydrogen (H_2), Carbon Monoxide (CO) and Acetylene) in the insulating oils in the transformer main tank using photo- acoustic spectroscopy or NIR technology. The equipment shall measure each gas individually and give results in ppm. Moisture should also be measured in ppm.

The Online Monitoring system for Power Transformer shall include Online Monitoring of the following parameters for Power Transformer:

a) 3 Gas DGA measuring Hydrogen (H_2), Carbon Monoxide (CO) and Acetylene (C_2H_2) plus moisture
b) Partial Discharge of the Transformer
c) Tan Delta & capacitance of the Bushings
d) Ambient temperature
e) Top and Bottom oil temperature
f) Transformer winding moisture tracking
g) Radiator Bank Temperature monitoring

The Online Monitoring system for Power Transformer shall support the operation and maintenance of a transformer with regard to at least the following aspects:

a) With the use of sensors, sophisticated modeling and diagnostic functions it should help to detect incipient faults at an early stage, inorder to avoid a catastrophic outage of the transformer.

b) It shall provide tools which enable the user to operate a transformer close to its thermal limits, with taking into account thermal aging and avoiding critical hot spot temperature. It shall support advanced management of possible overload conditions. Unit can continuously measure other critical parameters such as oil temperatures, load current, water content in oil, and cooling status which are complementary to the DGA information.

c) It shall enable the user to perform condition-based maintenance of the transformer and have an overview at a glance about the transformer by clear visualization of transformer condition by traffic lights within software user interface and with LEDs on control cubical in the field.

The Online Monitoring system for Power Transformer shall:

- Include data storage (>1 year)
- web-server and integrated modem
- be GPS free and no active electronics placed on the top of transformer
- be connected to SCADA or DCS using known protocols such as Modbus, DNP3 or IEC61850
- support RS232, RS485, Fibre optic, 3G, Ethernet carriers
- include 3 x LED Indicators (Power, Service, Alarm) and Alarm relay contacts

The Technical Particulars of the online monitoring system includes the following:

4.1.3.2.11.2 Dissolved Gas Analysis

- Be capable of correlating 3 fault gases, moisture-in-oil, oil temperature, and ambient temperature to the transformer load
- Gas Analyzing shall be on the Photo Acoustic Spectroscopy (PAS) or NIR (Near Infra-Red) Spectro-photometry or any other competing technology without the need of any consumables.
- Be required to have a separate oil inlet pipe and separate oil return pipe to ensure quality of oil sampling.
- Have an embedded web-server to allow remote access using any smart device (such as smart phone or tablet) based on the user providing access via Ethernet or SIM.
- Not require download and install of any third party software for communication with the online DGA monitor.
- Have an on board 7 inch colour touchscreen HMI to allow review of data, graphs and the password protected control of settings.
- Supply access to Instructions on how to take a manual oil sample accessible via the touch screen HMI

4.1.3.2.11.3 Bushing Monitoring

- Bushing monitoring shall be by direct measurement of bushing capacitance and Tan Delta by Schering bridge principle. It shall be connected at the bushings Test Tap, through properly designed adaptors, including protections in order to disallow the Test Tap pin to remain floating, even with the signal cable disconnected from the adaptors.
- Provide hourly summary, indicating:
  a) Transformer Status (ON/OFF)
  b) Current Polar Plot (through web app)
  c) Relative (%) and Referenced (pf) Capacitance, Relative (%) and Referenced (%) Power Factor
  d) Top oil, Bottom oil, Tap Changer and Environmental Temperatures, plus Humidity. Data shall be provided through additional sensors added to the system

4.1.3.2.11.4 Partial Discharge Monitoring

- Each partial discharge monitoring system shall be based on UHF technique and immune from noise from electrical connections at bushings, line corona etc.
- PD monitoring should be done by providing 2 nos. of UHF sensors of drain valve type suitable for PD frequency range of 100MHz to 1500MHz with fully shielded sensor and extra port for functionality check and calibration signal.
- PD monitoring module shall be based on wide band signal processing technique and should be immune from noise by using transformer tank as faraday cage.
- The PD monitoring system should be provided with PD monitoring software for trending PD activity and generating advance warning.

4.1.3.2.11.5 Central Server

- Shall display the list and status of all monitored devices
- Allow direct connection to the monitored device and periodically retrieve the data from each monitoring device
- Display the Condition Group of each monitoring device (good, normal, defective, faulty, failure)
- Upgrade each device when a new software release is available
- Notify alarms through email
- Provide secure connection with proper user credentials and user roles

4.1.3.2.11.6 Software

The operating software used in the monitoring server shall be the multitasking and real- time operating system

The software of the monitoring IED must include and not limiting to the following:

(a) The expert system provides the user with recommendations and information to optimize the operation and maintenance of the transformer/reactor by means of algorithms for analyzing the on-line acquired variables which are implemented in the software.

(b) Dissolved gas analysis and diagnostic tool according to MSS, Doernenburg, Rogers, extended Rogers, IEC 60599, Duval and Key Gas.

(c) Report generator, which automatically creates protocols with status information about the transformer and its main component.

(d) Each monitoring unit to come with two laptops for report generation and analysis and module shall be equipped with Ethernet / USB port and communication cable to facilitate communication to a laptop.

4.1.3.2.11.7 Operation

The tap changer shall be operated in the following modes:

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

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

Parameter	**Requirement**	
Input Power	Mains power supply	90 - 250 VAC, 47 - 63 Hz, 300W max
Dissolved Gas Analysis	H_2	5 - 5,000 PPM
	C_2H_2	0.1 – 50,000 PPM
	CO	1 – 50,000 PPM
	H_20 (RS)	1 - 100% RS
	Accuracy	± 5% or ± LDL (whichever is greater)
Bushing Monitoring	Input channels	2 sets of 3 phases, simultaneous acquisition on all channels
	Simultaneous channels	3 (up to 6)
	Sensors	Bushing Tap Adaptors
	Input measuring range	0 - 200mA

Parameter	Requirement	
	Accuracy	Amplitude: 0.1%, Relative Phase Angle: 0.05°
	Resolution	12 bit
	Sampling rate	>10 kS/s
	Power system frequency	50 - 60Hz, ± 0.01 Hz
Communication Options	Protocols	Modbus, DNP3 & IEC61850
	Carriers	RS232, RS485, Ethernet, Fiber, 3G
	HMI	7" High Resolution Colour LCD
DATA- Partial Discharge and Bushing	Acquisition mode	Continuous
	Trending	Hourly, daily, weekly, monthly
	Storage	> 1 year
Alarms	High-vis LED's	Red, Amber, Green
	Alarm relay contact	4 x NO or NC, user configurable
I/O	Analog inputs	3 x PT100, 3 x 4 - 20 mA, 1 x Load CT
	Digital inputs	5 x 24V isolated

4.1.3.2.11.8 TESTS REQUIREMENTS

The Online Monitoring system for Power Transformer shall be inspected and tested in accordance with standards and this specification. It shall be the responsibility of the manufacturer to perform or to have performed all the tests specified. Tenderers shall confirm the manufacturer's capabilities in this regard when submitting tenders. Any limitations shall be clearly specified.

4.1.3.2.12 Condition Controlled Maintenance Free Type Breather

4.1.3.2.12.1 General Design and Construction

The main Transformer tank and On-load Tap Changer conservators of Power Transformers with HV ratings of 132kV and above shall be fitted with a Maintenance-Free type silica gel Breathers which shall be equipped with a humidity sensor, a condition based microprocessor control unit and LED status indication.

The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.

The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.

The material & external construction of the breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oll, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0° C to +80°C. Degree of Protection shall be at least IP55

The Breather shall be equipped with test button which should allow carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time. It will also have LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:

All necessary software required for downloading and analyzing the logger data shall also be provided by the supplier. Control unit shall be equipped with a USB / RS 485 port for downloading the operational data logged by the unit.

The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied with the equipment. Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference. The control unit shall be equipped with suitable heater to prevent moisture condensation.

4.1.3.2.13 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.

4.1.3.2.14 Manufacturing, Inspections and Tests

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

4.1.3.2.14.1 Inspection/Witnessing of Tests

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

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

4.1.3.2.14.2 Factory Tests

Transformer Tests

a) 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.

b) Routine Tests

Routine tests as far as applicable shall be carried out according the IEC Publication 60076.

The following routine tests shall be applied to all power transformer:

- Resistance measurements of all windings at all tappings.
- Ratio tests for all tappings and vector relationship tests.
- Measurement of no-load losses and currents.
- Measurements of impedance voltages (at maximum, principal and minimum tappings), short circuit impedances and load losses. Load losses shall be measured at both rated currents when ONAN and ONAF cooling are specified.
- Determination of efficiencies at 50%, 75%, 100% and 120% load at maximum temperature of the winding and 0.8 power factor lagging and unity power factor for all ratings (ONAN, ONAF ratings).
- Zero sequence impedance measurement.
- Induced voltage and separate source voltage withstand power frequency, dielectric tests on all windings on all phases including neutral points.
- Full wave impulse withstand tests. The transformer shall be subjected to a complete series of tests. Such tests shall be applied to the HV winding line terminal of each phase as well as to the neutral points.

  Tests on on-load tap changers.
- Routine tests on all transformer accessories such as motors, contactors wiring, etc.
- Partial discharge measurements.
- Measurements of capacity between the windings and each winding and ground.
- Oil leakage test. The complete oil filled transformer with bushings and radiators fitted and any other attachment normally in contact with oil shall be tested at a positive pressure measured at the tank bottom of twice the column of oil in the transformer when the transformer is cold, but in any case not less than 70kPa. Alternatively the radiators may be tested separately with the same pressure. The test period shall be not less than 12 hours.
- Core insulation test, 2 kV, 50 Hz for one minute.

c) 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.

d) Type Tests

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

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

4.1.3.2.14.3 Site Tests

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

Tests shall include but not be limited to the following:
- Dielectric oil tests.
- Insulation dryness by an agreed method.
- Electrical and functional control of voltage control equipment and cooling system.
- Core to tank insulation.

4.1.3.2.15 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.

4.1.3.2.16 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.

4.1.3.2.17 Evaluation of Losses and capitalization

4.1.3.2.17.1 Guaranteed Output and Losses, Liquidated Damages

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

4.1.3.2.17.2 Transformer Output

If the guaranteed continuous output at rated voltage of any transformer has to be reduced below the guaranteed value in order to maintain the temperature rises of any part of the transformer within the guaranteed limits, liquidated damages shall be paid at the rate of USD 2 577 per kVA.

4.1.3.2.17.3 Transformer Losses

If the total transformer losses of any transformer, as determined by these, without any tolerances, at rated voltage, frequency and 100% rated kVA (on principal tapping) exceed the guaranteed total losses, the excess in losses shall be 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.

4.1.3.2.17.4 Rejection Limits

Should any transformer fail to meet the guaranteed output by more than 5% (five per cent) or the total losses should exceed the total guaranteed losses by more 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.

4.1.3.2.17.5 Evaluation of Losses

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

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

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

4.1.3.2.18 Transformer Drawings

The following shall be included with the Bid:

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

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).

b) Drawings showing the arrangement of the core and windings including core clamping arrangement.

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

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

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

f) Drawings of proposed rating and diagram plates.

g) Catalogues of all accessory equipment and fittings.

4.1.3.3 Distribution and Auxiliary Transformers

4.1.3.3.1 General

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

4.1.3.3.2 General Design

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

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

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

ii) With voltage applied up to 10% more than the rated tapping voltages and without injurious overheating.

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

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

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

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

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

i) Unless otherwise approved, sealing shall be effected by means of a bolted cover design employing 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.

4.1.3.3.2.1 Windings

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

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

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

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

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

4.1.3.3.2.2 Cores

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

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

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

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

4.1.3.3.2.3 Tapping Switches

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

A fully insulated off-circuit, externally manually operated ganged tapping switch shall be supplied, capable of withstanding the specified impulse voltage when connected to the transformer windings.

Clearly visible tap position indication shall be provided. The tapping switch shall be operated by means of an external handle that can be positively located and locked in each operating position.

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

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

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

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

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

4.1.3.3.2.4 Outdoor Bushings

All line terminals and neutral connections where specified, shall be brought out to porcelain outdoor type terminal bushings in accordance with DIN 4253 with minimum creepage distance 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.

4.1.3.3.3 Tanks and Conservators

4.1.3.3.3.1 General

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

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

All external surfaces and parts made of steel are to be thoroughly shot blasted and cleaned, after which two coats of priming paint, preferably of zinc chromate, one

intermediate coat and one coat of finishing paint are to be applied. The 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.

4.1.3.3.3.2 Tanks

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

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

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

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

4.1.3.3.3.3 Conservators

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

The fittings detailed in Table 1, shall be provided on all transformer conservators.

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

Oil level gauges on conservator tanks shall be of the refracting plate glass or other approved type, marked with the level at 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.

4.1.3.3.3.4 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

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

Y = Required N = Not Required

4.1.3.3.3.5 Insulating Oil

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

4.1.3.3.4 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.

4.1.3.3.5 Packing and Transport

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

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

4.1.3.3.6 Drawings and Diagrams

4.1.3.3.6.1 To be submitted 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:

a) General arrangement drawing of each rating of transformer offered showing: -

i) Minimum clearance (phase to phase and phase to earth) on H.V. and L.V. bushings including clearance H.V. to L.V.

ii) Positions and identification in a separate legend of all fittings with type numbers.

iii) Size and position of all fixing holes.

iv) Total weights with and without oil and core lifting height and weight.

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

c) Detailed dimensioned drawing of bushings, silica gel or plain oil seal type breather, and conservator.

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

4.1.3.3.6.2 To be submitted with Contract

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

Rating and diagram plate drawing shall be supplied.

4.1.3.3.7 Evaluation of Losses

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

SECTION VI

4.1.4 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

CIVIL WORKS

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4.1.4 PARTICULAR SPECIFICATION – SUBSTATION CIVIL WORKS

4.1.4.1 General

4.1.4.1.1 Summary and Location of the Works

The works to be constructed include the following:

4.1.4.1.2 132kV Substation

4.1.4.1.2.1 132/xxx kV Transformer Bay/ Line Bay/Bus Bar/Bus Section/Bus Coupler Bay

One complete 132kV / xxx kV Transformer Bay (HV & MV) shall be constructed as follows:

a. Site clearance and disposal of spoil from site.
b. Bulk Earthworks and Platform establishment (cut, back fill, rock excavation, black cotton excavation and disposal, compaction, area grading, gabions, retaining walls, ballasting) of entire plot.
c. Design and construction of a reinforced concrete transformer plinth for the new 23 MVA, 132/33 kV power transformer. The plinth shall be designed to accommodate a future 45 MVA transformer, complete with an oil containment bund, an oil interceptor pit and an oil–water separator.
d. Equipment foundations in reinforced concrete.
e. Erection of substation equipment steel support structures and bay gantries
f. Control building with a minimum floor area of 350sq meters
g. Internal access roads -paved
h. External access road improvement (acceleration and deceleration lanes at tarmac road junction, culverts/drift, drainage)
i. Parking lot and offloading bay
j. Reinforced concrete cable trenches and ducts at crossings
k. Internal and External Storm water Drainage
l. Area grading and ballasting layer
m. Site restoration and landscaping work
n. Chain-link perimeter fence for the entire plot perimeter with minimum 2no separate gates with electric fence and razor wire
o. Internal Chain link demarcating live areas from unauthorized access (office, yard and guardhouse)
p. Lightning protection and earthing system
q. Switchyard lighting including solar lamps as per electrical specification
r. Addressable fire protection system
s. Equipment erection and commissioning
t. Any other works necessary for full completeness of the facility civil works scope.

4.1.4.1.2.2 132kV Control Building_ Outdoor Switchgear

The control building shall contain the following rooms:

a) Control and protection Panel room to accommodate the necessary Protection and control panels and space for future expansion (One more bay for transformer and two Lines)
b) Battery and Battery charger room (to accommodate both protection and communication batteries and chargers)
c) AC and DC distribution boards room
d) Control Office room with furniture (document storage cabinets, chairs, key rack, and office tables) minimum
e) Kitchen with cabinets, dish rack, oven cooktop and sink
f) Communication equipment room
g) 2 no. washrooms with gender separation and showers with ramp access
h) Store room for spares
i) Electrical system, Plumbing, air conditioning system and fire protection system (detection and suppression)

j) Appropriately placed emergency doors
k) Sloped roof with fire retardant ceiling and insulation
l) Rainwater harvesting, storage and reticulation system minimum capacity of 5,000 litres elevated and 10,000-liter ground mounted water tank with connection to nearby county water supply system with metering
m) Foul water/sewerage drainage including septic tank/connection to existing sewer line
n) Storm water management system
o) Fireproof doors and tempered burglar proof windows
p) Emergency lighting
q) All the rooms shall be pressurized to avoid dust
r) Minimum area for the Control building without Indoor switchgear shall be 350 square meters. With indoor switchgear shall be minimum 450square meters

4.1.4.1.3 66 kV Substation

4.1.4.1.3.1 66 kV Transformer Bay/ Line Bay/Bus Bar/Bus Section/Bus Coupler Bay

One complete 66kV / xxx kV Transformer Bay (HV & MV) shall be constructed as follows:

a. Site clearance and disposal of spoil from site.
b. Bulk Earthworks and Platform establishment (cut, back fill, rock excavation, black cotton excavation and disposal, compaction, area grading, gabions, retaining walls, ballasting) of entire plot.
c. Design and construction of a reinforced concrete transformer plinth for the new 10 MVA, 66/33/11 kV power transformer. The plinth shall be designed to accommodate a future 23 MVA transformer, complete with an oil containment bund, an oil interceptor pit and an oil–water separator.
d. Equipment foundations in reinforced concrete.
e. Erection of substation equipment steel support structures and bay gantries
f. Control building with a minimum floor area of 350sq meters
g. Internal access roads -paved
h. External access road improvement (acceleration and deceleration lanes at tarmac road junction, culverts/drift, drainage)
i. Parking lot and offloading bay
j. Reinforced concrete cable trenches and ducts at crossings
k. Internal and External Storm water Drainage
l. Area grading and ballasting layer
m. Site restoration and landscaping work
n. Chain-link perimeter fence for the entire plot perimeter with minimum 2no separate gates with electric fence and razor wire
o. Internal Chainlink demarcating live areas from unauthorized access (office, yard and guardhouse)
p. Lightning protection and earthing system
q. Switchyard lighting including solar lamps as per electrical specification
r. Addressable fire protection system
s. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope

4.1.4.1.3.2 66kV Control Building_ Outdoor Switchgear

The control room building shall contain the following rooms:

a) Control and protection Panel room to accommodate the necessary Protection and control panels and space for future expansion (One more bay for transformer and two Lines)
b) Battery room (to accommodate both protection and communication batteries)
c) AC and DC distribution boards and battery chargers' room
d) Control Office room with furniture (document storage cabinets, chairs, key rack, and office table) minimum

e) Kitchen with cabinets, dish rack, oven cooktop and sink
f) Communication equipment room
g) 2 no. washrooms with gender separation and showers with ramp access
h) Store room for spares
s) Electrical system, plumbing, air conditioning system and Fire protection system (detection and suppression)
i) Appropriately placed emergency doors
j) Sloped roof with fire retardant ceiling and insulation
k) Rainwater harvesting, storage and reticulation system minimum capacity of 5,000 litres elevated and 10,000-liter ground mounted water tank with connection to nearby county water supply system with metering
l) Foul water/sewerage drainage including septic tank/connection to existing sewer line
m) Storm water management system
n) Fireproof doors and tempered burglar proof windows
o) Emergency lighting
p) All the rooms shall be pressurized to avoid dust
q) Minimum area for the Control building without Indoor switchgear shall be 120 square meters.

4.1.4.1.3.3 66/33kV or 33/11kV Control Building_ Indoor Switchgear

The control room building shall contain the following rooms:

a) Indoor Switchgear room
b) Control and protection Panel room to accommodate the necessary Protection and control panels and space for future expansion (One more bay for transformer and two Lines)
c) Battery room (to accommodate both protection and communication batteries)
d) AC and DC distribution boards and battery chargers' room
e) Control Office room with furniture (document storage cabinets, chairs, key rack, and office table) minimum
f) Kitchen with cabinets, dish rack, oven cooktop and sink
g) Communication equipment room
h) 2 no. washrooms with gender separation and showers with ramp access
i) Store room for spares
t) Electrical system, plumbing, air conditioning system and Fire protection system (detection and suppression)
j) Appropriately placed emergency doors
k) Sloped roof with fire retardant ceiling and insulation
l) Rainwater harvesting, storage and reticulation system minimum capacity of 5,000 litres elevated and 10,000-liter ground mounted water tank with connection to nearby county water supply system with metering
m) Foul water/sewerage drainage including septic tank/connection to existing sewer line
n) Storm water management system
o) Fireproof doors and tempered burglar proof windows
p) Emergency lighting
q) All the rooms shall be pressurized to avoid dust
r) Minimum area for the Control building with Indoor switchgear shall be shall be minimum of 250 square meters

4.1.4.1.4 33kV Substation

4.1.4.1.4.1 33 kV Transformer Bay/ Line Bay/Bus Bar/Bus Section/Bus Coupler Bay

One complete 33kV / xxx kV Transformer Bay (HV & MV) shall be constructed as follows:

a. Site clearance and disposal of spoil from site.

b. Bulk Earthworks and Platform establishment (cut, back fill, rock excavation, black cotton excavation and disposal, compaction, area grading, gabions, retaining walls, ballasting) of entire plot.
c. Design and construction of a reinforced concrete transformer plinth for the new 2.5 MVA, 33/11 kV power transformer. The plinth shall be designed to accommodate a future 10 MVA transformer, complete with an oil containment bund, an oil interceptor pit and an oil–water separator.
d. Equipment foundations in reinforced concrete.
e. Erection of substation equipment steel support structures and bay gantries
f. Control building with a minimum floor area of 120 sq meters
g. Internal access roads -paved
h. External access road improvement (acceleration and deceleration lanes at tarmac road junction, culverts/drift, drainage)
i. Parking lot and offloading bay
j. Reinforced concrete cable trenches and ducts at crossings
k. Internal and External Storm water Drainage
l. Area grading and ballasting layer
m. Site restoration and landscaping work
n. Chain-link perimeter fence for the entire plot perimeter with minimum 2no separate gates with electric fence and razor wire
o. Internal Chainlink demarcating live areas from unauthorized access (office, yard and guardhouse)
p. Lightning protection and earthing system
q. Switchyard lighting including solar lamps as per electrical specification
r. Addressable fire protection system
s. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope

4.1.4.1.4.2 33kV Control Building _Outdoor Switchgear

The control room building shall contain the following rooms:

a) Control and protection Panel room to accommodate the necessary Protection and control panels and space for future expansion (One more bay for transformer and two Lines)
b) Battery room (to accommodate both protection and communication batteries)
c) AC and DC distribution boards and battery chargers' room
d) Control Office room with furniture (document storage cabinets, chairs, key rack, and office table) minimum
e) Kitchen with cabinets, dish rack, oven cooktop and sink
f) Communication equipment room
g) 2 no. washrooms with gender separation and showers with ramp access
h) Store room for spares
u) Electrical system, plumbing, air conditioning system and Fire protection system (detection and suppression)
i) Appropriately placed emergency doors
j) Sloped roof with fire retardant ceiling and insulation
k) Rainwater harvesting, storage and reticulation system minimum capacity of 5,000 litres elevated and 10,000-liter ground mounted water tank with connection to nearby county water supply system with metering
l) Foul water/sewerage drainage including septic tank/connection to existing sewer line
m) Storm water management system
n) Fireproof doors and tempered burglar proof windows
o) Emergency lighting
p) All the rooms shall be pressurized to avoid dust
q) Minimum area for the Control building without Indoor switchgear shall be 120 square meters.

4.1.4.1.4.3 11 kV Bays

One complete 11kV bay shall be constructed as follows:

a. Equipment foundations in reinforced concrete.
b. Erection of substation equipment steel support structures and bay gantries
c. Internal access roads -paved
d. Reinforced concrete cable trenches and ducts at crossings
e. Storm water Drainage
f. Area grading and ballasting layer
g. Site restoration and landscaping work
h. Chain-link perimeter fence for the entire plot perimeter with minimum 2no separate gates
i. Lightning protection and earthing system
j. Switchyard lighting including solar lamps as per electrical specification
k. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope

4.1.4.1.4.4 11kV Auxiliary Supply Transformer Bay

One complete 11kV Auxiliary Supply Transformer bay shall be constructed as follows:

a. Equipment foundations in reinforced concrete.
b. Erection of equipment steel support structures
c. Reinforced concrete cable trenches and ducts at crossings
d. Lightning protection and earthing system
e. Switchyard lighting including solar lamps as per electrical specification
f. Equipment erection and commissioning

Any other works necessary for full completeness of the facility civil works scope

4.1.4.1.5 33 kV Switching Station

a) Site clearance and disposal of spoil from site.
b) Earthworks (cut, back fill, compaction, area grading and ballasting) of entire plot.
c) Equipment support structures and bay gantries.
d) Prefabricated Control building adequate for the facilities
e) Access roads
f) Reinforced concrete cable trenches and ducts
g) Area drainage
h) Ballasting layer of 100 mm thickness
i) Site restoration and landscaping work
j) Chain-link fence for the entire plot
k) Lightning protection and Earthing system
l) Switchyard lighting
m) Equipment erection and commissioning
n) Any other works necessary for full completeness of the facility civil works scope

4.1.4.1.6 Other Buildings

4.1.4.1.6.1 Separate Office Building (As per Scope)

In addition to the Control/Switchgear Building, the Contractor shall design and construct a separate single-storey Staff Office Building within the substation plot. It shall have a floor area of not less than 50 m². All materials and workmanship shall comply with the Particular Specifications for Substation Civil Works and the applicable Kenyan building regulations and standards. The Contractor shall separate the Office Building from the HV Switchyard with a chain-link fence and a lockable gate. Staff shall be able to reach the Office Building without entering the switchyard.

a) an open office with a demarcated area for the Supervisor/Manager and furniture (document storage cabinets, chairs, key rack, and office table) minimum 50sqm

b) Kitchen with with base and wall cabinets, a dish rack, an oven with cooktop, and a sink with drainer
c) 2 no. washrooms with gender separation and showers with ramp access
d) Store room with lockable door
v) Electrical system, plumbing, air conditioning system and Fire protection system (detection and suppression)
e) Appropriately placed emergency doors
f) Sloped roof with fire retardant ceiling and insulation
g) Rainwater harvesting, storage and reticulation system minimum capacity of 1,000 litres elevated
h) Foul water/sewerage drainage including septic tank/connection to existing sewer line
i) Storm water management system
j) Airconditioning
k) Electrical and Plumbing
l) Fireproof doors, emergency door and tempered burglar proof windows and fire protection
m) Emergency lighting
n) Minimum area for the Control building without Indoor switchgear shall be 120 square meters.

Before starting construction, the Contractor shall submit the design drawings, room layouts, service layouts and material samples to the Project Manager for review and approval. The Contractor shall bear all costs of complying with this clause, and these costs shall be deemed included in the Contract Price.

4.1.4.1.6.2 Guardhouse

Demarcated guardhouse with washroom facilities min area 50sqm and :

a) Furniture floor mounted storage facility with locking facility and serving the various gate
b) 2 no. washrooms with gender separation and showers with ramp access
c) Store room with lockable door
w) Electrical system, plumbing, air conditioning system and Fire protection system (detection and suppression)
d) Appropriately placed emergency doors
e) Sloped roof with fire retardant ceiling and insulation
f) Rainwater harvesting, storage and reticulation system minimum capacity of 1,000 litres elevated
g) Foul water/sewerage drainage including septic tank/connection to existing sewer line
h) Stormwater management system
i) Airconditioning
j) Electrical and Plumbing
k) Fireproof doors, emergency door and tempered burglar proof windows and fire protection
l) Emergency lighting

4.1.4.1.7 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.
The contractor shall prepare a civil worksite methodology before commencement of works. An updated works program to be always availed on site

4.1.4.1.8 Stages

The following shall guide:

- Preliminary Design (Topographical Survey, Geotechnical Investigations, Hydrological Survey, Statutory Approvals, Civil Works Methodology, Standard

Operating Procedures, Quality Management Plan, Safety, Health and Environment Plan, Organogram)
- Design Stage (Relevant Standards and Specifications, Drawings and Designs, Revision of Drawings, Statutory Approvals/Requirement)
- Construction Stage (Mandatory inspections, Routine inspection, Factory and Site acceptance tests, Hold points, Works Program, Communication plan, quality assurance)
- Closure (As-built drawings, Water Supply and Electricity Supply account transfer to KPLC.)

An updated works program to be always available on site.

4.1.4.1.9 Documentation, Drawings and Designs

Any drawings issued with these documents are for tendering purposes only.

The Contractor's obligations with regard to preparation and submission of drawings, calculations, samples, patterns, models etc. are stated in the Conditions of Contract. The Contractor shall prepare and submit to the Project Manager for approval dimensioned general and detailed design drawings and other pertinent information of all the Civil works specified in the Bid Documents accompanied by relevant design calculations. Designs shall be carried out in accordance with standards and specifications applicable in Kenya, including but not limited to British Standards, Eurocodes, ASTM, The National Building Code 2024, Kenya Roads Design Manual etc.
Drawings shall be submitted in soft and hard copies as per Conditions of Contract. A laminated hard copy of approved designs shall be displayed in the site office for access by the Project Manager. The Contractor shall also provide relevant design software with a laptop to the Project Manager for Civil works design.

On completion of the project and as a condition before issuance of the Taking Over Certificate, As-built documents shall be submitted for filing ato allow Operations and Maintenance and shall at least contain the following information as described under "Final Documentation" of GCC:
- Detailed description of the civil works, the individual components, relevant clearances, tolerances, allowable temperatures, settings, sizes etc.
- Descriptions of main civil works including earthworks, subsurface structures, terrestrial structures, drainage, cabling, road layouts, lightning protection, substation lighting, fire protection systems etc.
- Operational instruction. These shall illustrate the operational sequences in a clear and concise way in a manual (drainage cleaning, oil separator desludging, roof/gutter, HVAC, fire systems, electric fence, water system) with maintenance schedules
- Test reports
- As-built drawings (DWG, PDF, GIS shapefiles) before Taking Over;
- Warranties register
- Training of KPLC staff with attendance records
- Keys register

4.1.4.1.10 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.

4.1.4.1.11 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 organization and staff proposed to direct and administer the performance of the Works.
The information to be supplied to the Project Manager shall include Drawings showing the general arrangements of his temporary offices, camps, storage sheds, buildings and access roads, and details of Constructional Plant and Temporary Works proposed.

The contractor shall provide a design for a Works signboard for review by the Project Manager.

4.1.4.1.12 Site Office

The contractor shall provide a suitable temporary office, with a room capable of holding meetings, a Project Managers office (furnished with desk, cabinet, phone, printer), and clean toilet facilities. Drinking water, site instruction book, visitors book, weather chart and safety occurrence/ toolbox minutes book, and PPEs shall be provided on site for access to Project manager within all working hours. Approved working drawings shall be laminated and displayed on site.

4.1.4.1.13 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.

4.1.4.1.14 Dealing with Water

The Contractor shall keep the whole of the Works free from water and he will be deemed to have included in the Contract Price doors 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.

4.1.4.1.15 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.

4.1.4.1.16 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.

4.1.4.1.17 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.

4.1.4.1.18 Water Supplies for the Works

The Contractor shall make his own arrangements for the supply of palatable water for his staff on site, the Project Management Team and water for the Works.

The Contractor must make all arrangements including the supply of pumps and motors, 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 utilizing any water source for the Works. The contractor shall connect the site to main water supply on completion of works..

4.1.4.1.19 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.

4.1.4.1.20 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.

4.1.4.1.21 Survey Beacons

During the progress of the Works, the Contractor shall not remove, damage, alter or destroy in any way any permanent beacons or survey beacons. Should the Contractor consider that any survey beacon will be interfered with by the Works, he will notify the Project Manager, who, if he considers necessary, will make arrangements for the removal and replacement of the beacon.

If the Contractor removes or disturbs a beacon without the prior permission of the Project Manager, he shall be liable for the full cost of its replacement together with the full cost of re-establishing the data relevant to it. The contractor shall establish the beacons once handed over the site.

4.1.4.1.22 Basic Survey and Setting Out

The Contractor shall appoint a suitably qualified Surveyor to set out the Works from the beacons and shall plot cross sections at 10 m intervals and submit to the Project Manager for approval. The Contractor will survey the sites provided in detail, and the exact locations shall be agreed with the Project Manager. The details of beacons and benchmarks shall be provided in the site survey drawings.

4.1.4.1.23 Design life and Service Conditions

The Contractor is required to design and construct the works so that they are fit for the purpose specified by the Employer to satisfy a level of durability and functionality that extends over a minimum of 50 years or as specified by the design life of the station transformer or relevant critical equipment. Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice and shall comply to Local and Regional codes of practice. Necessary safety factors shall be included. The service conditions shall be as per the conditions of contract

4.1.4.1.24 Spare parts and Tools for operations and maintenance

The Contractor shall provide mandatory civil spares as per the Employer’s requirement

4.1.4.1.25 Facility Handover to the employer.

The contractor shall submit water and electricity accounts documents closure or transfer to the employer project manager during facility handover or before issuance of completion certificate.

The contractor shall also prepare a handover pack: warranties (roof, waterproofing, paint, AC, fence energiser, CCTV), certificates (NCA compliance, occupation, fire safety audit, electrical installation), keys and access cards register, as-builts and O&M (Section A).

4.1.4.2 CIVIL CONSTRUCTION MATERIALS FOR THE WORKS

4.1.4.2.1 General

All materials shall comply with appropriate local or regional standards unless otherwise required hereinafter. Such standards shall be to the approval of the Project Manager.

The Contractor shall before placing any order for materials or manufactured articles for incorporation in the Civil Works, submit details of the manufacturers or suppliers for the approval of the Project Manager. The manufacturer or supplier shall submit samples, technical data sheets, type tests or all necessary details for approval as required by the Project Manager.

4.1.4.2.2 Preliminary Survey

4.1.4.2.2.1 Topographical survey

The contractor shall carry out a detailed land survey to demonstrate the shape, elevation and features of the site, including both natural and man-made elements. The contractor shall collect data on the spatial locations, coordinates and elevations of relevant features within the site plot and the surrounding area. Important information to include neighbouring plots, data for terminal drainage points, nearest main road and capture all existing services (overhead, terrestrial and underground).

4.1.4.2.2.2 Geotechnical survey investigation

The contractor shall collect all data he deems necessary for preparation of his bid. The Contractor shall include in his prices the price of rock or if encountered.
The contractor shall carry out a detailed examination of the site's surface and subsurface soil and rock conditions to assess its suitability for construction. This survey shall involve collection and analysis of material samples, and assessment of groundwater levels to guide earthworks, drainage and foundation designs. The contractor shall submit a method statement for the investigations, procedures, depths, analysis methods, tools and equipment and identifying locations for sample collection and tests. This shall be reviewed by the Project Manager before commencement of works.
The sub-soil tests shall be carried out by any method as stated hereafter under the supervision of a qualified person, who shall be subject to approval of the Project Manager. Any boulder rocks encountered shall be removed completely. The geotechnical investigation shall also be required to provide swell, PI and shrinkage tests. Design treatment shall be carried out as per results: full removal and replacement, lime or cement stabilisation, moisture barriers, or piled/under-reamed foundations for buildings and heavy plinths. Removal depth of expansive material shall be governed by the active zone.

4.1.4.2.2.3 Hydrological Survey Investigation

The Contractor shall carry out a hydrological survey and investigation of the substation site, surrounding catchment areas and proposed access roads to establish the existing drainage patterns and assess potential surface runoff and flood risks. The investigation shall include catchment delineation, analysis of historical rainfall data, identification of natural watercourses and drainage paths, assessment of historical flooding, estimation of peak runoff rates and identification of suitable storm water discharge points.

The findings shall inform the design of storm water drainage systems, culverts, outfalls, erosion protection and flood mitigation measures to ensure adequate drainage of the substation site and access roads without adversely affecting adjoining properties or existing drainage systems.

The Contractor shall submit a Hydrological Investigation Report, including relevant maps, rainfall data, hydrological calculations, identified flood risks and recommendations, to the Project Manager for review and approval before finalisation of the detailed drainage designs.

4.1.4.3 EARTHWORKS

4.1.4.3.1 Bush Clearing

The areas of the platform and borrow pit shall be cleared of all trees, vegetation and roots. These shall be neatly stockpiled within 3 km of the site at locations agreed with the Project Manager and shall remain the property of the land owner.
Any structures on site to be demolished and removed by the contractor and to be included in the price schedule.

4.1.4.3.2 Removal of Top Soil

The top soil within the areas of platform and shall be stripped to an approximate depth of 200 mm and stockpiled at locations agreed with the Project Manager for later use on embankment slopes. Any top soil that shall not be reused shall be dumped at the designated local authority dump sites. Overburden in the borrow pit shall also be stripped to a depth specified by the Project Manager and stockpiled for later use in rehabilitation.

4.1.4.3.3 Classification of Materials

Earthworks shall be under the contractors' scope and considered fully priced by the contractor. The contractor shall familiarize with site conditions before tendering.

4.1.4.3.4 Order of Work

The construction of cuttings, side drains and embankments shall proceed in a methodical and orderly manner. It shall be solely the Contractor's responsibility to arrange his methods and programme of work so as to ensure that the earthworks are carried out by the most efficient and economical method possible with the type of plant employed on the Works.

All trimming of cuttings, and embankments, drains and shoulders to the specified slopes and shapes, shall be carried out concurrently with the earthworks that are being carried out at that particular site and level.

4.1.4.3.5 Fill Material

"Fill-material" shall mean material deposited in accordance with these specifications from any of the classes specified in order to build up an earthworks construction to formation level as shown on the Drawings or as ordered by the Project Manager. The Contractor shall obtain the fill material from a source approved by the Project Manager.

Fill materials will generally be obtained from cuttings. If the material obtained from this source is insufficient or unsuitable extra material shall be obtained from borrow areas. All fill material (other than rock fill in lower layers) shall pass 75mm BS sieve size.

The following materials are generally unsuitable for construction of fills.

- All materials containing more than 5% by weight of organic matter (such as top soil, materials from swamps, plants and vegetable matter)
- All expansive soils such as black cotton soils with swells of more than 3% as measured in the CBR test.
- All clay soils with plasticity index exceeding 50.
- All materials having a moisture content of 105% of the optimum moisture content (standard compaction)

Rock fill can be used provided that boulders greater than 0.2 m3 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.

4.1.4.3.5.1 Compaction of fill

Materials other than rock fill shall be placed in layers of compacted thickness not exceeding 300 mm. Thicker layers can only be permitted where very heavy compacting equipment is available and trial sections have proved that the required compaction will be readily achieved over the layer depth. The minimum layer thickness shall be twice the maximum particle size of the compacted material.

Fill material shall be compacted throughout to a dry density of at least 95% MDD at OMC (standard Compaction AASHTOT99) except the top 300 mm of the fill which shall be compacted to 100% MDD (AASHTO T99).

Where rock fill is used it should be placed in the bottom of the embankment. The largest sizes shall be placed in layers of 1.0 meter thick. The interstices shall then be filled with smaller rocks and approved filler material. The whole layer shall then be compacted until the interstices are completely filled or until the required settlement is obtained. Heavy vibratory rollers are generally the most suitable machines for compacting rock fill.

The specified compaction shall be achieved over the full width of the embankment. Any area inaccessible to the roller shall be consolidated and compacted using approved mechanical tampers.

4.1.4.3.5.2 Compaction of in situ Sub grades

After removing the top soil and/or 600 mm minimum thickness (or as determined by geotechnical report) of unsuitable /expansive soils and before placing fill, improved sub grade or gravel wearing course, the upper 300 mm of in situ sub grade will be compacted to 100% MDD standard compaction. Compaction in cuts without improved sub grade will likewise be compacted to 100% MDD standard compaction

4.1.4.3.6 Spoil Material

"Spoil-material" shall mean material excavated in accordance with these specifications from any of the classes specified, and which, being obtained from the excavation of side drains, cuttings or below the road embankment is unsuitable for the requirements of the Works. Spoil material shall be removed from the Site to a spoil tip which should be to a site acceptable by respective local authorities and shall be approved by the Project Manager.

4.1.4.3.7 Expansive Material

The Contractor shall excavate and remove all expansive (black cotton) soils within the substation platform, foundations, cable trench routes, internal roads and other

areas shown on the drawings or directed by the Engineer, to the depth established by the geotechnical investigation, presently estimated at a minimum depth of 600mm below existing ground level, or until a firm, non-expansive stratum approved by the Engineer is reached.

Excavated material shall be classified as unsuitable and shall be carted away and disposed of at a licensed spoil site off the site. The excavation shall be backfilled with approved granular material (gravel/murram) placed in layers not exceeding 150 mm compacted thickness, each layer compacted to not less than 95% MDD (AASHTO T180).

The Contractor shall provide all necessary support to excavation faces, dewatering and keeping excavations free of water. He shall also arrange for levels to be taken jointly with the Engineer before and after excavation for measurement purposes. Final depths shall be confirmed on site by the Engineer, and quantities shall be measured as excavated.

Material removed may be stockpiled for later use in slope protection or spoiled to a tip as instructed by the Project Manager.

4.1.4.3.8 Surplus Material

"Surplus-material" shall mean material excavated in accordance with these specifications from any of the classes specified and which is temporarily surplus to the fill requirements and shall be carted to a designated stockpile for re-use later elsewhere in the Works, or to an approved spoil tip.

4.1.4.3.9 Side Drains

Where side drains are required excavating the lines, slopes and widths as designed by the Contractor and approved by the Project Manager shall shape them. The side drains shall be finished off so that the formation levels and camber or super elevation of the formation, level and cross fall of the shoulders, and shape and invert levels of the side drains are everywhere in accordance with the Drawings.

Any excess depth or width excavated from the side drains shall be backfilled and made good to the satisfaction of the Project Manager at the Contractor's expense.

All other types of drains are specified separately in this Specification.

4.1.4.3.10 Excavation in "Rock"

The Contractor shall excavate rock wherever it is encountered in foundations, trenches, cable ducts, drainage channels and platform formation, to the lines, levels and dimensions shown on the drawings or as directed by the Engineer.

For measurement and payment purposes, rock means any material that, in the opinion of the Engineer, can only be removed by blasting, by pneumatic or hydraulic breakers, or by wedging and splitting. Boulders or detached masses of rock exceeding 0.25 m^3 in volume also count as rock. Material that can be removed by an excavator or by hand tools (pick and shovel) is not rock, however hard it is to excavate.

Before excavating any material classified as rock, the Contractor shall notify the Engineer, who will record the extent and levels jointly with the Contractor. Rock excavated without this joint measurement will be paid for as ordinary excavation.

Blasting shall not be carried out without the Engineer's prior written approval and a valid permit from the relevant authorities. Where blasting is approved, it shall be controlled so that it does not damage existing structures, overhead lines, foundations or the surrounding formation.

Rock excavation shall be measured as extra over excavation in any material, net to the dimensions shown on the drawings. Over-break shall be backfilled with concrete or approved material at the Contractor's own cost.

a) Excavation Level
Unless otherwise directed, the formation of the platform can be founded on rock. However, rock shall be excavated to an average level 150 mm below the formation and in no place less than 100 mm below the formation. Any boulder rocks encountered shall be removed and disposed of.

b) Backfilling for Surfaces
Any excess excavation in rock below the formation shall be backfilled and compacted using approved fill material. Excess excavation in the invert of drains shall not be backfilled, but the rock surfaces shall be trimmed, and all loose particles removed, to allow laying of drainage blocks or as may be required.

c) Excess Excavation of Slopes
Where side slopes are over-excavated no backfilling will be required but the slopes shall be trimmed to a neat shape and safe angle as is acceptable to the Project Manager. The sloping sides of all cuttings shall be cleared of all rock fragments, which move when pressed with a crowbar.

d) Hard Material
The provisions of this Clause do not apply to hard and common materials, which materials shall be excavated to the lines and levels shown on the Drawings or as instructed, within the permitted tolerances.

4.1.4.3.11 Setting Out and Preparation for Earthworks

The Contractor shall set out the earthworks and the tops of cuttings and toes of embankments at intervals 10m. Reference pegs shall be provided clear of the earthworks and at right angles to the centre lines, from which the centre lines and levels can be re-established at any time.

Before the construction of any earthworks in the fills, the levels of the existing ground shall be agreed between the Contractor and the Project Manager. If the Contractor fails to take the requisite levels then the ground levels determined by the Project Manager shall be taken as correct.

4.1.4.3.12 Construction of Earthworks to Formation

All earthworks up to formation shall be formed and completed to the correct lines, slopes, widths and levels shown on the Drawings and with the sub grade parallel to and at the correct depth below the profile, camber, cross fall or super elevation shown for the finished level, unless otherwise directed by the Project Manager.

Embankments and fills shall be constructed only of suitable material obtained from the excavation of cuttings. If the Contractor encounters material which he considers unsuitable for earthworks, then he shall forthwith inform the Project Manager, who shall instruct the method of use or disposal of such material. If insufficient material can be obtained from the cuttings, additional material may be borrowed from approved borrow pits.

The Project Manager may direct that certain soils be excluded from certain layers and other soils set apart or obtained from borrow and used only for these layers, in which case the Contractor shall comply with the Employer's or the Project Manager's directions and shall allow in his price for such selection of materials.

4.1.4.3.13 Unsuitable Material Information

Where, in the opinion of the Project Manager, unsuitable material occurs in cuttings, the Contractor shall excavate it to the depths and widths directed and replace it with selected fill material to form an improved formation.

4.1.4.3.14 Spreading and Compaction of Embankment and Fills

Embankments and fills shall be laid out and compacted to achieve a stable platform with sufficient bearing capacity and stability. Tests shall be carried out as per local regulations and standards for compaction design.

4.1.4.3.15 Drainage of Works

All cuttings, embankments and borrow pits shall be kept free of standing water and drained during the whole of the construction.
Should water accumulate on any part of the earthworks, either during construction or after construction, until the end of the maintenance period, giving rise to soaking or eroding conditions in the earthworks, the Project Manager may order the Contractor to remove and replace at the Contractor's expense any material which has been so affected.
All drains shall be maintained throughout the Contract in proper working order. The Contractor must allow in his price for draining the earthworks satisfactorily at all stages during the construction and arrange his methods and order of working accordingly. The entire platform shall be adequately drained and all cable trenches including those in switchgear building should be well drained. The minimum slope of drain channels shall be 1:200.

4.1.4.3.16 Tolerances

The following tolerances will be permitted in the finish of the formation to roads and platform:
a) The level of the formation should be within +/- 100 mm of that specified.
b) On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.
c) The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

4.1.4.3.17 Protection of Embankment Slopes

The top soil and expansive material removed from the Works shall be placed on embankment slopes as directed by the Project Manager. The slopes shall be trimmed to form a gradient not less than 1 on 5 unless otherwise directed.

4.1.4.3.18 Grassing of Slopes /Slope Protection/Stone Pitching

The surface of embankment slopes, after placing of top soil, shall be planted with grass or best suited method as per Project Manager’s approval. Unless instructed otherwise by the Project Manager, the type of grass shall be indigenous. While planting, the area shall be irrigated for as long as necessary to ensure that the grass is properly established and has completely covered the ground. Grass should only be planted in the rainy season. Slope protection and Stone pitching shall be provided as per the designs.

4.1.4.3.19 Borrow Pits

Where it is necessary to borrow material for construction, suitable pits shall be provided by the Contractor to the approval of the Project Manager. All borrow pits must be carefully cross sectioned before and after excavation in order to determine the quality of earth excavated.
After removal of material for use, the area must be rehabilitated by the Contractor so that it will not prove a hazard to man or beast or a source of erosion. The sides of the excavation must first be sloped and then any previously stockpiled top soil spread as far as possible.
At some borrow pit locations, further cleaning and fencing etc., may be required.

4.1.4.3.20 Soil Sterilization

In order to stop the growth of vegetation and incidence of pests, the Contractor shall apply an approved herbicide and pesticides over the platform area. A damp-proof membrane shall be applied to the entire switch yard before placement of ballast. Long term pesticides shall be used around control building and any other required area.

4.1.4.3.21 Earth Electrode

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

4.1.4.3.22 Platform Areas

The substation platform areas shall be at least 1.5 times the area required by the facility developed area.

4.1.4.4 DRAINAGE

The Contractor shall design for area drainage of the works in compliance with local or regional standards and codes of practice to the approval of the Project Manager (BS 8301, BS 6031, CP 2005, etc). The Contractor shall be responsible for carrying out data collection for design calculations working with relevant Local Authorities. The designs shall be sufficient for a 50-year design life and shall incorporate surface and subsurface drainage mechanisms.

The contractor shall obtain approvals from relevant authorities to connect exit channels or pipes to the public systems. The Employer's Safety Health and Environment policy shall apply to the quality of effluent released from the site. The Drainage designs shall consider potential future substation additions and shall avoid discharging excessive water into existing drainage areas.

4.1.4.4.1 Stormwater Drainage

The Contractor shall design, supply, construct, test and commission a complete surface and subsurface stormwater drainage system covering the entire substation site. This includes the switchyard, buildings, access roads, parking areas and perimeter. The system shall collect all runoff and discharge it safely to the external discharge point. It shall prevent flooding, ponding and erosion, and the Site shall remain self-draining on completion. The system shall be fit for the purposes defined in this clause.

4.1.4.4.1.1 Design

The Contractor shall carry out a hydrological assessment based on meteorological data for the area. It shall include runoff calculations and the sizing of all drainage components. The system shall be designed for a storm with a minimum return period

of 1 in 20 years. Within the substation and all maintenance areas, its capacity shall be at least twice the calculated design flow (safety factor 2.0).

The Contractor shall establish the level and location of the external discharge (terminal) point at the lowest point of the catchment. All site levels shall be set relative to this point and shall remain above it. Design calculations, drawings and method statements shall be submitted as Contractor's Documents for the Employer's review under Sub-Clause 5.2 before the relevant works start.

4.1.4.4.1.2 Scope of components (including but not limited to)

No open drains shall be used in the switchyard. Use covered drains or pipes with subsoil drains beneath the gravel surfacing where applicable as per the Employer's assessment. Open lined drains may be applied outside the switchyard where suitable.

Culverts shall be required at road crossings and site entrances, with headwalls and wingwalls, catch pits, inspection chambers and manholes at junctions and changes of direction, plus cleanout points and attenuation basins where required as well as Outfall structures with energy dissipation and erosion protection. Perimeter cut-off drains to divert external runoff shall be applied where required and connection to public drainage or a natural watercourse where applicable.

4.1.4.4.1.3 Performance requirements

Drains shall be laid to self-cleansing gradients. No ponding is allowed in the switchyard, cable trenches or transformer bunds. The drainage layout shall leave uninterrupted access for operation and maintenance.

All runs, outlets and cleanouts shall be accessible for inspection and maintenance. Materials (pipes, channels, filters) shall be non-metallic, comply with relevant standards, and be strong enough for their purpose.

4.1.4.4.1.4 Minimum levels (above external finished ground level, FGL)

Element	Minimum
Building finished floor level	600 mm
Top of equipment foundations	200 mm
Top of cable trench walls	150 mm
Internal cable trench floor (relative to external cable trench floor) higher, with a sloped transition at building junctions	300mm

The Finished Ground Level shall be graded so that no flooding can occur.

4.1.4.4.1.5 Oil-contaminated water

Water from transformer bunds shall not discharge into the stormwater system. It shall drain by gravity from the transformer oil interceptor sump to the oil separator tank. The separator shall be positioned and levelled to allow this. The Contractor shall design an oil collection pit below the Transformer to trap burnt oil. The volume of this pit shall be 120% of transformer oil capacity. The Contractor shall use the specifications for the transformer plinth applicable. The pit shall be done in reinforced concrete around the transformer plinth and shall have galvanized steel grating with inert crushed rock in a layer of minimum thickness of 200mm. The size of the gravel to be 60-120mm.

The Contractor shall design for minimum spec, galvanized steel pipes to be used from oil collection pits to the Burnt Oil separator tank. Design must also ensure that no oil is released to the environment, subject to Local Authority requirements. The design must allow for exit of water naturally without use of pumps

The Contractor shall specify a full-retention separator to BS EN 858-1/-2 Class I (≤ 5 mg/l oil in discharge), capable of holding the full oil volume of the largest transformer, fire a lockable desludging access cover and gravity outfall. Discharge to meet EMCA effluent standards.

4.1.4.4.1.6 Approvals

The Contractor shall obtain all NEMA, WRA and relevant authority approvals for discharge to a watercourse or connection to public drainage.

4.1.4.4.2 Flood level and Platform Level

The Contractor shall be required to provide a flood risk assessment. Finished platform level ≥ 1-in-100-year flood level plus freeboard with a climate-change uplift on rainfall intensity stated in the ERs.

Control building Finished Floor Level shall be a minimum of 600 mm above external Finished Ground Level. The external finished ground level shall also be a minimum 600mm above the surrounding external level.

4.1.4.4.3 Roof Drainage

For buildings, roof water gutters and downpipes shall be designed to meet the requirements of relevant standards and national building code and BS EN 12056-3. Materials and components for rainwater goods shall conform to the relevant BS or Eurocodes. Manufacturer Data sheets shall be submitted to the Project Manager for review and approval.

Gutters shall be adequately supported and not sag. Gutters and downpipes shall, unless otherwise shown on the drawings, be approved plastic coated steel or heavy gauge PVC of minimum diameters 200mm and 150mm respectively. One downpipe shall be provided for approximately every 50sqm of roof area. Gutters and downpipes including supports shall be designed for a concentrated load of 100 kg. Screens or strainers shall be provided to prevent debris from clogging the down pipes. Joints shall be lapped 150 mm in the direction of the flow and soldered. Slip joints shall be provided to allow for expansion.

Storm water from the switchgear building roof shall be drained to the main water reservoir tank and main drainage.

Surface water from roofs of buildings other than the switchgear building shall be drained to down pipes with catch pits, which shall be connected to a suitable underground drainage system. For buildings with air-conditioning, the external unit drains shall be extended to discharge away from the paved apron.

4.1.4.4.4 Paved areas Drainage

For paved areas, drains shall be provided adequately to ensure timely removal of accumulated water that could cause potential safety hazard or damage equipment. These shall include roads and parking areas, building aprons, tops of equipment foundations etc. whose tops shall have sufficient slope. There shall be no obstructions in the drains.

4.1.4.4.5 Cable trench Drainage

External cable trenches shall be sloped at a minimum of 1:250 slope and drain pipes or channels adequately placed to allow flow of water. Internal cable trenches shall be adequately sealed to prevent any backflow of water. The transition from building to yard in cable trenches shall be sloped away from the building to avoid backflow.

4.1.4.4.6 Area Drainage

The formation level of the site is to be formed with uniform cross-falls of minimum 1:300 in the same direction as the natural drainage path of the surrounding environment. Drainage channels minimum slope shall be 1 in 200 and subsurface drains installed where appropriate or necessary. All storm water to be drained outside of the station.

Embankments and cuttings are to have drainage facilities at their top or bottom. In areas where there is a risk of water runoff the substation shall be protected from failure by means of gabions, retaining walls, and stone pitching or otherwise to the employer's approval. Stone for pitching to drains, inlets and outlets of culverts, to embankments and around structures shall consist of sound un-decomposed rock. Precast concrete tiles may also be used.

The contractor shall install concrete culverts of minimum diameter 900mm for storm water drainage (with 200mm thick concrete haunching) for the purpose of providing free flow of storm water at the substation entrances and or exits. The contractor shall also provide 200mm thick reinforced concrete plastered head walls. At the main gate, cut off drainage with grating shall be provided to ensure external water does not flow into the Site.

4.1.4.4.7 Sub-surface Drains

4.1.4.4.7.1 General

The Contractor shall design and install a sub-surface drainage system to collect infiltrated and ground water and remove it from the platform. It shall be used mainly within the switchyard, where open drains are not permitted. The system shall prevent waterlogging of the platform, equipment foundations and cable trenches.

4.1.4.4.7.2 Design basis

The design shall be based on site investigations and data obtained by the Contractor. These shall cover soil type and permeability, topography, groundwater levels and historical hydrological data for the area. The design shall also comply with applicable Kenyan regulations and recognised international standards. Design calculations and layout drawings shall be submitted as Contractor's Documents for the Employer's review before installation.

4.1.4.4.7.3 Pipes

Pipes shall be perforated or slotted, non-metallic (uPVC or HDPE), and suitable for subsoil drainage. Pipes shall be at least 100 mm diameter for lateral drains and 150 mm for collector drains, or larger if the design requires. Pipes shall be laid at a minimum gradient of 1% toward the outlet, with no back falls.

4.1.4.4.7.4 Trenches and cover

The minimum cover from finished ground level to the top of the pipe shall be 300 mm. Depth shall be increased where needed to intercept the groundwater table or to protect the pipe from loads.Trench bottoms shall be trimmed true to grade and free of soft spots before pipe laying.

4.1.4.4.7.5 Filter

Trenches shall be lined with a non-woven geotextile filter membrane, with joints overlapped by at least 300 mm. The membrane shall be wrapped over the top of the filter backfill. Filter backfill shall be clean, graded crushed stone, compatible with the pipe perforations and the geotextile. The stone used for platform surfacing may be used if it meets this requirement.

4.1.4.4.7.6 Access and outlets

Sub-surface drains shall discharge into catch pits, inspection chambers or the stormwater system. They shall not discharge onto open ground within the platform. Rodding eyes or cleanout points shall be provided at the head of each run, at every change of direction, and at intervals not exceeding 30 m. Inlets and outlets shall be protected against erosion, blockage and ingress of fines.

4.1.4.4.7.7 Testing and records

Before backfilling, the Contractor shall verify invert levels and gradients by survey. Each run shall be flow-tested to show free drainage to the outlet. As-built levels and layouts shall be included in the as-built drawings.

4.1.4.4.8 Foul water Drainage

The Contractor shall design, supply, install, test and commission a complete foul water drainage and treatment system. It shall serve all substation buildings and facilities. The system shall be fully separate from the stormwater and oil drainage systems, and no cross-connections are permitted.

4.1.4.4.8.1 Design

The system shall be designed for a as determined by the Employer. Peak flows shall be derived from fixture units. The design shall comply with the Public Health Act, the EMCA (Water Quality) Regulations, and county requirements. Calculations and drawings shall be submitted as Contractor's Documents for the Employer's review before construction.

4.1.4.4.8.2 Pipework and access

Pipes shall be uPVC or HDPE, minimum 100 mm diameter, laid to self-cleansing gradients not flatter than 1 in 40, on granular bedding and surround. Vent pipes shall be provided to maintain trap seals and disperse foul air. Manholes shall be provided at every junction and at every change of direction, gradient or diameter, at no more than 45 m spacing. Manholes shall have airtight covers of a load class suited to their location.

4.1.4.4.8.3 Treatment and disposal

Where no public sewer is available at the site, on-site treatment shall be provided. The treatment unit shall be a septic tank / bio-digester, watertight, sized for the design flow and a desludging interval of at least 10 years. Effluent shall discharge to a soak pit, which shall be sized from percolation tests carried out by the Contractor on site. Effluent quality shall meet NEMA discharge standards. The treatment unit shall be sited downslope of buildings, at least 30 m from any borehole or well, and with vehicle access for desludging.

4.1.4.4.8.4 Testing and handover

All pipework and manholes shall be tested for water tightness before backfilling, to BS EN 1610 or equivalent. The complete system shall then be flow-tested. The Contractor shall hand over as-built drawings showing routes, invert levels and unit locations, together with an O&M manual that includes the desludging schedule.

4.1.4.4.8.5 Approvals

The Contractor shall obtain all county public health and NEMA approvals for the system.

4.1.4.5 QUALITY CONTROL

The Contractor's Quality Management Plan shall describe in detail all the tests and procedures to be carried out on materials and works. These shall adhere to relevant standards, Codes of practice and local regulations and shall be carried out by approved accredited laboratories. These tests shall be witnessed by the Project Manager and results shall be submitted routinely and periodically

The Employer shall require an ISO 9001-based Quality Management System; project Quality Plan; Inspection and Test Plans with Hold/Witness points for each work package; materials testing at KENAS-accredited (ISO/IEC 17025) laboratories or the State Department's Materials Testing and Research Division; a minimum test-frequency table (compaction, concrete, blocks, aggregates, galvanising thickness); Non-Conformance Reporting register and a monthly quality report.

4.1.4.5.1 Tests on Completion (civil)

The Contractor shall carry out the civil Tests on Completion in accordance with "Tests on Completion" of the Conditions of Contract. The purpose of the tests is to demonstrate that the completed civil, structural and building works, and the building services installed under this Section, are complete, comply with the Employer's Requirements and the approved Contractor's Documents, and are fit for the purposes for which they are intended.

The civil Tests on Completion are additional to, and do not replace, the tests on materials and workmanship carried out during construction under "Testing by the Contractor", nor the electrical, protection, control and telecommunication tests specified elsewhere in the Employer's Requirements. Where a civil test depends on electrical systems (e.g. lighting, fire detection, alarms to SCADA), it shall be carried out jointly and coordinated with the electrical testing programme.

Successful completion of the civil Tests on Completion is a precondition for the issue of the Taking-Over Certificate for the Works or any Section as per "Taking Over the Works and Sections". No review, witnessing or acceptance of any test by the Employer's Representative shall relieve the Contractor of any obligation or responsibility under the Contract.

All tests under this Clause, including labour, materials, water, power, instruments, laboratory charges, specialist attendance, sampling, transport of samples and reporting, are included in the Contract Price.

4.1.4.6 ROADS

Where necessary external access roads to the substation sites shall be constructed to gravelling / murram standards. Substation land next to paved roads shall have access road and acceleration-deceleration lane to paved standard. All connections to main roads shall be approved by the relevant authority prior to construction.

Roads shall be designed and constructed with regards to the relevant standards, specifications and codes of practice such as the Kenya Roads Design Manual, and design shall be informed by the expected traffic load

4.1.4.6.1 Earthworks and Road Subgrade

The Contractor shall design for roads earthworks to formation level as per the Kenya Roads Manual earthworks. Formation material layers shall be designed to achieve respective strength and dimensional requirements of the governing standards. The road layers shall conform to the requirement of the Kenya roads design manual and shall be subject to routine and mandatory tests approved by the Project Manager.

4.1.4.6.2 Geometry

The Contractor shall design roads with minimum width of five (5) meters with the alignments allowing for low loader trailers. The contractor shall provide a swept-path analysis for the transformer low-loader and mobile crane indicating the maximum gradient and minimum curve radii per the transport study. They shall also verify bridges and culverts on the public access route for the transformer transport mass.

4.1.4.6.3 Subgrade Materials

The Contractor shall design for substation road to be compacted to 100% MDD and OMC after grading and shall have final paving layer of minimum standard paving blocks to meet estimated load weight.

4.1.4.6.4 External Access Roads

The horizontal alignment and geometric design shall be to relevant road design manuals. The Contractor shall design access to the station from the main feeder road to the substation plot. All roads shall have road drainage respectively. The external access roads shall have provisions for acceleration and deceleration lanes, and a construction-phase traffic management plan shall be required of the Contractor.

4.1.4.6.5 Internal Access Roads

The internal road network shall let vehicles reach every item of equipment that needs inspection, maintenance, replacement or emergency response. Internal substation road shall be compacted to 100% MDD after grading and shall have final paving layer of minimum standard paving blocks to meet estimated load weight.

The paving blocks shall be installed to BS EN 1338 / KS (tensile splitting strength) and shall have minimum thickness of 80mm for light traffic, 100 mm on the transformer route and heavy-vehicle areas. Laying shall be carried out as per BS 7533 with designed sub-base, bedding, edge restraints, channels and kerbs and a minimum strength class of 49N/mm2.

The road shall also have adequate provisions for drainage of water and shall be constructed to a fall that will allow proper drainage of the road. All roads shall have road drainage respectively.

4.1.4.6.6 Parking and Offloading Lot

The contractor shall design for a parking lot area that shall also be used as the offloading bay. This area shall be adequate to accommodate the Employer's staff and maintenance vehicles, with sufficient room for turning of maintenance trucks.

4.1.4.6.7 Damage and making good

Any damage occasioned to the road network by whatsoever cause during construction shall be repaired accordingly and handed over defects free

4.1.4.7 GRAVEL WEARING COURSE ROADS

4.1.4.7.1 Materials Requirements

Gravel standard roads comprise of a single layer of selected granular material placed directly on the sub grade to serve as a pavement and as surface-wearing course. The gravel for the single layer should be of adequate quality to guarantee the following:

a) General

In general gravel wearing course materials should comply with the following:

- They should have sufficient cohesion to bind the particles together and prevent the surface from 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		
Size (mm)	**% passing by weight**	
	Class 1	**Class 2**
37.5	-	100
28	100	95 – 100
20	95 – 100	85 – 100
14	80 – 100	65 – 100
10	65 – 100	55 – 100
5	45 – 85	35 – 92
2	30 – 68	23 – 77
1	25 – 56	18 – 62
0.425	18 – 44	14 - 50
0.075	12 - 32	10 - 50

c) Plasticity Requirements

Plasticity index of the gravel should not exceed 15 and shall not be less than 5 in wet areas (annual rainfall greater than 500 mm per year). In dry areas (annual rainfall less than 500 mm per year) maximum plasticity index shall be 30 but subject to a minimum of 10.

d) Bearing Strength Requirements

A minimum CBR (after 4 days soak) of 20% at 95% MDD and OMC (Modified AASTO T180) is required

e) Construction Procedures

Gravel materials are excessively coarse in their “as dug” state. Appropriate processing is therefore necessary to bring them to the required gradation. This is normally done on the road by using grid, cleat or sheep’s foot rollers. Oversized particles which cannot be broken down to the required size shall be removed. The minimum thickness of a compacted layer shall not be less than 125 mm.

f) Sub-grade Layer

During this process the sub grade layer shall be graded to level, parallel to the cross fall or chamber and profile shown on the approved design drawings or directed by the Project Manager and to agreed tolerance.

g) Tolerances

The following tolerances will be permitted in the finish of the formation to roads and platform:

a) The level of the formation should be within +/- 100 mm of that specified.

b) On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.
c) The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

4.1.4.7.2 Pavement

The single gravel layer should consist of a minimum thickness necessary to avoid excessive compressive strain in the sub grade and to compensate for the expected gravel loss under traffic during the period between re-gravelling.
Where the top 300 mm layer of the formation level embankment or natural ground sub grade has a CBR greater than 5%, the following thicknesses shall be provided:
• Roads within the Switch Yard not subjected to heavy commercial vehicles– The minimum compacted thickness of 125mm.
• Access roads outside the Switch Yard and roads within the Switch Yard likely to be subjected to heavy commercial vehicles during construction and during periodic maintenance. – Provide a 250 mm thick compacted layer.
In addition to the above, where the in-situ sub grade or the embankment material has CBR strength of less than 5% then:
• Top 300 mm layer of the fill / embankment shall be made with selected imported material with CBR (after 4 days soak) of between 7 and 13%.
• Where in situ sub grade an improved sub grade 300 mm thick of imported materials with CBR (4 days Soak) of between 7 and 13% shall be laid.

The above thickness shall extend to cover the shoulders to a minimum of 1m. A cross fall of 4% shall be provided. Compaction will be in layers not thicker than 200 mm and will achieve compacted densities of 95% MDD (Modified AASHTO T180) at compaction moisture contents of between 80% and 105% OMC.

4.1.4.7.3 Drainage

The Contractor's design shall provide for adequate and timely removal of storm water. The drainage system shall comprise a network of trenches, pipes, culverts etc. `

4.1.4.7.4 Road marking and Furniture

The contractor shall use thermoplastic retro-reflective road marking paint on the road kerbs to BS EN 1871 with performance to BS EN 1436. Road signs shall be installed per the Traffic Act signs rules (speed limit 10 km/h, PPE zone, danger signs). to the Employer's approval. The Contractor shall also demarcate the parking area as per the designs approved by the Project Manager. The Contractor shall provide well marked safety balustrades, and all relevant road furniture for the Works.
Colours to be used shall be black and yellow as per the Employer's corporate colour scheme.

4.1.4.7.5 Existing Bitumen Standard Access and Internal Roads

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

4.1.4.8 FENCING

4.1.4.8.1 Boundary Establishment

The Contractor shall construct fencing along the perimeter of the land/plot handed over. The fence shall include gates and shall comply with the requirements of the following clauses.
The perimeter fence shall be constructed to ensure boundary establishment from beacon to beacon. No part of the structure shall breach the boundary. The height of the perimeter wall shall maintain a minimum height of 2700mm from FGL. The

perimeter wall shall be built of weatherproof materials and protected from the elements.

Fences, gates and the electric-fence system to be earthed or isolated per the IEEE 80 touch-voltage study, with insulated sections where they cross the earth-grid boundary. The electric-fence earth must be separated from the substation grid by the distance in IEC 60335-2-76.

4.1.4.8.2 Masonry wall

The contractor shall design substation fence in masonry with adequate structural integrity to meet the design life of the substation. The masonry shall be dressed Natural stone of 10N/mm2 minimum compressive strength as per British standards. The wall shall have a structural framework of reinforced concrete beams and columns at minimum 3m spacing. The contractor shall provide a reinforced concrete beam at finished ground levels.

Structural designs shall be carried out for the wall, and shall be informed by the geotechnical and topographical surveys.

The fencing shall be mounted with an electric fence and razor wire. The electric fence shall be designed to have minimum 8 Strands separated at 50-100mm spacing. The strands shall be minimum 2mm diameter made from galvanized high tensile steel wires or zinc and aluminum coated, with tensile strength of minimum 1200N/mm2. Posts for the electric fence shall be galvanized steel anchored minimum 350mm within the reinforced concrete columns. The electric fence energizer shall adhere to IEC 60335-2-76.

The top of the wall shall have coping to protect the stonework. The contractor shall provide razor wire of minimum 450mm diameter placed together with the electric fence. Expansion joints shall be provided at every 30m with adherence to local regulations.

4.1.4.8.3 Masonry Wall Gates

The minimum width of the gate from post to post shall be a minimum of 6m to allow for heavy vehicles. The gate shall have two leaves on the main road for vehicular traffic, and a separate pedestrian access gate for pedestrian traffic. The design of the leaves shall allow opening in either direction and shall have adequate hinges to carry the weight of the gates. The gates shall be provided with wall passes and anchored on RC columns designed for the purpose.

The gate shall conform to the Employer's standards including but not limited to:
i. Material specifications such as leaf materials, paint, joinery, structural support etc.: to match the substation design life
ii. Colour to match the Employer's Corporate colours

4.1.4.8.4 Chain-link fence

Where the plot covers more than 1-acre, chain-link fence shall be used to demarcate the switchyard area.

Chain-link fence shall be used to demarcate the guardhouse from the switchyard. The chain link shall be constructed on concrete posts subject to project manager approval. The binding wire to be used shall be flexible aluminium wire of steel galvanized wire of right gauge.

Dimensions

i. Height of chain link fabric:
- 2 000 mm if within substation,
- 2700mm for perimeter

ii. Barbed wire:
- 3 wires above fabric, height of 300 mm, on supporting arms facing outwards from Site at 45^0 angles.

iii. Maximum distance between posts or columns:
- 3000 mm, except where interrupted by gate.

iv. Terminal posts: including end, corner and straining posts;
- 89 mm outside diameter
- 114 mm outside diameter at gates.

v. Embedment lengths of terminal posts:
- Corner and straining posts 1100 mm
- End posts 1200 mm
- Gate posts 1400 mm

vi. Tension bars and bands:
- locate at terminal posts to fix fabric, bottom wire and barbed wire.

vii. Top rail: "extra-strong" pipe, 43 mm outside diameter.

viii. 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.

4.1.4.9 Gates

4.1.4.9.1 Chain link fence gate

Gate width: free distance between 2 gate posts, 1500 mm for single gate (pedestrian access), 6000 mm double gates (vehicular access). Pedestrian gate shall be separated and shall have access control and Gates shall be bonded to the earthing system.

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

Gates: able to open in either direction to 1800. Gates to be hinged on a kingpost and not directly hinged on the concrete column.
Gate hardware: three hinges, latch with padlock accessible from either side of gate, latch catch. Gates to be of solid panel, gauge 16 and designed to Project Manager's approval.

Top of posts and uprights: weatherproof tops.

4.1.4.9.2 Materials

Fabric: ASTM A 392, 2 000 mm high, 3.8 mm diameter (No. 9 gauge) steel wire, 50 mm diamond pattern, twisted and barbed finish at top, knuckled wires at bottom, zinc coated.

Pipes: ASTM A 120, steel pile, hot-dipped zinc coated after welding, diameter and weight size as shown on drawings, unthreaded ends, free from burrs.

Fence fittings: ASTM F626, hot-dipped zinc coated according to ASTM A123.
Barbed wire: ASTM A121, 2.51 mm diameter wire in strand (No.12-1/2 gauge), 2 strands with 4-point barbs spaced at 125 mm, Class 3 zinc coating.
Bottom wires: 5 mm (No. 6 gauge) steel wire, 500 g/m2 zinc coating. This shall be surrounded by a concrete beam (C20) as shown on the drawings.

Fence fittings: ASTM F 626, steel tension bars and bands, nuts and bolts, weather proof tops of commercial aluminium alloy, malleable cast iron, or rolled or pressed steel, cast iron and steel fittings hot-dipped galvanised with 500 g/m2 according to ASTM A123.
Concrete: 25MPa at 28 days

4.1.4.9.3 Installation

Install fencing and gates according to ASTM F 567 unless otherwise indicated, and to drawings and this Specification.
Level ground surface so that space between finished ground surface elevation and bottom of fabric does not exceed 50 mm.
Plumb and align posts to within 10 mm.

Install posts of a gate at same elevation regardless of difference in ground level.
Set posts in concrete footings in form of truncated cone, according to ASTM F 567, and as follows:

FOUNDATIONS	ORDINARY SOIL		SOLID ROCK	
(Dimensions)	Line Posts	Terminal Posts	Line Posts	Terminal Posts
Depth	1000 mm	1600 mm	300 mm	500 mm
Diameter at top	250 mm	300 mm	150 mm	150 mm
Diameter at bottom	350 mm	400 mm	150 mm	150 mm

Make joints in fabric at terminal posts. Fasten as follows:
a) Every 450 mm along top rail, braces and bottom wire;
b) Every 300 mm on line posts.
Secure barbed wire to terminal and gate posts with tension bands, and to gate uprights with hooks. Install bottom wire in middle of last line of mesh

4.1.4.10 SWITCHYARD

4.1.4.10.1 Site Setting Out

The Contractor shall carry out setting of the site before commencement of works. He shall ensure application of current technology to ensure accuracy to establish control points, transfer design coordinates and mark out key features. The contractor shall keep detailed records of these setting out activities and copies shall be submitted to the Project Manager.

4.1.4.10.2 Site Layout

The Contractor shall prepare the arrangement of elements in the site to ensure flow of construction activities, proper and safe placement of routes and facilities, reduction of clutter and compliance to local regulations. The layout shall also allow safe maintenance of facilities and shall provide for future expansion. The layout shall consider the site topography, traffic flow, space allocation, stakeholder coordination

and environmental impact. The Contractor shall submit a site layout with temporary facilities indicated to the Project Manager before commencement of works.

4.1.4.10.3 Area Grading

The substation shall be levelled and shaped to ensure a stable and safe uniform surface suitable for equipment placement, earthing systems and access to equipment. The area shall remain well drained with no pooling of water.

4.1.4.10.4 Stone for Platform Surfacing

The stone shall be hard and durable crushed rock with a maximum particle size of 40-60 mm and not more than 15% shall pass a 9.5 mm sieve. The stone layer to be spread uniformly over the finished surface of the platform shall have a thickness of 100 mm.

4.1.4.10.5 Water Harvesting and Reticulation

The design of the substation shall allow for rainwater harvesting, a storage and reticulation system. The design shall provide for collection of rooftop rainwater to meet the station needs. The Employer's minimum specifications include provision of gutters on buildings, with downpipes leading to a ground mounted water storage tank of minimum volume 10,000litres. The water shall then be pumped to elevated storage of minimum 5,000 litres to enable reticulation to all wet areas including but not limited to Kitchen, washrooms, battery room, guardhouse and an external tap.

The Contractor shall use food-grade UV-stable tanks with level indicators, filtration plus UV for potable use to KS EAS 12, a solar-powered pump with float switch, and a metered county connection where available.

The design shall incorporate alternative supply where available. The contractor shall seek approval and apply for an account if supply is available nearby which shall be transferred to the Employer's name upon completion of works.

4.1.4.10.6 Lightning Protection

The substation shall be designed for lightning protection, and the contractor shall provide structural designs for lightning protection structures/ lightning arrestors. All steel support structures shall be grounded to the earthing system (refer to electrical specification).

4.1.4.10.7 Switchyard Lighting

The Contractor's designs shall include designs for illumination of the perimeter wall and the switchyard. The designs shall also include solar powered lamps adequately distributed in the switchyard for emergency lighting. (refer to electrical specification)

4.1.4.11 STRUCTURES

4.1.4.11.1 Excavations

The Contractor shall carry out excavations for reinforced concrete foundations in accordance with the approved designs and to the approval of the Project Manager and to fit in with the programme of construction. The contractor shall also prepare a Works Methodology for excavation.

4.1.4.11.2 Shoring and Timbering of Excavation

The Contractor shall be entirely responsible for the safety of all excavations, for the prevention of injury to workmen and for the stability of the faces of the excavation. The adjacent road surfaces must remain trafficable, and cracking or cave-ins must be avoided.

All shoring and timbering shall be done to the approval of the Project Manager, who may order such shoring or timbering to be strengthened or altered if he considers this necessary in the interests of the work or to safeguard against accidents to workmen or cave-ins.

4.1.4.11.3 Bottom of Excavations

In no case shall broken stone for under drainage or concrete be placed in an excavation until the surface on which such materials are to be placed has been approved by the Project Manager. The Contractor shall advise the Project Manager whenever the bottom of any excavation is ready for inspection or whenever it is necessary to cover up the work. In default of such notice the foundation shall on the order of the Project Manager be uncovered by the Contractor and reinstated at no extra charge.

4.1.4.11.4 Dewatering

The whole Works shall be constructed in dry and the Contractor shall be held responsible for keeping all excavations free from water, whatever the source or cause may be, and shall properly deal with and dispose of water by use of sufficient temporary works, plant and appliances so as to ensure that the whole Works is executed in a satisfactory dry and safe manner, and costs for all dewatering operations shall be included in the price for civil works.

4.1.4.11.5 Disposal of Excavated Material

All material excavated under this Contract shall be disposed of in accordance with the instructions issued by the Project Manager. Selected material required for back-filling shall be removed to a tip found by the Contractor and the Contractor shall be responsible for ensuring that the required amount of spoil is set aside.

4.1.4.11.6 Other Services

Where trenches pass near or across other services, the Contractor shall take every precaution against damaging such services. These services shall be properly supported in the trench until back-filling is complete and the back-filling shall be thoroughly compacted under and around such services.

4.1.4.11.7 Backfilling and Compaction

Back-filling shall be carried out either with selected spoil as set aside, or with imported selected spoil, or other material to the approval of the Project Manager. No back-filling shall be done until all the formwork has been removed together with pieces of timber, cement bags, vegetation and or other rubbish.

All back-filling shall be compacted in layers not exceeding 150 mm thick and shall be sprayed with water to bring the moisture content to the optimum to achieve designed values of compaction according to the designs, standards and codes of practice.

4.1.4.11.8 Depth of Concrete Structures

These include foundations to Transformers, equipment pedestals, gantries, towers, fence/boundary wall and building works. The depth of these foundations shall be determined by bearing, settlement, uplift, overturning and active zone criteria as guided by the site geotechnical report with a minimum depth of not less than 1200 mm from the existing ground level. All equipment foundations shall be designed as the base and pedestal type.

The transformer pedestal shall cover the entire mounting of the transformer base. Its foundation shall allow for oil collection pit draining to an oil separator. The depth of the oil separator shall allow for self-draining of water.

Where necessary, Firewalls shall be introduced and shall be made of reinforced concrete as guided by the electrical designs.

4.1.4.11.9 Material Specifications for Concrete works

- Aggregates

a) Shall conform to BS 882 requirements.
b) Shall be stored in separate heaps on hard, self-draining surfaces.

- Water

Shall be fit to drink/ potable and inert.

- Reinforcement

Shall conform to BS 4449.

- Reinforced Concrete

Shall conform to BS 8110 and BS 8004

- Steel

Shall conform to BS 5950

- Cement

Shall conform to BS 12

Shall be determined based on purpose and application area, with minimum of 42.5N as the standard. Special cements shall be only be used subject to the Project Manager's approval. For example, in coastal environments, cement shall be sulphate resistant.

Cement shall be used within 6 weeks of manufacture, and the Contractor shall make storage arrangements to ensure use of earliest consignment. It shall be stored in a moisture free environment. Different types of cement or different manufacturer cement shall not be mixed in a single cast or for a single element.

Additives shall not be used in this project.

4.1.4.11.10 Concrete work

4.1.4.11.10.1 Work Method Statement

The Contractor shall provide a detailed work statements with specific procedures and quality management plan for all concrete works specific to the site.

4.1.4.11.10.2 Formwork

Formwork shall be sufficient to achieve smooth finish free of projections, voids, etc. This shall be specified on drawings and be within the tolerances specified in the following table as well as to provide an acceptable surface for applied finishes, where required.

- Line and Level1mm per metre not exceeding 5mm
- Pockets, Sleeves etc. +/- 5 mm
- Bases +/- 50 mm

The type of ties to be used shall be such that the required finish is achieved and does not become marred by subsequent corrosion. Ties to be set out to definite pattern to the Project Manager's approval. Rubbing down is allowed only after the Employer's or the Project Manager's approval of the surface to be treated.

All concrete works including foundation bases must have formwork. No casting shall be done direct to earth sides.

4.1.4.11.10.3 Reinforcement

Reinforcement shall not be heated or re-bent for this project. It shall be of strength specified in BS 8110 and of ribbed type only. It shall be free from any material likely to impair bond or initiate corrosion. It shall be bent and fixed according to the bending schedules as per BS 8110 detailing. Reinforcement shall be tied with soft iron wire to Project Manager's approval and shall be supported to maintain the following minimum cover as per BS 8110.

The Contractor shall inform the Project Manager in good time to allow inspection before concreting.

NOTE: Holding down bolts shall be supplied under the civil works part or by the main contractor if he so decides, and in any case be included in the turnkey price. Design anchors shall be designed to BS EN 1992-4 and shall be grade 8.8 hot-dip galvanised bolts set with steel templates (position tolerance ±3 mm, level ±5 mm) and non-shrink cementitious grout. The contractor shall be required to carry out pull-out verification

4.1.4.11.10.4 Design Mix

Not less than 2 weeks before the start of concrete work, the Contractor shall submit to the Project Manager for his approval a statement of proposed mix proportions for the various grades required in the project. (Note: the grade is the characteristic strength or the cube strength below which not more than 5% of the result may be expected to fall when tested at 28 days).

The statement shall include proportions of cement, fine and coarse aggregate, and water, the maximum and minimum slump and the target strength for each grade. A certificate from an accredited laboratory that the proposed mix will meet the requirements must accompany the statement.

The proportions stated and the materials used may not later be altered without the written approval of the Project Manager. Cost of mix designs to be borne by the Contractor.

4.1.4.11.10.5 Batching

The Contractor shall use weigh-batching or ready-mixed concrete from a BS EN 206-conforming plant for structural grades.
Volume batching only for blinding or mass concrete and:

a) Be by mass in accurately calibrated scales or by volume in soundly constructed gauge boxes making due allowance for bulking of the fine aggregate.
b) Be in proportion to whole sacks of cement.

4.1.4.11.10.6 Mixing

Shall:

i. Be done mechanically in a machine (concrete mixer) in good condition, large enough to carry the whole mix, controlled by a competent experienced operator.
ii. Carry on for sufficient time to ensure complete mixing of the ingredients.

4.1.4.11.10.7 Placing

Shall:

a. Be under the control of a competent, experienced overseer.

b. Be in a manner to prevent separation of the ingredients.
c. Be a continuous process until the pour is complete.
d. Be complete within the time stipulated in BS 8110

4.1.4.11.10.8 Compaction

i. Shall be done by immersion (poker) vibrator in the hands of experienced operators.
ii. Concrete shall not be moved by vibrator.
iii. Shall be sufficient to remove all air pockets and honey-combing and to ensure complete dense concrete cover to all reinforcement
iv. Shall comply to BS 8110

4.1.4.11.10.9 Sampling and Tests

The Contractor shall prepare concrete cubes with sampling to BS EN 12350/12390. Conforming to BS EN 206 (e.g. at least 1 sample per 25 m^3 or per day per mix). Slump test shall be carried out on every truck for ready mix concrete. Core testing procedure shall be carried out for non-conformance. The Contractor shall then cure the concrete cubes in the environment stipulated in BS 8110 and arrange for transport of cubes to approved testing laboratories. The results of these tests shall be submitted to the Project Manager routinely and in a timely fashion.

4.1.4.11.10.10 Curing

a) Shall commence early on the morning following the placing of the concrete.
b) Shall be affected by keeping the concrete in a permanently wet state.
c) Membranes shall not be used.
d) Shall continue for a minimum of seven (7) days or such longer time as may be required by the Project Manager.
e) Water used shall meet requirement of BS 8110

4.1.4.11.10.11 Stripping of formwork

i. To soffits shall not be struck until 7 days after placing of concrete (but see below for (props).
ii. To vertical faces shall not be struck until 14 days after placing concrete.
iii. Props to soffits shall not be struck until 14 days after placing concrete.
iv. Shall not be stripped without the Employer's or the Project Manager's approval who may vary the above item in special circumstances.

4.1.4.11.10.12 Patching

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

ii. Is a sign of poor work-manship. The Project Manager shall have the right to reject the complete element if an unreasonable amount of patching has to be done, or if patching will spoil the appearance of the finished concrete.

4.1.4.11.10.13 Records

Shall be kept by the Contractor, showing date and time of each concrete pour, the weather conditions, the temperature, the number of the cubes which represent the concrete, the slump and any other items which the Contractor and/or the Project Manager consider relevant. These records are to be made available for the Project Manager inspection when required.

4.1.4.11.10.14 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.

4.1.4.11.10.15 Camber

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

4.1.4.11.10.16 Weather conditions

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

4.1.4.11.10.17 Cable Ducts and Trenches

The Contractor is responsible for all civil engineering works required for the cable runs between switchgear and buildings. The Contractor's design shall provide separate cable trenches for power and control cables to achieve separation as specified in Cable laying particular specifications. All cable trenches shall be designed in reinforced concrete with minimum thickness of 150mm.

The Contractor shall design for the trench dimensions depending on the type and size of cables, the load requirements, turning radii of cables and local regulations.

Size of the ducts and trenches shall be obtained from the cable schedule plus ≥ 25% spare capacity. The contractor shall provide a separate duct or segregated tray for fibre (IEC 61850 / digital-substation readiness). Covers shall be designed to BS EN 124 class by location (B125 walkways, D400 road crossings), each liftable by two persons (manual-handling limits) or with lifting keys, non-slip, with rodent-proof sealing. Precast or polymer-concrete trench systems may be allowed as alternatives.

Serviceable cable trenches shall allow access for installation and maintenance without pulling, and this shall be provided for by maintaining minimum width and depth of 800mm.
Power and control cables shall be laid on suitable hot dip zinc galvanized cable racks and perforated cable trays and in separate trenches. The anchorage of cable racks shall be adequately designed for to allow the weight of a person and the load from all cables.

The trench bottom shall be designed to allow free drainage by sloping a minimum of 1:200 and provision shall be made for a serviceable sump at the lowest level. The cable trench walls shall be raised a minimum of 150mm above the final ground level to prevent storm water entry. Cable trenches shall be provided with exit drains and sumps as necessary. Concrete cable trenches shall be adequately drained to open drains,or where necessary soak pits of adequate capacity or shall be connected to the general drainage system such that they will remain as dry.

Cable trench entry points shall be sealed to prevent the entry of dust, vermin water, etc., using suitable materials. The transition between building and external trenches shall adequately slope away from the building. Cable entries into buildings and road crossings shall be through 150 mm diameter heavy gauge ducts or in reinforced concrete cable trenches Two (2) lines of 150 mm diameter heavy gauge of spare ducts shall be provided.

All road crossings shall require a reinforced concrete duct with provisions for spare ducts. The ducts shall be constructed in such way that they will be able to withstand the weight imposed on them at a minimum depth of 1.2m and shall use HDPE/uPVC ducts (BS EN 61386-24), concrete-encased, designed for BS EN 1991-2 traffic or transformer-transport loads, with draw ropes and end sealing. Provide ≥ 2 spare ducts (as specified). Drainage shall be provided at duct terminal points.

The Contractor's design shall provide construction joints at 30m or less along the cable trench. These shall be adequately sealed to prevent ingress of moisture by application of movement joints with PVC water stops and sealant at spacing per BS EN 1992-3 / design.

Cable trenches in the switchyard shall be covered using reinforced concrete covers, designed for the maximum likely imposed loads appropriate to their location. The trench covers shall have steel angle line protecting the edges. The trench covers will be constructed such as to allow easy access to the trench by means of handles or otherwise installed for every fourth cover. The top of cable trench walls shall be raised a minimum of 150mm above the finished ground level to prevent water from flowing in.the trench covers will be fitted into grooved sides of the trench walls for a flush top of trench and covers.

Cable trench covers inside the building shall be designed with equivalent of 6mm thick metal chequer plates or higher specification material. This shall be reinforced with 25x25x4mm angle iron welded underneath along the edges and across in 'X" formation with allowance for easy handling on removal (provide drop-down handles for easy handling and non-trip safety). In areas where heavy traffic is expected, trench covers shall be recommended to be concrete finished with terrazzo to match the floor finish.

4.1.4.11.10.18 Cable Galleries

Where cable galleries are deemed necessary, anchorage of support brackets and clamps shall be adequately designed for.
Cable entries to be 150mm below the finished internal cable trench level.

4.1.4.11.10.19 Equipment Foundation Structures

The Contractor shall design equipment support structures to comply with relevant design manuals and local regulations. The equipment support structures shall be designed to endure substation loads and operational stresses. Their design shall also adhere to safety and testing requirements. The Steel support structures for the substation equipment shall be hot formed, hot dip galvanized, with a minimum zinc coating thickness > 110 microns and shall adhere to BS 5950. All steel support structures for equipment to be tubular, and for gantries to be in lattice angle channels.

Design calculations and shop drawings shall be submitted to the Project Manager for his approval prior to fabrication of members.
The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc. Steel structures shall be designed to anchor in the reinforced concrete foundations. The design for anchor bolts shall incorporate pull out strengths.

Other steel structures not made for equipment support (MKs and LV boards supports) shall have a coating > 100 microns. The Project Manager shall prefer bolts for joinery on site. Welding on site shall be prohibited on galvanised members except with an

approved procedure (WPS/PQR to ISO 15614) and repair per ISO 1461 cl. 6. All other connections shall be bolted. All steelwork shall be transported, handled, stored on site and erected so that members are not damaged or subjected to excessive stresses.
All steel support structures shall be grounded to the earthing system.

4.1.4.11.10.20 Equipment Steel Structures

The Contractor shall design Steel support structures for the outdoor substation equipment in hot formed galvanized steel to BS 5950. The equipment support structures shall be designed to endure equipment loads, wind and earthquake loads and operational stresses. Load combinations shall include conductor tension, short-circuit forces (IEC 60865-1), wind, seismic and maintenance loads. Deflection limits for disconnector and CT/VT supports shall be carried out as per equipment manufacturer.

The galvanising specification shall be as per ISO 1461 (Section C). Structural steelwork shall be shop-fabricated from structural shapes of steel in lengths suitable for easy transport and erection. All workmanship and fabrication shall be in accordance with the best practice and shall comply with the requirements of B.S. 5950.
Their design shall adhere to safety and testing requirements as per standards, specifications and codes of practice for substation equipment support structures.

The Project manager shall approve use of tubular or lattice angle channels steel structures for equipment support. Steel structures shall be designed to anchor in the reinforced concrete foundations. The design for anchor bolts shall incorporate pull out strengths.

The contractor shall incorporate in his design all elements that support equipment from steel support structures, their anchorage and concrete foundations. All steel support structures shall be grounded to the earthing system.

4.1.4.11.10.21 Erection and Commissioning of equipment support structures

The Contractor shall carry out erection of steel structures as per design and erection manual guide.

4.1.4.12 CONTROL BUILDING AND GUARDHOUSE

4.1.4.12.1 ARCHITECTURAL DESIGN

4.1.4.12.1.1 Substation Building Size

The Contractor shall design a Control Room Building to house control facilities and associated gear as per Scope of Works. The Contractor shall design room numbers and size as per the specific equipment, with consideration for operating conditions, access, safety and maintenance as well as provide spare room for future expansion. At the very minimum, room schedule and sizes shall be based on equipment layouts plus ≥ 30% spare panel space. Minimum clear heights, floor loading (panels, batteries), cable-trench layouts and maintenance clearances shall be based on manufacturer data.

Where applicable, the contractor shall also design a guardhouse for security personnel. The guardhouse design shall include washrooms with showers. The design for substation buildings shall conform to relevant building codes and local regulations.

4.1.4.12.1.2 Roof

The contractor shall incorporate in his design all elements that support the roof of the building. Fireproof and fire-resistant materials shall be preferred. Substation roof design shall prefer sloping roofs to prevent accumulation of water. The roof design shall compliment the overall building layout, ensuring adequate draining and sufficient space for maintenance and access too equipment. The roof shall be able to support any equipment that may be installed on top, including antennas and radios. Choice of materials shall comply with the local climate conditions.
The Contractor shall submit manufacturer and fabricator profiles to the Project Manager for review for all materials, accessories and fixings prior to procurement. The Project Manager may conduct due diligence and may require samples of the materials for inspection and testing, these costs shall be borne by the contractor. The Contractor shall provide the methodology on roof assembly before construction.

Roof structure
The Contractor shall design roof trusses, purlins and accessories in steel. The design shall incorporate all loads guided by the location of the site and shall be weatherproof. The design shall consider worst case maximum load with regard to regional weather data. The design shall comply to BS 5950 and installation shall be carried out as per Structural steelworks guidelines in this document. The trusses shall be weatherproofed accordingly.

Insulation
Insulation sheeting will be laid before installation of roofing sheets. The Contractor shall submit manufacturer technical data sheets and specifications for approval by the Project Manager, and a minimum thickness of 10mm shall be preferred.

Roof Structure
Structural steelwork shall be shop-fabricated from structural shapes of steel in lengths suitable for easy transport and erection. The Project Manager shall prefer bolts for joinery on site. Welding on site shall be minimized and cold galvanized.

All workmanship and fabrication shall be in accordance with the best practice and shall comply with the requirements of B.S. 5950. The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc. All steelwork shall be transported, handled, stored on Site and erected so that members are not damaged or subjected to excessive stresses. Fabrication and erection shall comply with B.S.5950 Part 2. Steel structures shall be designed to anchor in reinforced concrete. The design for anchor bolts shall incorporate pull out strengths.

Roof sheets
Roof sheeting shall be hot dip galvanised troughed mild steel sheeting of IT5 profile or similar approved by the Project Manager. They shall be of minimum thickness 0.5 mm. The sheeting shall have approved plastic coating on face side. Type and brand of such sheeting shall be proposed by the Contractor and supported by the technical data sheets and manufacturer specifications.

The Project Manager shall prefer that the sheets shall be laid with a minimum 200mm end laps and double corrugation side laps away from the prevailing wind. The sheets shall be fixed to purlins with galvanised coach screws and seating washers.

Holes for screws shall be carefully drilled in the ridges of the corrugations and J-bolts used. Great care shall be exercised to avoid damage and disfiguration to the surface

coating of the sheets. At eaves and exposed edges, the corrugations shall be closed with purposely made corrugation closers.

The contractor shall provide eaves of minimum 1m on all four sides of the building, otherwise provide canopies above doors and windows on gable sides.

Switchgear building - ceiling
The Contractor shall design for the provision of ceilings consisting of fore-manufactured sheets, mounted on steel grids jointed to roof structures. The ceiling shall be designed to be reaction-to-fire class A1/A2-s1,d0 (BS EN 13501-1. If gypsum, the boards shall be of minimum 12mm thickness and shall have cornices.

The ceiling shall have an escape hatch in the office and in the washrooms. The contractor shall provide a ladder for maintenance within the Control Building. The external soffit shall be finished with T1G, light gauge steel or aluminum or any alternative material that shall guarantee service through the design life of the substation.

4.1.4.12.2 SUPERSTRUCTURE

4.1.4.12.2.1 Setting out Walling

The Contractor shall provide proper setting out rods and set out all work on the same for courses, openings, heights, etc. and shall build the walls and piers, etc. to the widths, depths and heights indicated on the drawings and as directed and approved by the Project Manager.

4.1.4.12.2.2 Materials

a) Cement
Cement shall be as described in concrete works in this document

b) Fine Aggregates
Fine aggregates for concrete blocks shall be as described for fine aggregate in Concrete Works.

c) Coarse Aggregate
Coarse aggregate for concrete blocks shall be good, hard, clean aggregates from an approved quarry. It shall be free from all de-composted materials and shall be graded up to 7 mm, and all as described for coarse aggregate, Concrete Works.

d) Machine cut stone
This shall be to BS 5628.
This shall be to approval of project manager and meet minimum required specifications. Minimum requirement is compressive strength of 7N/mm2.

e) Natural Dressed Stone
This shall be to BS 5628, with a minimum 200 mm solid block or machine-cut stone for the external envelope (security, fire, thermal mass). Fire-separating walls (EI 60–120) shall be required around battery, comms and switchgear rooms.

f) Concrete Blocks
Concrete blocks for walling may be provided by the Contractor complying with B.S. 6073 and made in approved block manufacturing machines. Minimum thickness of blocks in external walls shall be 150 mm, and in internal walls the thickness shall be minimum 100 mm.
Blocks in external walls shall be hollow type. The volume of the cavities shall be not more than 50 % of the gross volume, and the dimensions of the cavities arranged so

that each cavity is vertically continuous when the blocks are bonded. Blocks in internal walls shall be of the solid type. Samples of the proposed block types shall be approved by the Project Manager before any walling work is commenced.

Blocks shall be cast under sheds in suitable block manufacturing machines either power driven or hand operated. The form shall be of steel, and accurately made to size to give the required shape and squareness of block. The concrete shall be vibrated during casting to achieve a dense and uniform concrete. The material shall contain only sufficient water to obtain full chemical reaction of the cement and to give proper workability of the constituents.

The ratio of combined aggregate to cement shall not exceed 3:1. The Contractor shall present his proposal for mix recipe supported by test results for the Project Manager's approval. Concrete shall have minimum 28 days strength of 20N/mm2 in accordance with B.S. 1881. Mixing shall take place in mechanical mixers so as to thoroughly mix the constituents to a uniform consistency before casting.

On removal from the machine the blocks shall be carefully deposited on edge on boarding or a clean concrete floor under sheds so as to prevent drying out by the sun for 3 days. During this time blocks shall be kept constantly damp. The blocks may then be laid on edge in the open and kept damp by spraying or covering with wet hessian or by other means for a further 5 days. The blocks may then be stacked if required, but not more than one meter high, and in such a way as to prevent damage to the edges and corners.

No blocks may be used in building or be transported to site before having reached required 28 days strength criterion. All concrete blocks shall be of even texture and properly mixed ingredients and all portions of the block shall be properly set and hardened concrete.

Blocks shall be free from cracks or blemishes and shall be true to shape and size with clean sharp edges and corners and with corners truly square. Damaged blocks shall immediately be removed from the site. No dimension of a block shall deviate individually by more than 3 mm from the correct size. The average length, width and height of a sample of 15 blocks should neither be longer nor less than 2 mm than the correct size.

Dressed natural stone blocks at least 200mm width may be used as alternative to the concrete blocks.

4.1.4.12.2.3 Mortar

The cement mortar is to be mixed in the proportions of1 Cement: 4 Sand, and thoroughly incorporated with a sufficiency of water. Any cement mortar which has been left for more than one hour shall not be used in the Works.

4.1.4.12.2.4 Walling

All block work shall be laid in raking stretcher bond solidly bedded, jointed and flushed up in mortar. Where wall faces are to be plastered the joints shall be raked out to form a key. The blocks shall be thoroughly wetted for at least 24 hour before laying.

Walls shall be carried up evenly course by course. During laying an open joint not less than 15 mm wide shall be left between the ends of all concrete lintels, whether pre-cast or cast in-situ and the blocks adjacent to these ends. These open joints shall be left as long as possible during construction and not filled until plastering or other works render such filling necessary. All such joints shall be properly filled in before the completion of the work. External walls shall be reinforced with two 8 mm high yield

steel bars in every third horizontal mortar joint. The building shall be designed as a framed structure.

Block work which is not to be rendered or plastered shall be finished with a fair face and the blocks shall be selected for even texture and unmarked faces, regular shape and square unbroken arrases. The block work shall be pointed as the work proceeds with a neat joint. Where block work is to be rendered or plastered the joint shall be raked out 10 mm deep as the work proceeds to form an adequate key.

Galvanized steel ties with fishtailed end cast into the concrete spaced at alternate courses and extending not less than 150 mm into the block joints. All mortar joints are not to exceed 15 mm or less than 12 mm.

4.1.4.12.2.5 Lintels

Concrete lintels shall be used for all openings and shall be reinforced with two 12 mm high yield steel bars. Lintels shall have a minimum bearing of 500 mm at the ends.

4.1.4.12.2.6 Doors

General

Metal doors shall be supplied by approved manufacturers.
All doors shall be painted as specified under Painting and Decorating. All locks shall be master-keyed with three master keys supplied in addition to three regular keys for each door or gate.The Contractor's rate shall include all supplies, site works, painting and hardware.

Doors

Placement of doors shall be in accordance with the approved building drawing. The contractor shall submit manufacturer profile for approval by the Project Manager before procurement.

Door frames shall be pressed steel frames made from minimum 2 mm thick steel sheeting and reinforced where door closers are fixed. The main door shall have a latch provision to accommodate the Project Manager's Standard Padlock. Thresholds shall be made from rolled steel sheeting approximately 100 mm wide and 12 mm high.

Door shall be filled with mineral wool acoustic insulation and lined both sides with steel sheeting minimum 1.25 mm thick. Total thickness of door shall be minimum 45-55 mm. Door frames are to be complete with 100 mm, loose pin steel hinges welded in position and adjustable striking plate.

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

Frames shall generally be built-in during construction of the walls and securely fixed. A gap shall be left between the top of the frame and the soffit of the lintel during construction. Frames shall be adequately strutted to prevent distortion and shall be protected from damage during other work.

Door frames and similar components shall be fixed with countersunk screws or bolts with heads set into the frames. Walls shall be built as close as possible to the frames and the gap filled solid with mortar at each course. Render shall be neatly brought up to the frame and well tamped into any remaining cavities.

The junctions between window frames or external door frames and external finish or block work shall be caulked tight with approved mastic or mortar wherever required, and neatly pointed. Mastic so used shall have long-term resistance against weather, insects and ultra-violet light.

Doors wider than 800 mm shall have three 100 mm hinges. Other doors may have two hinges except where specified or detailed otherwise. Door stops shall be fitted by screwed fixings where necessary.

All doors shall have fire resistance by room, e.g. EI 60 for general rooms and EI 120 for switchgear and battery rooms, tested to BS EN 1634-1 or BS 476-22. Panic hardware to BS EN 1125 on escape doors. Self-closers to BS EN 1154.

Entry ways
Entry to rooms with panels and equipment shall be via ramps. These ramps and steps where necessary, shall be of reinforced concrete.

4.1.4.12.2.7 Windows

Placing of windows in accordance with Switchgear building drawings.

Unless otherwise indicated windows shall consist of aluminium sub-frame with clear glass of approved thickness. Windows shall be from an approved supplier and the details thereof shall be approved by the Project Manager. Windows shall be operable and provided with corrosion resistant metal insect screens or as directed by the Project Manager.

Frames shall generally be built-in during construction of the walls and securely fixed. Widows are to be built in to walls truly vertical square with six-ties per frame.

All aluminium or steel windows are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue. The aluminium window frames shall be KPLC blue and of minimum 2.5mm thickness. Window panes shall be of minimum thickness 6mm thickness which is shatterproof with toughened (BS EN 12150) or laminated (BS EN 14449) glazing..

Windows are to be fitted complete with casement fastening, stays etc. All windows shall have approved burglar bars, and approved means of opening/locking. The contractor shall ensure burglar bars do not obstruct designated escape routes and shall provide escape doors instead

4.1.4.12.2.8 Door and Window Furniture

Ironmongery shall be strongly made, well finished, good quality "stock pattern" articles. Ironmongery for windows and doors shall be galvanised or other approved manufacture for external use. Samples of all items shall be submitted to the Project Manager for approval before they are used for the Works.

All doors except emergency doors shall be lockable. External doors shall have approved security locks in the Employer’s standards. ironmongery shall be cleaned, oiled, adjusted and left in perfect working order.
Emergency doors shall be provided accordingly as per the safety requirements, complete with approved panic lock.

All ironmongery shall be of the best respective types required and no alternative articles will be accepted unless approved. Articles described as brass must be solid brass and not brass finish. Chromium plated articles must be plated satin finish on solid brass or other approved metal.

Where items for ironmongery are required to be fitted to steel door frames, etc., the Contractor must ensure that the Manufacture makes provisions for the correct fitting or lock striking plates, hinges, cleat holes, bolt keeps, etc.

Ramp access shall comply with National Building Code 2024 accessibility and the PwD Act 2025: ramp gradient ≤ 1:12 with handrails, an accessible WC, door clear widths, tactile and visual signage.

Locks and Keys
Locks are to be two levers unless otherwise described. All locks are to be provided with three keys which must be handed over to the Owner on completion of the Works with identification labels attached.

Steel
Steelwork for general building construction is to be of approved manufacture complying generally with the appropriate British Standards and free from all defects, oil, dirt, loose rust, scale or other deleterious matter.

4.1.4.12.2.9 MV Switchgear Room

Openings for pressure release: In the MV switch-gear room it is necessary to arrange for openings for pressure release in case of explosion in one of the switch-gears. To avoid damage in the room/building any pressure shall be released through the openings as described.

Location of these openings must be beneath the ceiling on both longitudinal walls in the switch-gear room. The Contractor must calculate number and size of this pressure openings, and submit his proposal for approval.

Sufficient number of MV cable ducts through MV switch gear room wall joining the switchyard MV cable trenches shall be provided. The size of these ducts shall be big enough to accommodate Single core 630mmsqr MV cables. The position and number of the ducts shall be discussed and approved by the project manager. Spare duct shall be sealed to prevent entry by vermin.

4.1.4.12.2.10 Finishes

Schedule of Finishes

Room	Floor	Walls	Ceiling	Remarks/Notes
All Rooms	Terrazzo	Plaster and Painting, Tiles for wet areas	Sheet/plate-fire resistant	Sheets for ceilings = Prefabricated/ manufactured colour and type in accordion with approval of the employer. Switchgear building: External/internal colour in accordance with approval of the employer

4.1.4.12.2.11 Plaster and Floor Covering

Materials
Cement and water to be as before described. The sand to be screened through a sieve of 10 to 15 and meshes to 1 cm and to be washed if directed.

Mixing
All materials for mixing are to be used in proper gauge boxes and they are to be strike measured and not tamped down in boxes. Proper non-absorbent stages are to be used for mixing and storing mortar. No foreign matter must be mixed with the mortar.

The materials are to be mixed dry before adding water through a fine hose spray. No cement mortar which has taken its initial set will be allowed to be used.

Plaster Thickness
Unless otherwise specified all wall plasters should not be less than 13 mm thick and not more than 19 mm thick.

Cement Plaster
Cement plaster for external use to be composed of one part cement to four parts sand and for internal use to be one part cement to five parts sand.

Form Key
Rake out joints and roughen if necessary to form key for plaster.

For concrete surfaces, hack and apply 1:1 cement sand slush to form key. Continuously wet for 7 days and then apply plaster.

All brickwork and concrete works should be brushed down to remove dust and any other loose material.

Wetting
All internal and external brick or concrete surfaces are to be wetted well before plastering. All cement plaster must be kept wet for at least 7 days.

Repairing Defects
All defective plaster, cracks, hollows, etc., are to be cut out to a rectangular shape, the edges undercut to form a dovetail key and to be made good to finish flush with the edge of the surrounding plasterwork.

All patches will be to the approval of the Project Manager and if the defects cannot be made good satisfactorily then the whole surface is to be removed and re-plastered at the Contractor's expense.

4.1.4.12.2.12 Glazing and Painting

Glass
All glass is to be of approved manufacture, free from bubbles, waviness, scratches or other imperfections and is to be well bedded, puttied and back puttied and secured with glazing pins or clips in steel sashes or with sprigs in wood sashes.

All glass shall be carefully cut to the required sizes so that all panes of figured or textured glass are uniform in appearance with the pattern parallel to the edges and wired glass shall be so cut that the wires are parallel to the edges.
The window glass for switchgear room shall be shatterproof type.

Putty
Putty for glazing to steel sashes is to be of approved proprietary brand. Rebates are to be thoroughly back puttied before glazing and all putty is to be carefully trimmed and cleaned off so that back putty finishes level with the top of sections internally, external putty covers sight lines exactly and finished straight and true. Rough surfaces to putty will not be allowed and any defective putty will be cut out and replaced at the Contractor's expense.

Rebates of wood sashes are to be given one coat of priming immediately before glazing.

Mirrors
Glass mirrors are to be of the thickness specified, of selected quality glass, silvered on back, with protective sealing coat and erased edges, unless otherwise described.
Generally
Allow for removing and replacing all cracked, broken or defective glass and leave thoroughly clean and perfect at completion.
Materials for Decoration
All paints, primers, varnishes, emulsions, stopping, etc., to be of approved manufacture. The contractor is to use proprietary ready mixed paints obtained from an approved supplier.
When a coat of proprietary paint is applied, the manufacturer's priming and previous coats suitable for the particular type are to be used.

All materials must be brought on to the site in unopened tins, and no dilution or adulteration will be permitted, unless approved by the Project Manager.

Emulsion Paint
Emulsion paint shall be PVA (Polyvinyl Acetate) alkali-resisting formulated with high washability and capable of resisting 8000 scrub test. The first coat to be specially formulated base coat for direct application to the specified surface.

Fillers
Higher grade cellulose fillers are to be used internally and premixed filler to be used externally.

High Gloss Paints
Primers for application to bare metal to be red oxide primer for iron and steel. For galvanised metal to be an approved zinc chromate or galvanised iron primer. For application on wood or plaster etc., to be an approved alkali primer.

Finish enamels
Finish enamels to be synthetic enamel high capacity paint with high coverage and high gloss finish unless otherwise described.

Workmanship
All surfaces are to be free from moisture, dust, grease and dirt and rubbed down smooth according to approved practice.

All plaster to be free from efflorescence and treated with one coat of petrifying liquid, approved sealer or alkali primer if required. Hard wall plaster to be glass papered before decorating.

Rectifying defects to decorated surfaces due to dampness, efflorescence, chemical reaction, etc., will be to the Contractor's account, as these surfaces must be checked and the appropriate precautions taken before applying the decoration.

Metalwork must be scraped free of rust, primed as described and finished as later specified.

Galvanised sheet iron, pipes, etc., are to be cleaned down to remove manufacturer's ammoniated dichromate protective covering, primed as described and finished as later specified.

Coated pipes are to be cleaned down, stopped and primed with one coat of aluminium primer and finished as later specified.

All knots in woodwork to be treated to prevent bleeding. Large or loose knots to be cut out and be replaced with sound wood, or cut back and filled. Small knots to be treated with two thin coats of Shellac in methylated spirits. Woodwork to be glass papered to a smooth surface with all sharp 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 grain fill as necessary with filler as described.

Note
a) *All paints specified are to be obtained from an approved manufacturer by project manager and used in strict accordance to manufacturer instructions.*
b) Their representative will check the paints being used and the method of application and will advise accordingly.
c) This section of the work to be carried out by an approved firm of decorators who must allow for the very best finish possible and of the highest quality obtainable.
d) The prices must allow for the removal and refitting of all beads, fittings, fastenings, ironmongery, etc., removed for decoration purposes to be carried out by skilled tradesmen of the appropriate trade

4.1.4.12.3 Structural Design

The Contractor shall provide a detailed structural design for the Control Building and the Guardhouse. They shall apply the same principles as the Foundation designs in this section of the document.

4.1.4.12.4 Furniture

The Contractor shall provide furniture in the Office room of the Control building, as well as the guardhouse to Project Manager's Approval. Provision shall be made for storage of PPEs in the guardhouse leigh

4.1.4.12.5 Mechanical System- Plumbing and HVAC

Washrooms
The contractor shall include in his designs, two gender separated washrooms. These shall have a water closet each, a wash hand basin and a showerhead. They shall be supplied from the high-level water storage. Extractor fans shall also support proper ventilation. These shall be accessed from outside.
Kitchen
The contractor shall design for a kitchen area with countertops for microwave and utensil drying rack, as well as storage cabinets.

AC Installation
The Contractor shall supply and install minimum six (6) number AC units including wiring and insulator for the unit. The design for these AC units shall be done by the contractor and calculations approved by the Project Manager. The design shall take special consideration for projects in coastal or high humidity areas. The ACs shall be sized by heat-load calculation (equipment plus solar gain). N+1 redundancy for

control, relay and comms rooms. Inverter units with low-GWP refrigerant (e.g. R32/R290) in line with Kenya's Kigali Amendment HFC phase-down. Include temperature and failure alarms to SCADA.

The external AC unit drain ducts shall be directed to main drain and should not drain to the building apron. Wall mounted extractor fans shall be provided in the battery and washrooms.

4.1.4.12.6 Electrical System

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

The Employer reserves the right to reject any of the contractor suppliers if he feels the product does not meet the contract specification. All electrical fittings and plumbing materials are subject to Project manager approval.

4.1.4.12.6.1 Electrical Services General Description

The complete electrical installation shall comply with KS IEC 60364 / BS 7671 and works shall be carried out by an EPRA-licensed electrical contractor with an installation certificate. Emergency lighting shall be designed to BS 5266. Should there be any conflict between local standards and what has been specified the sub-contractor should draw it to the attention of the Project Manager.

Lighting

Luminaries shall be fluorescent lamps except for the toilets and outdoor lighting (except switchyard and perimeter lighting) where GLS lamps can be utilized. In switchgear room: 250 lux is required. In offices 500 lux is required.

a. All luminaries shall be supplied, installed and tested by the electrical sub-contractor.
b. All metal work on the luminaries shall be connected to an insulated earth protective conductor.
c. Lighting Control Switches
d. Outdoor lighting shall be controlled from an automatic timer control system.
e. Lighting control switches shall be flush pattern with white finished plates.
f. Grid switches shall have 5 or 10 amp rating, generally where fluorescent discharge luminaries are controlled switches have 10Amp rating whereas with low energy PL lamp, 5 amp switches shall be installed.
g. Provide emergency lights both inside and outside the building on each side on DC supply.
h. Provide security lights with solar backup system.

Socket Outlets and Accessories

Reference should be made to the Standards given above for details on the socket outlets and accessories. Socket outlets to be mounted at 300 mm above floor level.conduit cast into the building structure shall be of the heavy duty PVC type. PVC conduits shall not be fixed to the surface of the structure

4.1.4.12.6.2 Battery Bank room

The room shall have an independent door opening to the switch yard, and shall have no inter connecting alley between this room and rest of the switchgear/control room. It shall also be installed with 2no. Exhaust fans for blowing battery fumes out of the room, one working and one on standby. They shall be composed of a non-sparking

wheel construction and motor shall be explosion-proof type. Fans shall be wall mounted axial type with back draught dampers. The room's doors shall have applicable fire and security rating. Walls shall be protected against electrolyte splashing by applying an approved light-colored and resistant enamel paint.

Heavy duty PVC pipes shall be used instead of cable trench and they must not be on flush level with the floor (minimum 50mm off and above the floor).

Appropriate signage shall be provided outside the battery room. Appropriate PPEs for maintenance and handling of the batteries shall be provided. Racks and trays shall be designed for and provided. These shall be treated for resistance to electrolyte.
Floor finish shall be an approved acid-resistant epoxy coating applied as per approved manufacturer's specifications.

Lighting luminaries, sockets and switches within the battery room shall be explosion-proof and subject to approval by the PM The design shall consider that all possible sources of ignition including arcing sparks excessive surface temperature can be controlled and the probability of explosion reduced to acceptable low levels.

Ventilation design shall be carried out to IEC 62485-2 (hydrogen dilution calculation), with the room under negative pressure. The battery room shall be provided with a tap and sink with cold water supply (emergency eyewash) (ANSI Z358.1-type), spill containment and acid-resistant floor (as specified).

If Li-ion batteries are used, add NFPA 855 / IEC 62933-5-2 provisions (off-gas detection, separation, suppression). Kenya OSHA 2007 applies.

4.1.4.12.7 FIRE PROTECTION

4.1.4.12.7.1 External Fire Protection

A minimum of 2no. 25kg Dry powder Fire extinguishers with trolleys shall be provided with proximity to the Transformer in the yard. The contractor shall provide 6no. sand buckets.
All instructions and labels shall be in English. Fire extinguishers shall be provided in the guardhouse. One fire extinguisher (foam) shall also be provided at the control building on the side facing the switchyard.
In the cable trenches, fire retardant approved by the Project Manager shall be used at junctions of cable trenches and sprayed on the cables. Reinforced Concrete firewall shall be provided between equipment and the control building and/or transformers that breach the relevant clearance allowed. Provide firewalls where separation between transformers, or between a transformer and a building, is less than the IEC 61936-1 / IEEE 979 distances for the oil volume (Fire resistance ≥ EI 120 (2 h)). Firewall shall extend beyond the tank and conservator (height and width margins per IEC 61936-1). Design shall be carried out to BS EN 1992-1-2 for fire and shall take into consideration wind and seismic loads.

4.1.4.12.7.2 Building Fire Protection system

Fire Detection and suppression
The building shall be fitted with addressable fire and smoke detection system to BS 5839-1 / EN 54. Aspirating smoke detection for relay and comms rooms shall be considered. Automatic clean-agent suppression (inert gas or FK-5-1-12) to ISO 14520 / NFPA 2001 for control, relay and communication rooms, with room integrity test.

The system shall integrate Interface alarms to SCADA/Regional Control Centre and The contractor shall train the local staff on use of the installed system.

Fire Suppression system at substation level

Portable fire extinguishers shall be provided under this Contract. Portable, wall mounted, hand held extinguishers shall be 9.5kg pressurized control discharge CO_2 extinguishers (electrical rooms), ABC dry powder and AFFF/foam as appropriate, to KS/ISO 7165 or BS EN 3. Quantity and location shall be informed by a fire risk assessment (minimum per room type). Signage shall adhere to ISO 7010. Annual servicing contract shall also be set. The number of units within the Substation shall be a minimum of 6 Number. The body of the extinguisher shall be seamless, welded and brazed as appropriate. The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin.

Extinguishers shall be capable of controlled partial discharge. The type shall be of that recharge unit that is locally available. The extinguishers shall be walls mounted, attached, and located in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the instructions for operation face outwards.

Fire Evacuation Plan

The station layout shall have areas designated for assembly of people in the event of a fire alarm. A fire evacuation plan shall be designed and displayed at all entry points and approved by the Project Manager. Adequate signages shall also be placed within the substation to guide movement during evacuation.

SECTION - VI

4.1.5 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

CABLES

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4.1.5 Particular technical specifications – 66kV, 33kV AND 11kV Cables

4.1.5.1 Cables

4.1.5.1.1 General

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

All cables shall be suitable for operation:

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

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

4.1.5.1.2 Conductors

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

4.1.5.1.3 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 watertight copper or aluminium seal
- A layer of swelling tape to prevent axial ingress of water along the screen
- A layer of earthing screen of stranded aluminium or copper
- An outer LDPE (low density polyethylene) sheath for water tightness and mechanical protection.

4.1.5.1.3.1 Laying up and Fillers of Three Phase Cables

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

4.1.5.1.3.2 Manufacturer's Identification

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

4.1.5.1.3.3 Armour

All cables shall be armoured according to approved manner

4.1.5.1.4 Testing

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

4.1.5.1.5 Sealing and drumming

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

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

4.1.5.1.6 Current carrying Capacity and Design Parameters

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

4.1.5.1.7 Terminations

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

The terminations for the cables shall be of an appropriate heat shrink design incorporating a suitable arrangement for stress control, and rain sheds for outdoor use.

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

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland

4.1.5.1.8 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.

4.1.5.2 Installation

This extract from KPLC's "Medium Voltage Underground Distribution Handbook" determines the minimum acceptable conditions for installation of Underground cables.

4.1.5.2.1 General

The cables will be laid in trenches that will be as straight as possible avoiding sharp bends.

The areas where trenches are to be excavated will be marked clearly on the ground. If the location of other services is known, they will be marked in order to take necessary precautions.

Before construction commences trial pits will be made in order to confirm the soil strata of the planned trenches and to confirm the location of other services.

Safety precautions such as covering the trench, fencing and warning signs will have to be provided for during the period of work.

When designing the plan for the trench layout, the minimum radius will be as in the following table.

TABLE 3.1: BENDING RADII

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

D = cable diameter

4.1.5.2.2 Cable Marker

Cable markers shall be installed at the beginning and end of the cable run on the surface all along the route, at all changes of direction, and above all joints, above cable duct entries and exits and at an interval not exceeding 50m along the cable route. This information as well as details about the joint (i.e. joint location) will be also recorded on a map.

4.1.5.3 Excavation of Trenches

The trench will be dug vertically to a minimum depth of 600mm or more as required.

All precautions must be made so as not to cover any services e.g. fire hydrants with soil that may be encountered in the path of the trench.

During construction on public roads passage and access of motorists and pedestrians to commercial areas must be maintained.

In order to reduce the cost of reinstatement on roads and pavements the digging shall be done at intervals of 2-3 m and a gallery or tunnel dug underneath.

If trenches are constructed in soggy or inconsistent soil, the cables will be laid inside a duct as a protective measure and precautions taken to prevent the entry of water at the ends or joints of the ducts

The bottom of the trench must be made of firm material in order to prevent collapse of the base that may subject the cable to mechanical stress.

When several cables of different voltages are laid in the same trench they will be placed at different depths. The cables of the higher voltage will be placed deepest.

Where the trench is too deep as to cause instability to the walls of the trench shoring will be placed to provide lateral support to the trench walls.

The separation between two groups of cables will be a minimum of 250mm. If this separation cannot be attained, they will be laid in ducts or will be separated by a layer of bricks.

4.1.5.3.1 Joint Holes

Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

4.1.5.3.2 Backfilling of Trenches

Once the cable has been laid the trenches must be back filled to an adequate compaction level. Care must be taken to ensure that the first layer 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.

4.1.5.4 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.

4.1.5.5 Ducts

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

a) they will be installed in a level position and concreted where possible to provide mechanical protection throughout its length, they will have a depth of 1.2m.

b) future expansion will be provided for by providing one or several spare ducts depending on the location of the crossing.
c) at all times the cables should be adequately protected.
d) road and railway crossings must be planned in full detail.
e) 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.

4.1.5.6 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 cannot be attained in this case the cable will be laid in a duct.

Cables must be protected with a layer of protecting slabs, which will also indicate their presence.

For armoured cables the excavated materials without mechanically sharp objects will be adequate enough to backfill the trench.

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

4.1.5.7 Galleries

When the number of cables justify the use, they shall be laid in galleries.

The cables will be fixed to the cable trays by means of brackets or clamps.

All metallic elements will be earthed with independent connectors if there are circuits of different voltages.

Electric cables will not be installed where there are inflammable materials.

4.1.5.8 Parallel Separation

4.1.5.8.1 Low Voltage Cables

Medium Voltage cables may be laid parallel to Low voltage cables as long as there is always a minimum distance of 250 mm between them. When this distance cannot be attained, a solid brick wall shall separate them, or they will be placed in ducts.

4.1.5.8.2 Medium Voltage Cables

The distance to be maintained in the case of parallel situations of underground Medium Voltage lines is 250mm. If this distance cannot be achieved a protective brick wall will be installed between them, or one of them will be installed within ducts.

4.1.5.8.3 Telecommunication Cables

In the case of parallel laying of subterranean electric cables and telecommunications wires, they must be as far as possible from each other. As long as the cables both electric and telecommunications are buried, a minimum separation of 2 meters must be maintained at all times. This distance could be reduced further to 250mm between ducts.

The clearances must be in accordance with agreements between KPLC and other relevant authorities.

4.1.5.8.4 Water Steam etc.

In parallel layouts between power cables and buried water pipes a minimum distance of 0.5m will be maintained in a horizontal projection. If these clearances cannot be maintained the cables will be laid in ducts.

4.1.5.8.5 Oil Pipelines

The minimum distance between the cables and the oil pipelines will be 0.5 m. The cable will be protected from any gas leaks.

4.1.5.8.6 Sewers

In parallel layouts of electric cables with sewerage conduits, a minimum distance of 0.5m will be maintained, the cables will be adequately protected if this distance cannot be maintained.

4.1.5.8.7 Fuel Storage Tanks

There will be a minimum distance of 1.20 meters between cables and fuel storage tanks, apart from providing adequate protection for the electric cables.

4.1.5.8.8 Foundations of Other Services

When there are structural supports for public transport, suspended telecommunication wires, street lighting, the electric cables will be laid at a distance of at least 500mm from the outer extremities of the supports or foundations of the structures. This minimum distance shall further be increased to 1.5m if the support or foundation is subject to continuous stress towards the curb sides.

If this separation cannot be maintained a resistant mechanical safety measure must be used throughout the length of the support and its foundation, extending to a length of 500mm, on both sides of outer extremes.

4.1.5.9 Crossing of Roads and Railroad Tracks

4.1.5.9.1 Public Roads

When crossing streets and roads cables must be laid at depths of at least 1.2m. The ducts must be durable and mechanically strong and must have a minimum diameter of 150mm in order to permit the easy passage of the cables within the tubes. Conditions specified in the Electric Power Act must be observed at all times. Spare ducts must be provided where necessary.

4.1.5.9.2 Railroad tracks

Crossing railroad tracks must be done with conduits laid perpendicular to the tracks at a minimum depth of 1.6m. 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.

4.1.5.10 Crossing Other Services

4.1.5.10.1 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.

4.1.5.10.2 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.

4.1.5.10.3 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.

4.1.5.10.4 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.

4.1.5.10.5 Gas

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

4.1.5.10.6 Sewers

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

4.1.5.10.7 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.

4.1.5.11 Transporting Cable Drums

Loading and unloading from trucks or appropriate trailers will always be made through an adequate bar that passes through the centre of the cable drum.

The cable drums will always be transported upright and never on its side.

When several cable drums are transported together they must be aligned back-to-back and have stopping blocks to prevent movement.

The stoppers should be uniform so that they do not pierce the cable insulation. The stoppers should span the whole length of the cable drum.

An alternative to stoppers may be to have wooden pieces nailed to the platform supporting cable drums. The stoppers will be placed at the reels of the cable drums.

The cable drum must not be tied down with ropes, cables or chains. Upon off-loading the cable drum the roll must not drop down from the truck or trailer, a provisional ramp with an inclination of not more than 1/4 will instead be constructed in the case where there are no pulleys for lifting the drum. The roll can be rolled of the ramp by means of guide ropes. Sand can be placed at the bottom of the ramp to act as shock absorber and brake for the cable drum.

When rolling the drum on the ground the rotational direction must be observed so that the cable does not come loose.

When the drum is rolled care must be taken to ensure that the drum is not rolled on rough ground. Care must also be taken to ensure the reel is not broken because the splinters can puncture the cable.

Where possible the cable drums should not be exposed to the elements.

4.1.5.12 Laying of the Cable

The cable drum will be installed on the site in such a way that the cable is reeled out of the top part of the drum and is not forced when the cable is laid.

During cable laying the drum will always be supported by means of a mechanical jack and a bar of the appropriate strength.

The base of the jacks will be sufficiently large as to ensure stability during operation.

When taking off the wood stoppers care must ensure that the material used in nailing them does no damage to the cable.

The cables must always be unrolled and laid with the greatest care to avoid torsion or kinks and always maintaining the correct bending radius of the cables (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.

4.1.5.13 Mechanical Protection

Underground electric lines must be protected against possible breakdowns caused by landslides, contact with hard bodies, and clashing of metal tools. For this purpose, a protective layer of hatari slabs of class 15 concrete will be placed.

4.1.5.14 Warning Signs

All cables must have a protection slab placed over the cables buried at least 200 mm above the cable layer. When the cables or groups of cables of different voltages are placed in vertical layers the protection slab must be placed over each layer.

4.1.5.14.1 Identification

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

SECTION VI

4.1.6 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

TELECOMMUNICATIONS

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4.1.6. Telecommunications

4.1.6.1. General requirements

The objective of the telecommunications system is to transmit and receive data, voice and Teleprotection signals. Telecommunication links based primarily on Fibre (OPGW and ADSS) multiplexers and on some cases Radio and PLC shall be established linking various equipment in substations to Regional Control Centres (RCCs). Necessary engineering required for transmitting data and speech signals to the Regional and National Control Centre(s) shall be included. The links shall consist of STM-1/4/16 SDH Terminal equipment(s), and shall be connected to existing KPLC network. KPLC has SDH network with the backbone mainly consisting of STM-1/4/16 network.

The telecommunication system to be provided shall be designed to transmit and receive data, voice, and Tele-protection signals where necessary.

Where the station is for Voltages above 66 kV the SAS/RTU and Telecommunications links shall be configured to have connection to both Regional and National Control Centres. These links shall include Tele-protection facilities with for four commands per line. For 33kV substations with a transformation capacity of less than 23MVA, the links shall be designed for connection to respective RCCs.

These specifications describe the basic requirements for the Telecommunications various systems. Tenderers are requested to submit with their offers the detailed catalogues, brochures and technical drawings with the specific items on offer clearly marked for the products they intend to supply. Tenderers must indicate on the specifications sheets whether the equipment offered comply with each specified requirement.

The tender documents shall be accompanied by type test and routine test reports certified by the National Testing or the National standards Institute of the country of origin. At her discretion, all equipment shall be subjected to inspection by the clients Engineers or representative at the place of manufacture where all routine tests on randomly picked sample(s) shall be carried out in their presence. Test reports shall be completed for each equipment and made available to KPLC after the tests have been carried out. All the dimensions and capacities of the equipment to be supplied shall not be less than those required in these specifications. Deviations from the basic requirements, if any, shall be explained in detail in writing with the offer, with supporting data such as calculation sheets, etc. The Procuring entity reserves the right to reject the products, if such deviations shall be found critical to the use and operation of the products.

4.1.6.2. Fibre Optic Ground Wire (OPGW)

The overhead earth wire shall be Fibre Optic Ground Wire (OPGW) with a minimum of 48 strands. The Fibre optic earth wire supplied shall be suitable for installation on transmission line and shall be supplied complete with all necessary fittings and optical joint boxes. The earth wire fittings and optical joint boxes shall be type approved.

The manufacturer of the OPGW shall be responsible for the supervision of installation by the Contractor; to ensure that system reliability requirements are met.
The fibre optic earth wire shall comprise an optical sub-unit containing optical fibres over which shall be laid aluminium, aluminium alloy or aluminium coated steel strands. The clad steel wire incorporated in fibre optic earth wire shall comply with the requirements of IEC

61232. Shaped aluminium or aluminium alloy wire sections shall conform to the requirements of the appropriate IEC standard.

The optical sub-unit shall withstand the temperature rise associated with the specified lightning fault current flowing in the earth wire without damage. The fibre optic earth wire (OPGW) shall be manufactured in continuous lengths of not less than 4,000 m.

The overall system design of the fibre optic system shall meet the following minimum requirements:
Single failure or degradation in any optical fibre not more than one year averaged over five years;
Failures or degradations affecting more than one optical fibre, not more than one in ten years;
Increase in optical system transmission attenuation due to accumulated ageing and other effects at the end of five years and not more than 0.05 dB/km.
The Contractor shall ensure that the fibre optic cable are not strained or damaged either mechanically or optically during stringing and/ or jointing.
The cable shall be capped before shipment to prevent the ingress of water.

4.1.6.2.1. Optical Fibre

Optical fibres shall be 48 core single mode and shall conform to IEC 793-2-BI. The fibre coating material shall be mechanically strippable. The optical fibre 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.

4.1.6.2.2. 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.

4.1.6.2.3. Optical Joint Boxes

Optical joint boxes shall be provided to protect the splice joint of optical fibre, 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.

4.1.6.2.4. Fixing Clamps

A bolted clamping system shall be used to attach the OPGW to the inside of the support, without drilling or modifications to the support steel work. The attachment clamps shall be

capable of being attached and detached from the support, without affecting the OPGW. Fixing clamps shall be made from a suitable grade of aluminium alloy complying with the requirements of BS 1490 and / or BS EN 1676. Bolts shall be made from mild steel grade S275JR to BS EN 10 025. Bolts and nuts shall be ISO Metric Black Hexagon to BS 4190 and shall unless otherwise specified be threaded ISO Metric Coarse Pitch to BS 3643: Part 2, Tolerance Class 7h/8g.

4.1.6.2.5. Non-Metallic Underground Fiber Optic Cable

Where required, the fibre optic cable shall be circular in cross section and shall be designed so that any cable strain is so directly imported on the optical fibres. The cable shall not include any metallic components to prevent high-induced voltages when used in switching or substation compounds.

4.1.6.2.6. Approach Fiber Optic Wire:

The ADSS/OPGW cable shall terminate at first structure after the bus bar at the substations. An underground fiber optic cable shall be run from this structure to the building. This approach cable shall be 48 core SM, armored, loose tube cable, with a dielectric central member. The cable shall be Kevlar yarn reinforced, steel tape armor and a UV resistant HDPE outer layer. It is for outdoor applications, in ducts, for direct burial or latched installations.

4.1.6.3. Fibre Optic Ground Wire Specifications

The specification are based on IEC 60793 that lays down specification for an underground fibre optic cable and Fibre optic ground wire (OPGW)

4.1.6.3.1. References

The following documents were referred to during the preparation of this specification. In cases of conflict, the provisions of this specification shall take precedence.

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

Item	Description	Applicable Standard
1	Optical fiber (Generic & Product Specs.)	IEC 60793 part I & II
2	Cable Tests	IEEE 1138
3	Temperature Cycle Test	IEEE Std 563
4	Cable Self Damping	IEEE Std 4
5	Lightning Test	EIA/TIA-455-16A
6	Salt Spray Corrosion	MCIT 048-200 6508
7	Temperature Cycling/Ageing/Water Immersion	MCIT 048 200 6508

Note: All cables must conform to ITU G655

4.1.6.3.2. Service Conditions

The cables and accessories shall be suitable for continuous outdoor operation in tropical conditions in high altitude areas with the following atmospheric conditions.

Parameter	Max	Min
Ambient air temperature		
Outdoor	+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%	
Average soil thermisivity	1.2Km/W	
Average depth of burial	1m	
Type of soil	Black cotton soil	
Height above sea level	1800 m	
EMC Class (IEC 61000)	Industrial environments	
Seismic coefficient	1.5	
Maximum solar radiation	1000W/m2	
Wind pressure on project area of conductors and cylindrical objects	400 N/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	

4.1.6.3.3. Optical Fibre Cable application and Characteristics

Application

- The cable shall be for underground and overhead installation alongside the high Voltage cables.
- The cable shall be suitable for laying in cable ducts and in the ground in switching stations.
- The cable shall have the pre-requisite Mechanical Protection to prevent damage during installation and due to other Human activities such as excavation
- The cable shall be suitable for laying in areas next to roads with heavy traffic.
- The cable shall be resistant to aggressive chemical substances, corrosion and moisture.
- The cable shall offer good protection against rodents.
- The cable shall be specifically manufactured for underground installation and shall be all dielectric, hence unaffected by Electromagnetic induction from the high Voltage underground Cables. This shall be specifically stated in the Tender Offer.
- Permissible continuous operating temperature for all the fibres without degradation in characteristics shall be –20°C to 70°C.
- The shipping and storage temperature range of the cable shall be –50°C to 70°C

4.1.6.3.4. Material and Construction

i. The cable shall be an all dielectric, Single Mode, 48 Optical Fibres cable specifically manufactured for underground Installation.

ii. A written confirmation shall be obtained from the cable manufacturer giving an assurance that the cable so offered is suitable for underground installation alongside the 33kV Power cables and that it will give a reliable communication link suitable for Protection of the 33KV cable, Speech and Data Transmission.

iii. 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.

4.1.6.3.5. Geometrical and Optical Requirements

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

Parameter	**Requirement**
No. of fibres	48
Length	Various
Core diameter	9-10 microns
Cladding diameter	125+/- 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

The single-mode 48cores fibre cables specified herein will fulfil the following optical specifications.

Parameter		**Requirement**
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.

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	

etc. for the 48 fibres.

All colour codes must be able to distinguish each fibre strand from all other fibre in the same cable.

4.1.6.4. Specifications for ADSS Cable

Where required in the specific line scope of works the ADDSS cable shall meet following technical and general requirements. ADSS can only be installed in an existing 33kv lines, and in that case it shall be specified in the specific scope of works.

4.1.6.4.1. Design Principles:

The proposed Fibre cable shall be single mode, 48 core all-dielectric self-supporting cable (ADSS).

The cable shall be designed and manufactured in accordance with the following standards:

- Cable IEEE 1222
- Fiber IEC 60793, ITU-T G.65X series
- Color code ANSI/EIA 359-A, IEC 60304

4.1.6.4.2. Route Survey:

Prior to design and installation, the contractor shall visit the route accompanied by KPLC staff to ascertain for themselves the requirements for the link. During this survey a pole count and a sketch for the cable installation shall be carried out. This sketch shall indicate the locations of splice boxes and the approximate distances between them. The poles shall also be assessed for their ability to support the ADSS cable. Any need for modification shall be determined at this stage.

Suitable drum lengths shall also be determined at this stage to reduce the number of joints preferably at section poles. KPLC shall assess the contractor's report and carry out modifications where it is felt necessary.

4.1.6.4.3. Installation:

The cable installation shall be aerial on existing power lines. Majority of these lines are on wooden structures and the ADSS cable shall be installed below the power line. The installation shall be done under live line conditions except in some instances where safe working clearance cannot be maintained.

It is not the intention of the employer to recommend any specific installation method but whichever method applied should be in accordance with the international standards, manufacturer's recommendation and within KPLC safety regulations.

4.1.6.4.4. Installation Materials & Fittings:

All bolts, nuts and clamps used during the construction shall confirm to IEEE standards that apply to testing and performance of Hardware for All-Dielectric Self Supporting cable (ADSS)

All fitting materials shall conform to the approve standards by IEEE1222. The contractor shall attach type test certificates from the certifying bodies

4.1.6.4.5. Splicing & Testing:

All joints shall be fusion spliced. The splice loss shall be equal to or less than **0.1db**. After all the terminations are done the cable shall be tested from ODF to ODF using the OTDR as well as power meter and the results tabulated.

4.1.6.4.6. Fittings & Spare Capacity

Unless otherwise specified in this specification, all requirements for individual components and completed cable shall be mainly in accordance with the following standard specifications.

1EE Std 1222, IEC 60794-4, IEC 60793-1, IEC 60793-2, IEC 60794-1, ITU-T G.650, ITU-T G.652, ITU-T G.655, EIA 492A, EIA 472A, EIA 598 or ANSI/EIA 359-A-1985, ISO 9001 and ISO 14001.

The Contractor shall include 10% spare cable capacity for future maintenance work on the link at agreed intervals.

4.1.6.5. Cable Accessories

Spliced joints/terminations

Spliced joints shall be suitable for the cable specified and shall contain all materials required to:

a) Mechanically connect the type and size of fibres specified
b) Optically connect the fibre specified
c) Provide the necessary di-electric strength within the joint;
d) provide an insulated outer housing;

The joints shall be designed and manufactured to ensure that all components and materials shall be suitable for use in the atmospheric conditions stated.

The complete components and materials shall be free from defects, which would be likely to cause them to be unsatisfactory in service.

The components and materials shall be manufactured to ensure high moisture sealing capacity, resistance to fungal and insect attack.

Specialized tools that are required during the jointing process shall be stated and the costs shall be quoted separately

All the fibres shall be terminated in the substation building using SC connectors in a patch panel properly mounted.

4.1.6.6. Factory Visit, Testing and Acceptance

Type and routine tests of the cable complete with accessories shall be carried out as per the requirement of the standards shown in the table below. Certified copies of such type test reports and certificates shall be attached to facilitate tender evaluation. Tenders without Type test Reports and certificates, certified by the National Testing or the National Standards Institute of the country of origin shall not be considered. Where available certificates from internationally recognized testing bodies can be included**.**

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	Temperature Cycling/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

The cables shall be routine tested at the factory. Advance copies of factory test reports shall be submitted to KPLC before her representatives are dispatched for acceptance test exercise. Authority to deliver/ ship the cables to KPLC stores shall be given only after the report from this exercise show that they comply fully with the specification and referenced standards.
The manufacturer shall be required to demonstrate that the accessories mentioned earlier a re mechanically and optically fit for the cable during acceptance testing.
KPLC requires an advance notice of four (4) weeks before the commencement of Factory Tests & Inspection to enable engineers make the necessary arrangements to witness the tests.

Where KPLC engineers or her representatives require to visit and to inspect the cables manufacturing facility, all necessary help shall be provided. Such inspection shall not in any way prejudice the purchaser's rights and privileges throughout.

4.1.6.7. Manufacturer Eligibility

Only manufacturers who have the following qualifications shall be considered for the supply of the cable

a) At least 10 years' experience in manufacturing of underground optical cables laid adjacent to single core power cables (33kv and above).

b) Exported at least 500km of fiber cable cables per year to at least 3 countries with the same service conditions mentioned in clause 5.1 (e.g. counties in Africa, Australia etc)
c) Should have ISO 9001:2002
d) Should have ISO 14001

Manufacturers shall indicate the delivery time versus quantities of cables, monthly production capacity and experience in the production of this type of cables

Manufacturers shall submit the manufacturing process flow chart with explanations of each stage and quality control measures undertaken.

A detailed list and contact addresses of previous customers outside the country manufacture shall be submitted with the tender. KPLC reserves the right to contact customers if necessary
The manufacture shall provide current e-mail address, fax and telephone numbers and contact person at the National Standards and Testing Facility of the country where the cable is manufactured and tested. KPLC reserves the right to contact the body if necessary

i. Information

Detailed draft design and construction drawings showing the cross sectional dimensions shall be submitted to KPLC before the manufacturing of the cables commence. KPLC undertake to submit their comments or approval for the drawings within three weeks of receiving the draft copies.
Sufficient relevant technical details and drawings shall be submitted for the purpose of Tender Evaluation. Tenders, which do not meet this requirement, will be considered non-responsive.
To facilitate comprehensive technical evaluation of the tenders, a clause-by-clause statement of compliance with the specification shall be submitted with relevant manufacturer's specification sheets, catalogues and brochure

ii. Packing

The cable shall be wound on wooden drums such as to prevent damage during transportation. The wooden drums shall be made from treated timber resistant to termite attack.
The following description shall be marked on one flange of the reel
a) Direction of rotation of the reel
b) Type of cable
c) Number of fibres and size
d) Length
e) Net weight and gross weight
f) Manufacturer's name
g) Year of manufacture

4.1.6.8. Optical Distribution Frames (ODF)

The optical fiber distribution frame (ODF) is installed for terminating optical fiber cables and patch cord. The distribution frame should include the metallic casing, adapter plate, splice tray, and other necessary materials for the termination of optical fiber cable. Therefore, it should be designed properly for the fiber splicing and distribution. Separate storage shelf and distribution shelf can be offered if required. The ODF shall be of corrosion resistance and robust construction; and shall allow both top or bottom entry for access to the splice

trays. Specific selection of the entry points shall be made at the time of installation. The ODF shall be installed on the international standard (ETSI 19”) equipment rack or cabinet rack. The optical fiber distribution frames shall include all necessary parts to complete the joint. This will comprise all components to protect and store the spliced fiber; and provide sheath continuity. The distribution frame shall be designed with enough spare capacity for fiber splices. The distribution frame shall be made from fabricated mild steel not less than 1.2mm thick or equivalent and painted in good condition. The design of the fiber distribution frame shall allow minor deviations from the escribed installation procedures without any harm to the fibres and the long-term performance of the installation. The shelf and the connection between shelves shall be designed to maintain minimum bending radius of 30mm, the connectors to be used shall be subject to approval by the Project Manager.

Assignment between station fibre cable and OLTE's shall be made by using patch cords between the termination box and the optic distribution frame. Capacity of the optic distribution frame shall allow free assignment between each individual fibre of the station fibre optic cables and the relevant optical I/O ports of the OLTE's.

The optic distribution frame shall be equipped with low loss optical connectors (< 0.25 dB including the loss in the bulk head, loss in the connector splice & the loss in the pig tail) of the screw-on type. Auxiliary connectors shall be provided to facilitate testing and maintenance of the fibres/equipment. All spare fibres shall be properly terminated and spliced on connectors of the same type within the frame

4.1.6.9. Fibre Terminal Equipment

The terminal equipment shall be the type SDH STM-1/4/16 optical terminal equipment and shall be supplied from 48 VDC source.

SDH (STM-1/4/16) multiplexer shall be installed in racks that are EMC compatible and suitable to work in HV system environments.

The multiplexer shall be based on the SDH technology, working on the basic transmission Bit Rate of 155.520 Mbit/s (STM-1). 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:

a) It shall have at least all the functions outlined in ITU-T G.783.
b) The PDH electrical tributary interfaces to the SDH equipment shall conform to ITU-T G.703.
c) The SDH electrical and optical interfaces shall conform to ITU-T G.703 and G.957.
d) The cross-connect offered shall be capable of providing non-blocking connection between virtual containers.
e) The Optical Power to be offered shall be such that under normal operating condition, the BER of the system at the receiver is better than 1x10-10. Error performance versus the receive signal shall be verified during the factory acceptance tests.

The multiplex structure shall conform to ITU-T G.707. Details of the Multiplex structure for the offered equipment including the usage of the overhead bits shall be detailed with the offer.
The synchronous optical interface protection shall be achieved by having 1+1 protection. The laser shall automatically cut-off when the link is disturbed. Redundant cross connect, where failure on either one shall not cause link outage, and path protection on the traffic interface and the 2 Mbit/s levels shall also be provided.

Timing and synchronization shall conform to ITU-T G. 783, G.811, G.812 and G.813. Timing references, number of timing references available, switching time to a different timing reference, type and level of clocks shall be stated in the offer.
The equipment shall automatically switch to another clock if the reference timing is lost and automatically revert back upon restoration. The accuracy of the internal clock as well as the details of the clock signal distribution shall also be stated in the offer.

The equipment shall be capable of diverting timing references between the STM-1, 2 Mbit/s and a G.703 tributary interfaces.
The SDH equipment shall be wired for the full STM-1 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):

a) Transmitter Power
b) Minimum receive Signal @ BER $1x10^{-10}$
c) Connector Loss
d) Repair Splice Loss
e) Power Penalty (Chromatic dispersion and LD reflection Loss)
f) Maintenance Margin (> 2dB)
g) Other Loss
h) System Margin

The SDH equipment to be offered shall provide the followings:

a) 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.
b) A Craft interface in accordance with ITU-T G.773 to allow a local terminal to access the network element.
c) An engineer order–wire which shall have conference and selective calling features.
d) Performance monitoring in accordance with ITU-T G.784 and G.826.
e) Optical safety as per ITU-T G.783.

The alarm functions shall include but not limited to:

a) Alarms classified as critical, major, minor, and information.
b) Indications of loss of incoming signal.
c) Visual and audible indication of alarms.
d) Test function of alarm indicators to ensure workability of alarm indicators.

e) Alarm functions shall be detailed by the Contractor, e.g. if implemented in Telecommunication Network Management System:-

Offered equipment shall have sufficient capacity for speech, Ethernet data, SCADA data etc. and capable of extension to higher capacity by adding relevant modules.

4.1.6.10. Spare Parts, Tools and Test Equipment

Spares for Telecommunications if required in the mandatory spare schedule, shall be one module for each type of the modules supplied. Specialised tests tools and equipment for testing, configuration and maintenance of equipment, shall be supplied. This shall include data tester and optical test tools.

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 be new and shall not however be available to the contractor during erection and commissioning. All licences required for commissioning of equipment shall be included. An OTDR (MTS 8000) or its Equivalent, and 1000mts of cable and Spice kit shall be supplied if required in the schedule for mandatory. The Contractor shall furnish a list of recommended spare parts for the OLTEs.

4.1.6.11. Documentation:

i. The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals. All manuals and As-Built-Drawings documents shall be supplied in three hard copies and a softcopy in PDF.
ii. Functional Design Specification (FDS)
iii. Test Specification for Factory Acceptance Test (FAT)
iv. Operator's Manual
v. Product Manuals

4.1.6.12. Training:

The Contractor shall provide 1 week training for four KPLC staff at the supplier's manufacturing premises on each Telecommunication type of equipment supplied and on site during installation works. All training costs shall be borne by Contractor including travel to manufacturers place. Accommodation which shall be borne by KPLC. The scope of each service shall be given. The training content shall be subject to approval of the project Manager.

4.1.6.13. Testing

The formal stages of testing to be performed fall into the following three categories:

- Type Tests Equipment shall pass these tests in order to be accepted for use under this Contract
- Factory Acceptance Tests (FAT) Systems shall pass these tests before they may be shipped to site. The employer shall witness FATs unless he waives this in writing. FAT preparation costs shall be borne by contractor except transport and accommodation. FAT shall be carried by two KPLC staff for 5 days..
- Site Acceptance Tests (SAT) Systems shall pass these tests before they may be put into operation and before they are Taken Over

4.1.6.14. System Acceptance

The System will be accepted by KPLC if both:

- The System and all items of equipment have successfully completed all the specified tests
- All failures, problems and reservations noted during the tests have been corrected to the satisfaction of KPLC.
- If either of these conditions has not been complied with, then the necessary corrective action shall be agreed between the Contractor and KPLC**.**

ADDITIONAL PARTICULAR TECHNICAL SPECIFICATION FOR TELECOMMUNICATION SYSTEM FOR HYBRID MULTISERVICE PLATFORM FOR UTILITIES

(1/10 Gbit/s MPLS-TP and STM-1/4/16 Multiservice Platform with integrated Access Multiplexer)

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8 Abbreviations

1 Scope of Specification

The specifications are **additions** to the *Particular technical specifications for Telecommunication system* provided in Section V of Volume II clause 4.1.6 of the issued bidding documents.

Summary of reference Standards

The Equipment shall comply with the latest recommendations for the plesiochronous and synchronous TDM hierarchies as well as packet switched features according to ITU-T, ETSI, IEEE, IEC, IETF and MEF. The equipment shall be type tested by an international, accredited and recognized lab. In particular the mentioned recommendations shall be covered.

2 General Requirements

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

The equipment offered shall comply with the latest ITU-T and IETF recommendations, ETSI and IEEE standards and be able to be interconnected with legacy multiplexer and other telecommunication equipment. On PACKET TRANSPORT LEVEL interfaces for optical MPLS-TP based transmission up to 10 Gbit/s shall be available. Enhanced traffic engineering using MPLS-TP technology as per relevant IETF standards shall be supported by providing VPWS, VPLS and Tree services using the MPLS-TP infrastructure. Activation of MPLS-TP functionality on SDH devices shall be possible without the need to exchange hardware.

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

MPLS-TP and PDH/ SDH functionality shall be natively integrated (true hybrid functionality) and available at the same time. No hardware exchange for enhancing traditional TDM systems with MPLS-TP shall be required.

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

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

The platform shall have means to cross-connect, drop and insert individual channels (64 kbit/s time slots), 2 Mbit/s framed (G.704) and unframed (G.703) signals. It shall also support termination and cross connection of VC-12, VC-3 and VC-4.
Equipment protection and various protection schemes shall be supported.
For stations with Teleprotection and telecommunication requirements an integrated Teleprotection function (distance and differential protection) has to be provided. External Teleprotection equipment is only accepted in stations, where existing equipment has to be extended.
Each network element shall be manageable locally as well as from an operation center. There shall be means available to supervise external/existing equipment. It must be possible to access the platform over a TCP-IP network.
Functionality / Interfaces for direct connection to following USER SIGNALS shall be available on hot pluggable plug-in modules for the equipment:

- Analog subscriber interface: subscriber FXS and exchange side FXO
- 4-wire E&M voice interface
- Programmable data interface V.24/V.28, V.35, X.24/V.11, RS-485 (2-wire/ 4-wire)
- 64 kbit/s codirectional/ contra directional electrical interface acc. to ITU-T G.703
- Alarm collection interface
- Teleprotection command interface as per IEC 60834-1
- Optical interface module for up to 4 protection relays compliant to IEEE C37.94
- IEC 61850 GOOSE based protection interface
- Binary signal (status and control) interface

- 2 Mbit/s electrical interface for unframed signals acc. to ITU-T G.703 and framed signals acc. To G.703 and G.704
- Circuit emulation function for E1, serial and telephony interfaces
- n x 2 Mbit/s electrical SHDSL ports for TDM services supporting copper pair bonding
- n x 2 Mbit/s electrical SHDSL ports for EFM services supporting copper pair bonding
- Ethernet interface 10/100/1000BaseT, electrical, RJ-45 or SFP based
- Ethernet Interface 100BaseFX and 1000BaseLX/SX, optical, SFP based
- Support of L2 switching functions
- Support of L3 routing functions
- Support of Power over Ethernet
- Ethernet interface supporting Ethernet over SDH (EOSDH, GFP ITU-T G.7041 and LCAS ITU-T G.7042 functions)
- Ethernet interface supporting Ethernet over PDH (EOPDH, MLPPP functions) On

TRANSPORT LEVEL the equipment shall support the following connection ports:

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

All optical MPLS-TP, SDH and Ethernet ports shall support SFP or SFP+ modules (small-factor pluggable unit) for short, medium, long and extra-long optical communication. ALS (Automatic Laser Shutdown) shall be fully supported.

The Multiservice Platform shall support at least the following Cyber Security features:

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

3 Teleprotection Requirements

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

Contact based Distance Protection application

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

- Guaranteed dependability and security as per IEC 60834-1 for distance protection signals, also in highly disturbed communication networks (e.g. with packet loss or bit errors).
- Guaranteed back-to-back latency of < 5 ms for high and extra high voltage line tripping.
- Availability of communication channel of 99.999%.
- Command addressing for Teleprotection signal shall be provided to prevent tripping if the signal is inadvertently re-routed through the telecommunication network.
- An automatic and periodic loop test (< 100 ms) has to be provided for a signal delay measurement.
- In case of loss of communication on main path a switch-over of the Teleprotection command to the standby path shall be hitless.
- Trip counters shall allow the supervision of the Teleprotection functionality.

- Enhanced channel supervision and warnings and alarming in case of communication channel performance needs to be provided (approaching critical threshold/ critical threshold passed).

- The configuration of the Teleprotection has to be integrated into the communication configuration tool of the multiplexer in order to ensure easy maintenance.
    - The Teleprotection function needs to be fully integrated into the network management system in order to ensure full visibility of the complete communication system.
    - Authentication of signals to detect data modification in WAN and replay of data.

Differential protection application

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

- Guaranteed performance for the differential protection interfaces as per the standards (IEEE C37.94, ITU-T G.703, G.712, G.823, V.11).
- Guaranteed maximum end to end asymmetry of ≤ 150 us for IEEE C37.94 channels.
- Guaranteed maximum end to end asymmetry of ≤ 400 us for all other legacy PDH interfaces commonly used for differential protection channels.

- Enhanced channel supervision as well as warnings and alarming in case of communication channel performance degradation (approaching critical threshold/ critical threshold passed).
- In case of loss of communication on main path a switch-over of the differential protection channel to the standby path shall be hitless.
- Guaranteed back-to-back latency of ≤ 6 ms for high and extra high voltage line tripping
- Availability of communication channel of 99.999%.
- Application oriented configuration possibility. Latency as a critical parameter for differential protection application shall be available as a configuration parameter by using the GUI.
- Authentication of signals to detect data modification in WAN and replay of data.

IEC 61850 GOOSE based protection

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

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

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

4 Hybrid Multiservice Platform Requirements

4.1 General Requirements

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

4.2 Safety

The equipment shall be safe to use and shall comply with EN 60950-1.

4.3 Ambient Conditions

- Storage and transport:
- Temperature range: - 25°C ... +70°C
- Humidity: max. 95% (no condensation)
- Operation:
- Temperature range: - 25°C … +65°C
- in fan less configuration: - 25°C … +55°C
- Humidity: max. 95% (no condensation)

4.4 Electromagnetic Compatibility (EMC)

The equipment shall comply with the EN 55032 class A, EN 61000-6-2, EN 61850-3, and shall be in conformance with CE.

4.5 Mechanical Construction

The equipment shall be available as a 19" shelf to be mounted in a 19" rack or 19" cabinet. It shall be of robust design. All modules shall be integrated in the same shelf. All connectors shall be accessible from the front and comply with international specifications.

4.6 Power Supply

The multiplex equipment shall operate from a nominal 48 VDC or 60 VDC battery, positive grounded. The equipment shall work satisfactorily over battery voltage variations of +20% / –15% (40.8 VDC - 72 VDC). The equipment shall support dual power feed (1+1 hardware protection) i.e. that two power sources can be connected directly to the equipment (two connection points).
The equipment shall supervise the power source and provide corresponding alarming in case of loss of either power source.

4.7 Packet Switched Capacity

The design of the backplane shall provide wire-speed GbE connectivity between the different slots and the central (redundant) Ethernet switching matrix slots. Between uplink slot positions a backplane capacity of n x 10 GbE shall be available ($n \geq 2$). For future upgrade purposes a 10 GbE backplane connection from the central Ethernet switching matrix to x different slots shall be available ($x \geq 5$).

The central switching matrix shall at least support 62 Gbit/s in full duplex wire- speed switching capacity in a lower scale version and at least 146 Gbit/s in a higher scale version. IPv4 routing shall be as an option with a capacity of at least 10 Gbit/s wired speed routing.

The combination of MPLS-TP and integrated IP routing interface card shall allow to offer L3 VPN services with fast L2.5 based transport functionality and IP routing at defined locations.

4.8 Circuit Switched Capacity

The digital cross-connect function shall be implemented in such a way that no single point of failure exists. The PDH cross-connect capacity shall be up to 128 x 2 Mbit/s non-blocking with a granularity of 64 kbit/s. Additionally, the equipment shall offer a scalable high-order SDH cross-connect capacity with at least 80x80 VC-4 and a low order cross-connect for VC-3 and VC-12 in the same equipment with a capacity of at least 48x48 VC-3 and 945x945 VC-12.

4.9 Redundancy Capabilities

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

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

4.10 Traffic Protection

4.10.1 1:1 Path Protection

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

4.10.2 1+1 Path Protection

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

If a path has switched to its standby route because the main route is disturbed this shall be indicated with an alarm. The switching shall be done within the multiplexer without using the Network Management System. SNCP protection on VC-12, VC-3 and VC-4 level shall be supported. Switching from main to backup path shall be automatically. Configuration options shall exist for reversible or non- reversible switching. Switchover time shall be less than 50 ms.

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

4.10.3 1+1 Section Protection

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

4.10.4 Hitless Protection for Teleprotection Data Channels

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

4.11 Network Topology

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

4.12 Synchronization

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

The equipment shall support synchronous Ethernet and a synchronization selection process based on ESMC (Ethernet Synchronization Message Channel).
The precision time protocol (PTP) as defined by IEEE/ IEC shall be supported for frequency and time of day synchronization.
For Teleprotection event recording it shall be possible to synchronize the event recorder of Teleprotection interfaces to a GPS. The GPS time shall be available for the Network Element time as well.

Configuration support for SyncE and PTP synchronization shall be available e.g. by means of wizards or guided configuration.
For TDM synchronization the equipment shall be capable of selecting the source of synchronization by means of SSM (Synchronization Status Messaging) on 2 Mbit/s PDH or SDH port or by means of a priority-based sequence.
The system shall provide 2 MHz inputs for the synchronization from other equipment.
The system shall provide 2 MHz and PPS outputs for the synchronization of other equipment.

4.13 Alarms

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

4.14 Maintenance Facilities

On hardware level the following maintenance features shall be supported

- Port mirroring

- SNMP based port and traffic class counter statistics (UC, MC, BC) On MPLS level the

device shall support at least the below OAM features

- LSP ping/ traceroute
- Delay measurement
- BFD

  Specifically, for Teleprotection interfaces the device shall support enhanced monitoring
- Configurable packet loss thresholds with warning and alarming functionality
- Graphical/ tabular performance histograms including 15 min/ 24 hours/ 7 days

statistics on legacy TDM interfaces the equipment shall provide

- Means to loop signals towards the network and towards the user on 64 kbit/s level as well as on 2 Mbit/s level. It shall indicate an alarm if a loop is activated.
- Performance monitoring and counters according to ITU-T standards.
- PRPS signal generator and analyzer for testing of N x 64 kbit/s and 2 Mbit/s paths.

4.15 Telephony

The equipment shall provide means to interconnect telephony subscribers and PBX systems. Analog as well as digital solutions shall be supported.

- Analog two wire subscriber and four wire subscriber/ trunk solutions
- Digital VoIP subscriber and gateway functionality (SIP)
- Echo canceller function for any digital voice signal.
- Power over Ethernet solutions
- Hotline services

4.16 Cyber Security

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

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

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

4.17 Quality of Service

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

- ≥ 8 hardware queues per physical port
- Configurable scheduling profiles
- Priority mapping tables (DSCP, PCP, EXP, PHB, TC)
- Priority configuration for individual protocols (e.g. PSC, MCC, …)
- Port- and service-based rate limiting (at least single rate two color marker (SR2CM))
- Port- and service-based shaping
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port

4.18 SNMP

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

- Alarms
- Interface counters

4.19 Local User Terminal

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

4.20 Network Management System

The network management system (NMS) shall have facilities to supervise, monitor, control and configure each equipment and the whole network. It shall have capabilities of fault, configuration, performance and security management. It shall provide various graphical views to the network such as geographical overview, logical network structure, and hierarchical view. The network management system shall allow to define different user profiles.

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

A comprehensive alarm management shall show current alarms such, that icons of the network elements change their colors according to the alarm level. The alarms shall be categorized as critical, major, minor alarms and warnings. A summary shall indicate the total number of alarms and warnings in the entire network. An alarm list shall list all alarms of the entire network according to the time of their occurrence. It shall be possible to filter alarms with various filter criteria. Operators shall be able to add comments to the alarms.

The NMS shall provide additional functionality such as centralized ESW handling with the possibility for scheduled ESW distribution and timed ESW activation on a node. Inventory management functionality allowing the upload of all the inventory information

of a complete network with detailed information on HW state, serial number or ESW information running on NEs and individual interface cards shall be provided.

The NMS shall provide a Graphical User Interface with definable network displays (maps). Icons symbolizing sub-networks, equipment and sections shall be available to be placed on a background image. Drill down to display greater details down to equipment port level shall be possible. An online help shall be integrated in the NMS.

The NMS shall provide a graphical shelf view of the devices. Currently installed and configured modules in the network element shall be displayed. Current alarm and status information for the different modules and ports shall be presented with dynamic coloring of the network element.

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

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

Main/Standby functionality shall be supported by the NMS. In case of a failure of the main NMS, the standby NMS shall take over. Replication of the databases shall be automatically performed.
The DCN (Data Communication Network) to access all Network Elements shall be based on TCP-IP. The equipment shall use a dedicated router to forward DCN IP datagrams. In addition, the router will support OSPF as dynamic routing protocol.
The management system shall offer an SNMP northbound interface for alarm integration into higher order network management systems.

5 Aggregation/ Transport Interface Requirements

5.1 MPLS-TP Functionality

The following MPLS-TP functionality shall be supported:

- Static configuration of MPLS-TP tunnels via configuration tool or network management system
- Bidirectional MPLS-TP tunnels
- Priority handling using L2 or L3 class of service information
- Special care needs to be taken for mission critical services, required performance parameters for teleprotection applications need to be guaranteed
- Port based MPLS assignment
- VLAN based MPLS assignment
- The following topologies shall be supported
  - Point to point virtual private wire services (VPWS)
  - Tree structures
  - Virtual private LAN structures (VPLS)
  - Hierarchical VPLS structures (H-VPLS)
- End to end Operation Administration and Maintenance (OAM) channel with at least

the following functionality
  - Continuity check messages (CCM)
  - Remote defect indication (RDI)
  - Route tracing (LSP ping/ trace route)
- 1:1 traffic protection with < 50 ms switchover time
- Management functionality using dedicated MPLS channel
- Circuit emulation of legacy services via MPLS-TP shall be supported.

5.2 Scalability of MPLS Solution

A lower scale and a higher scale version of the MPLS function shall be available. The lower scale version shall support at least

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

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

5.3 Ethernet Interface

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

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

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

5.4 SDH Interface

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

Prepared for STM-1/4/16 SFP's (small-factor pluggable units) for short, medium, long and extra- long optical communications (1310nm, 1550nm or xWDM)

- Prepared for electrical STM-1 (155 Mbit/s) SFPs
- Termination of the OS-, RS-, MS- and VC-4 layer
- Extraction and insertion of the SOH communications information
- Through connections of VC-12, VC-3 and VC-4
- Support of MSP (Multiplex Section Protection)
- Support of SNCP (Subnetwork Connection Protection)
- Ethernet over SDH (EoS) functionality based on GFP / VCAT / LCAS
- 1+1 SETS timing protection
- 1+1 hardware protection

The following maintenance functions shall be supported.

- Status indications

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

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

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

5.5 PDH Interface

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

5.6 SHDSL Interface

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

6 Access/ User Interface Requirements

6.1 2/4-Wire Interface (VF Interface)

The module shall provide at least 8 interfaces for voice channels with a bandwidth of 300 Hz -

3.4 kHz and 2 signaling channels (M E, M' E') per voice channel. Each voice channel shall be configurable to operate with or without CAS. With CAS it shall use the "a" and "b" bits for the two signaling channels.

The level shall be software adjustable within the following range in 4-wire operation:

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

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

6.2 Analog Subscriber Interface (FXS)

A module providing at least 16 subscribers shall be available. The ringing generator shall be integrated on the subscriber module. The ringing frequency shall be adjustable for 20Hz, 25Hz, and 50Hz. The following main functions shall be supported:

General:

- Constant current line feeding, Line test, Permanent line checks, CLIP (On-hook VF transmission), Metering

Downstream signaling:

- Ringing, Metering, Polarity reversal, No battery Upstream signaling:
- On/off-hook, Pulse and DTMF dialing, Flash impulse, Earth key

6.3 Exchange Interface (FXO)

The module shall provide at least 12 ports for remote analog subscribers of a telephone exchange (PAX, PABX). It shall provide the following functions:

- Pulse dialing, tone dialing (DTMF), earth key function, metering function (12 kHz or 16 kHz), flash impulse, polarity reversal, indication of busy lines

The following parameters shall be configurable by software:

- Input voice level -5 ... +4dBr, output voice level -7.5 ... -3dBr
- metering pulse enable/disable, signaling bit definition, loop back of voice to the telephone

6.4 Voice over IP Subscriber Media Gateway

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

6.5 Voice Frequency Telephony Processor

The module shall as voice frequency processing unit for PSTN signals, provide two echo cancelers for each bidirectional PSTN voice channel. It shall access up to 208 voice channels.

6.6 Party Line Telephone System (Engineering Order Wire)

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

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

6.7 Serial Data Interface

The following features shall be supported

- Programmable data interface V.24/V.28, V.35, X.24/V.11, RS-485 (2-wire/ 4-wire)
- Synchronous and asynchronous operation from 0.6 … 38.4 kbit/s
- Synchronous operation on 48, 56, n x 64 kbit/s (n = 1 … 32)
- 1+1 path protection, Point-Multipoint, Performance Monitoring, Data conferencing The conferencing function shall be EQP protected (1:1 hardware protection).

6.8 Ethernet/IP Interface

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

Layer 2 Ethernet switching/ MPLS attachment service access interfaces.

- At least 12 ports per module
- Ethernet electrical connection: 10/100/1000BaseT
- Ethernet optical connection: 100Base-FX and 1000Base-LX/-SX/-EX/-ZX

- Support of VLAN tag stacking
- Protection by means of xSTP or R-L2GP in case of MPLS based networks
- Port and VLAN based rate limiting
- Hard QoS (8 queues per physical port)
- Priority handling (PCP/ TC/ PHB/ EXP) shall be configurable
- Port based access (all traffic is mapped into MPLS-TP services)
- VLAN based access (separation of VLANs into different MPLS-TP services)
- Mix of port and VLAN based access and mapping into VPWS/ VPLS on the same physical port
- Configurable storm control for unicast, unknown unicast, multicast and broadcast per port
- Traffic policing/ rate limiting shall be supported
- Traffic type filtering shall be supported (multicast, broadcast, unicast)
- VLAN mapping shall be possible

Ethernet routing modules shall comply with the following specification. Low capacity layer 3 routing interface card with access to TDM bus.

- At least 4 ports per module
- Ethernet connection: at least 10/100BaseT
- Routing Protocols: static IPv4 routing, OSPF2 v2, RIP v2
- WAN protocols: PPP, MLPPP
- WAN capacity: up to 16 x 2 Mbit/s
- WAN ports: ≥ 30
- Redundancy: EQP (1:1 hardware protection) and VRRP
- Port based rate limiting
- Soft QoS (software queuing)

High capacity layer 3 routing interface card with access to 1 Gbit/s and upgradable to 10 Gbit/s backplane.

- At least 12 x FE/ GbE optical/ electrical SFP based front interfaces
- At least 16 x virtual routing functions (VRF/ VPRN)
- Wire speed forwarding on all ports (1GbE or 10GbE backplane access)
- At least IPv4 unicast routing (IPv6 ready)
- OSPFv2 (RFC 2328)/ static routing
- OSPF authentication (Simple/ MD5)
- VRRPv3 (RFC 5798)
- At least 1:1 NAT, one instance per VRF
- At least basic firewalling (ACL rules/ DoS protection/ port and VLAN based rate limiting)
- Layer 3 hardware supported QoS (DSCP, 8 queues per physical port)
- SNMP MIBs (at least IF counters/ alarms)
- Maintenance features (Ping/ trace route)
- At least 128 x VLAN interfaces per module
- At least 128 x VRRP instances per module
- At least 32 x VRRP link tracking per module
- DHCP forwarding

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

- At least 12 x logical EoS WAN ports per module
- EoS WAN port capacity of at least 2.4 Gbit/s per module
- Framing according General Framing Procedure (GFP) ITU-T G.7041
- Virtual Concatenation (VCAT) according ITU-T G.707
- Protection by means of Link Capacity Adjustment Scheme (LCAS) according ITU-T G.7042

A module with Power over Ethernet shall be available to power e.g. camera, telephone set (Voice over IP). MDI / MDIX shall be supported on electrical interfaces.

- At least 12 x PoE ports per module
- PoE and PoE+ standard. At least 2 x PoE+ with up to 30 W shall be supported per card. In case end devices do not need the full PoE+ power capacity the remaining PoE capacity shall be shared among all ports on the same module.
- At least 84 W of PoE power per module

6.9 Alarm Interface

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

It shall be possible to label an alarm. The label-text shall be read from the interface module and visible as well on the Network Management System as well as on the local craft terminal.

6.10 Teleprotection Command Interface

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

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

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

The Teleprotection module shall provide

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

The Teleprotection module shall further support

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

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

6.11 Optical Teleprotection Interface

This module shall have at least 4 optical ports each of them allowing direct connection to protection relays with interfaces complying with ANSI/IEEE C37.94.

- Each interface shall support all 12 time slots (64 kbit/s – 768 kbit/s) in accordance with ANSI/IEEE C37.94.
- The ports shall be configurable to be used also for connection with protection relays using the former interface operate according to IEC 60870-5-1, format class FT 1.2 on 1300 nm, single mode fiber using MCMI (Multi Coded Mark Inversion) line coding.
- Symmetry as well as jitter and wander values shall be guaranteed in order to meet application requirements regardless of the transport technology (TDM or MPLS-TP).
- IRIG-B outputs (optical and electrical) shall be available to pass on time of day information to end devices in case WAN supports transmission of accurate Time of Day information.
- PPS outputs shall be available to pass on synchronization information to

end devices. Redundant communication channels in line with application requirements shall be supported.

6.12 IEC 61850 GOOSE Protection Interface

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

- 4 x FE/ GbE interfaces (SFP based) for direct connection with the station bus of IEC 61850 substations
- Representation of remote IED for inter substation IEC 61850 GOOSE signal transmission
- Filtering capabilities for GOOSE messages
- Translation capabilities of GOOSE messages to resolve potential addressing/ naming conflicts between substations
- Redbox functionality for connection to PRP redundant station bus (one card/ two card solution)
- L2 firewall for access restriction from the WAN to the substation station bus

- Hitless redundancy for GOOSE protection communication channels
- Guaranteed data integrity thanks to authentication of data streams
- 6 electrical IRIG-B outputs for synchronization of end devices to GPS Grandmaster clock
- Optical IRIG-B output for synchronization of end devices to GPS Grandmaster clock
- PPS outputs for synchronization of end devices to GPS Grandmaster clock
- PTP gateway between PTP Telecom Profile and PTP Power Profile
- SNTP master functionality for providing time of day information to IEDs
- SNTP client functionality for full IEC 61850 compliance
- MMS status reporting to substation automation system for full IEC 61850 compliance
- Enhanced traffic supervision features providing full visibility of the communication channel performance
- Full integration in network management system and configuration tool
- Providing all optical interconnections from relay to relay through multiplexer without any converter boxes
- Processing time of IEC 61850 GOOSE Gateway shall be less than 200 µs

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

6.13 Binary Signal Transmission Interface

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

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

6.14 E1 Interface

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

6.15 Circuit Emulation Interface

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

- Impedance of 120 ohms (75 ohms with external balun)
- Supporting CRC-4 multi-frame according to ITU-T G.704 (administrative state configurable by software)
- The CAS signaling according to ITU-T G.704 table 9 shall be activated optionally
- 2 Mbit/s loop-back of the incoming signal as well as the loop-back of the internal signals
- Flexible, individual configuration of the 2 Mbit/s interfaces to the circuit emulation instances or to the TDM backplane
- SATOP (RFC 4553) “Structure Agnostic Transport over Packet” circuit emulation

method support

- CESOPSN (RFC 5086) “Circuit Emulation Service over Packet Switched Network” circuit emulation method support
- CESoETH (MEF8) “Circuit Emulation Services over Ethernet” method support

6.16 SHDSL Interface

The 2 Mbit/s SHDSL TDM interface shall provide means to interconnect the multiplexer over one or two pairs of copper wire up to10 km using G. SHDSL modulations. It shall communicate either with another interface of the same type or with a remote desktop terminal. Remote powering of the desktop terminal shall be available. Up to 8 x SHDSL interfaces shall be available on the module. In addition, a SHDSL interface complying with Ethernet first mile (EFM) standard as per ITU-T

G.991.2 shall be available. The same shall provide at least 8 x SHDSL EFM ports. The capacity shall be up to

22.8 Mbit/s if pair bonding is used. The capacity on 1 pair

shall be up to 5.696 Mbit/s.

6.17 SHDSL Desktop Terminal Equipment

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

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

6.18 SHDSL Repeater

7 Requirements for Cyber Security

7.1 Firmware

It shall be possible to check the integrity/authenticity of the equipment firmware (e.g. using a secure hash or digital signature).

7.2 System Time Synchronization

The equipment shall support SNTP client in order to keep the system clock automatically updated. The equipment shall have the capability to select one of the following operation modes:

- Broadcast

  The equipment listens for broadcast messages delivered by the SNTP server.
- Unicast

  The equipment queries periodically the SNTP server. The polling period must be configurable.
- Disabled

  The SNTP client is disabled. In this case the equipment shall ignore SNTP messages.

The equipment shall have the capability of using a primary and a secondary SNTP server when working in unicast mode. In case the primary server is not available the secondary server will be used.

7.3 Interfaces Used to Access the Management Agent

The equipment shall make provision for an Ethernet port (henceforth called “local management interface”) that allows access only to the local management agent (i.e. to the management agent running on the equipment itself but not to management agents running on remote equipment).

The equipment shall make provision for interface(s) that allow access to the management agent from a remote site through an IP network (henceforth called “routed management interface(s)”).

The equipment shall make provision for a VLAN dedicated exclusively to the traffic to/from the management agent (out-of-band management). The VLAN identification must be configurable.

The priority of the traffic flowing through the routed management interfaces shall be configurable (i.e. capability to assign a Class of Service to the management traffic).

It shall be possible to enable/disable the local management interface by configuration.

It shall be possible to enable/disable the routed management interface(s) by configuration. The IP address of the local management interface shall be configurable.

The IP address/addresses of the routed management interface(s) shall be configurable.

The local management interface shall not participate in dynamic routing protocol (i.e. the local interface and its IP address are not propagated outside the local equipment).

It shall be possible for a routed management interface to participate in a dynamic routing protocol. The participation shall be configurable.

7.4 Protocols Used to Access the Management Agent

The equipment shall support the following protocols for the communication between the management agent and the network management system (NMS)/craft terminal (CT):

1. Telnet
2. SSH
3. IPsec (tunnels between the NMS and the equipment management agent)
4. SNMPv3

Acceptance of unencrypted communication shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of unencrypted communication.

Acceptance of telnet sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of telnet sessions.

Acceptance of SSH sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of SSH sessions.

Acceptance of SNMP sessions shall be configurable, i.e. a configurable Boolean variable shall enable/disable acceptance of SNMP sessions.

7.5 Syslog

The equipment shall support the capability of sending event messages to up to ten different remote Syslog servers. Each server is identified by its IPv4 address.

The UDP port to which the Syslog messages are sent shall be configurable for each one of the ten Syslog servers.

Enabling generation of Syslog messages shall be configurable, i.e. a configurable Boolean variable shall enable/disable the generation of Syslog messages.

The equipment shall provide the capability to set the severity threshold for Syslog messages sent to a Syslog server, i.e. all messages with severity equal or higher the severity threshold will be sent to the Syslog server. Each one of the ten Syslog destinations has its own individual settings.

7.6 VLANs

The equipment shall support the capability to do at least the following: On access ports

(ports that connect to end equipment)

Reject VLAN tagged frames Tag VLAN untagged frames

On trunk ports (ports that connect to a remote equipment of the same type specified here)

Reject VLAN untagged frames

Forward a VLAN tagged frame only if the VLAN identification matches an entry in a list of explicitly permitted VLAN identifiers

On access trunk ports (ports that connected to a remote equipment not of the same type specified here – the remote equipment sends .1q tagged frames)

Reject VLAN untagged frames Double tag VLAN tagged frames

7.7 Access Control

The equipment shall support at least four network administrator roles. A set of rights (privilege level) as well as a password is associated with each role. The privilege levels will grant the following rights:

Role-4 (lowest privilege level)

Typically assigned to administrators that only require monitoring of the network operational status. Read access only.

Role-3 Typically assigned to administrators that besides monitoring the network operational status are also required to diagnose malfunctions.

Read access and write access to perform diagnostic operations (e.g. counter reset, test loops, etc.).

Role-2 Typically assigned to the network administrator.

Read access and write access for all operations except for cyber security **related operations.**

Role-1 (highest privilege level)

Typically assigned to the security operator.

Read access and write access for all operations including cyber security related operations (e.g. session management, password management, management of RADIUS access server related settings).

A network administrator accessing the equipment management agent shall be subject to authentication.

The equipment shall stop accepting logins for a login retry time after three consecutive unsuccessful login attempts.

The login retry time shall be configurable.

The equipment shall support a session time-out at least for an administrator logged in with Role-1 privilege level.

The equipment shall support both local and remote authentication. For remote authentication the equipment shall support remote RADIUS authentication.

If local authentication is used the equipment shall store the passwords encrypted.
If only remote authentication is used the equipment shall not store the credentials locally (they will be stored on the remote authentication server, i.e. the RADIUS server).
The choice between local, remote or both remote and local authentication shall be configurable. The following options shall be provided:

- Enable/Disable local authentication (i.e. against locally stored credentials) on local management interface.
- Enable/Disable local authentication (i.e. against locally stored credentials) on routed management interface.
- Enable/Disable remote authentication (i.e. RADIUS server) on local management interface.
- Enable/Disable remote authentication (i.e. RADIUS server) on routed management interface.
- Enable/Disable fall back to local authentication (i.e. against locally stored credentials) if both the primary and secondary RADIUS server (see later requirement) are unavailable.

The equipment shall support a primary and a secondary RADIUS server. If the equipment fails in contacting the primary server, it will automatically try to contact the secondary server.
The number of retries to contact the primary RADIUS server before the equipment switches to the secondary RADIUS server shall be configurable.
The time the equipment waits for a reply from the contacted RADIUS server shall be configurable.
The UDP port for the primary RADIUS server shall be configurable. The UDP port for the secondary RADIUS server shall be configurable.

7.8 Protection against BC, MC, UU and KU Storm

The equipment shall provide the capability to limit the ingress rate of Broadcast, Multicast, Unknown Unicast and Known Unicast frames on port basis.

7.9 OSPF Authentication

The equipment shall provide the capability to authenticate OSPF messages (e.g. MD5). This capability shall be provided for both DCN and user traffic OSPF capable routers.

7.10 Encryption

The equipment shall provide the capability to encrypt MPLS-TP traffic (end-to-end tunnel encryption). The MPLS-TP traffic can optionally be encapsulated in a VLAN.
The encryption shall be provided by a plug-in self-contained unit (henceforth designated as “encryption unit”) offering the following features:

- Eight (8x) SFP/SFP+ cages for electrical or optical 1 or 10 Gbit/s Ethernet
- AES-256 GCM encryption
- Four dedicated and independent (i.e. not shared) encryption engines for each one of four pairs of Encrypted/Unencrypted ports (i.e. the 8x ports are grouped into 4x pairs, for each pair one unencrypted port connects to the trusted zone whereas one encrypted port connects to the untrusted zone – henceforth such a port pair will be designated as “E/U ports-pair”)
- The 4x E/U ports-pairs shall be in turn grouped into 2x fully independent functional sub-units (2x E/U ports-pairs on each functional unit). Independent means that if one of the two functional sub-units is compromised it shall be possible to continue operation on the remaining sub-unit

- 1 or 10 Gbit/s wire-speed encryption capability for each encryption engine
- Management port dedicated exclusively to the management of the encryption unit
- MPLS outer label dependent encryption for MPLS-TP encapsulated traffic
- VLAN ID and MPLS outer label dependent encryption for VLAN plus MPLS-TP encapsulated traffic
- Up to 1024x keys to encrypt 1024x LSPs to arbitrary endpoints for each one of the four E/U ports-pairs (total 4x E/U ports-pairs X 1024 = 4096 encrypted LSPs)
- Encryption of layer 2 frames (e.g. PTP, ESMC) shall be configurable
- Encryption of OAM message shall be configurable
- PTP packet delay variation compensation
- Generation of high-quality random numbers for cryptographic keys (e.g. quantum random number generation)
- Tampering protection of solder and component sides of the PCB (Printed Circuit Board)
- Status LED indicators (at least 2x: one for unit status and one for traffic status)

Management of the encryption unit

- NMS (Network Management System) dedicated to the encryption unit. The NMS dedicated to the encryption unit will be henceforth designated as “E-NMS”.
- E-NMS manages the encryption units
- E-NMS generates and distributes master keys for each encrypted tunnel to both tunnel endpoints
- E-NMS handles the events, statistical data and alarms generated by the encryption units and has the capability to forward such data to the NMS used to administer the communication network (i.e. the NMS doing all non-encryption unit related management)
- Local management access (e.g. Ethernet interface to connect a CLI/GUI Craft Terminal).
- It must be possible to operate the encryption unit without E-NMS using only local management access
- Manual or E-NMS based MPLS tunnel configuration
- Manual or E-NMS based master key generation
- Secured connection between the encryption unit and the E-NMS (e.g. TLS)
- Interlock between E-NMS and local management access, i.e. if the encryption unit is under E-NMS management then it is no longer manageable via local management access

7.11 Teleprotection

The equipment shall provide authenticity, integrity and non-replay verification for both distance and differential protection applications when Teleprotection is transported over MPLS-TP.

The equipment shall use the NIST approved CMAC-AES256 algorithm.

If the equipment supports more than one WAN (Wide Area Network) channels then each channel shall have its own unique configurable key (e.g. if two WAN channels are supported, let us say WAN-1 and WAN-2, then 2x keys shall be supported: one key is used for the communication over WAN-1 and the other key is used for communication over WAN-2).

The equipment shall generate an alarm if the key in force is the default key.

The equipment shall generate an alarm every time an authenticity/integrity/replay check fails.

The equipment shall keep a local history in non-volatile memory of the failed authenticity/integrity/replay checks.

It shall be possible to read out the local history from the Network Management System.
It shall be possible to read out the local history from the Craft Terminal.

7.12 IEC 61850 GOOSE Protection Interface

The equipment shall provide authenticity, integrity and non-replay verification for IEC 61850 GOOSE messages when these messages are transported over MPLS-TP.
The equipment shall use the NIST approved CMAC-AES256 algorithm.
If the equipment supports more than one WAN (Wide Area Network) channels then each channel shall have its own unique configurable key (e.g. if two WAN channels are supported, let us say WAN-1 and WAN-2, then 2x keys shall be supported: one key is used for the communication over WAN-1 and the other key is used for communication over WAN-2).

The equipment shall support MAC address filtering (firewalling) to restrict access to the station bus from the wide area network interface. The approach shall be whitelisting, i.e. an Ethernet frame will be forwarded only if it matches an entry in a list of explicitly permitted MAC addresses.
The equipment shall generate an alarm if the key in force is the default key.
The equipment shall generate an alarm every time an authenticity/integrity/replay check fails.

7.13Synchronization and Test

Equipment Recommended list of equipment:

- Master clock for the synchronization of MPLS/ SDH equipment: Type M3000 or similar Suppliers: Meinberg or similar
- Optical Power Meter for 1300nm and 1550nm, handheld: OLP-6 or similar Suppliers: JDSU/Acterna or similar
- Digital Communication Analyzer: PFA-35 or similar for signal analysis on 64 kbit/s /2 Mbit/s level Suppliers: JDSU/Acterna or similar
- Optical Time Domain Reflectometer OTDR Suppliers: Anritsu, Fujicura or similar
- Test equipment for Teleprotection Module: Test set or similar Suppliers: Teleprotection module producer or similar
- Ethernet test equipment: CMA-3000 or similar Suppliers: Anritsu or similar

8 Abbreviations

ADM Add-Drop Multiplexed
ALS Automatic Laser Shutdown
BC Broadcast
BFD Bidirectional Forwarding Detection
CAS Channel Associated Signaling
CRC Cyclic Redundancy Check
DSCP Differentiated Services Codepoint
DTMF Dual Tone Multi-Frequency
EFM Ethernet First Mile
EN European Norm
EOW Engineering Order Wire
EQP Equipment Protection
ERPS Ethernet Ring Protection Switching
ESW Embedded Software
ETS European Telecommunications Standards
EXP MPLS experimental bits
GPS Global Positioning System
GUI Graphical User Interface
HDSL High Density Subscriber Line
IEC International Electrical Commission
ITU International Telecommunication Union
IP Internet Protocol
LER Label Edge Router
LSR Label Switch Router
MC Multicast
MPLS-TP Multi-Protocol Label Switching Transport Profile MSP Multiplex Section Protection
NE Network Element
NIST National Institute of Standards and Technology
NMS Network Management System
LAN Local Area Network
OAM Operation, Administration and Maintenance
OS Optical Section
OSPF Open Shortest Path First
PBX Private Branch Exchange
PCP Priority Code Point
PDH Plesiochronous Digital Hierarchy
PPP Point-to-Point Protocol
PRBS Pseudo Random Binary Sequence
PRP Parallel Redundancy Protocol
PSN Packet Switched Network
PTP Precision Time Protocol
PW Pseudo Wire
RS Regenerator Section

SDH Synchronous Digital Hierarchy
SNMP Simple Network Management Protocol
SOH Section Overhead
STM Synchronous Transport Module
STP Spanning Tree Protocol
SyncE Synchronous Ethernet
TC Traffic Class
TCP Transmission Control Protocol
TTI Trail Trace Identifier

UC Unicast
VC Virtual Container
VF Voice Frequency
VoIP Voice over IP
VPLS Virtual Private LAN Service
VRRP Virtual Router Redundancy Protocol

SECTION VI

4.1.7 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

OVERHEAD LINES

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4.1.7 PARTICULAR TECHNICAL SPECIFICATIONS FOR OVERHEAD LINES

4.1.7.1 66KV, 33KV & 11KV LINES

4.1.7.1.1 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 Technical Specifications, in which the general technical requirements are specified. The drawings enclosed in are for bidding purposes only.

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

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

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

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

The scope of work covers supply of equipment, engineering and design, manufacture, testing before shipment and packing seaworthy or otherwise as required, delivery of all equipment CIP site, construction and installation and commissioning.

Where the new line share the route with existing lines, the scope of work shall include all the necessary works/modifications that will be required to accommodate the lines along the same route. The hardware/fittings and conductors of the existing lines shall be re-used.

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

<u>Cross arms:</u>
Steel cross-arms shall be used in all cases including transfer (where applicable). Steel cross arms shall meet international accepted standards in addition to KPLC specifications for steel structures and line fittings.

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

<u>Lattice and Monopoles Towers</u>
Lattice or monopole towers shall be used for construction of 132 kV lines. The towers shall meet BS 8100, BS EN 50341 and BS EN 10163 and other internationally acceptable standards.

Optical Ground Earth Wire (OPGW)
OPGW (Optical Ground Earth Wire) shall be used in all 33kV lines and above. Standard size for KPLC is 48 cores single mode Optic fibre. Where Overhead line transitions to Underground cable, an Underground Fibre Optic cable will be laid together in the trace of the power cable.
OPGW earthing shall be done after every fourth pole.

Line conductor
The 11kV and 33kV Overhead line conductors shall be 150mm2 ACSR.
The 66 kV overhead conductor shall be 300 mm2 AAAC.
The 132 kV overhead conductor shall be 175mm2 Lynx or any other conductor specified in definite scope of work section.

Conductor Joints and terminations
All joints and terminations shall be of compression type for conductors of 150mm2 and above.

4.1.7.1.1.1 Nature and Extent of Work

The work covered by this Specification forms part of the KPLC's Distribution capacity enhancement Project and is for design, survey, supply, installation and commissioning of new Overhead Lines as specified herein and in the Attachments. The overhead lines will form part of KPLC's transmission and distribution network system.

The new lines may run in parallel with existing overhead lines, but due to constraints in wayleave in some areas/section of the lines, the existing lines shall be transferred to the new line. Where existing line is on wooden poles the wooden poles shall be replaced with Concrete poles.

The works to be carried out by the Contractor in accordance with the Specification and Condition of Contract and shall comprise and not limited to the following:

(a) Three-phase overhead lines having the particulars set out in the Scope of Works, Technical Schedules and Drawings attached to the Specification,
(b) the lines being complete with the survey, line conductors, insulators and fittings, poles and cross arms, Earthing (where required) and connections and all other fittings necessary to have a complete distribution line.

4.1.7.1.1.2 Design

The following drawings shall be submitted by the Contractor according to the time schedule for approval:

- Detailed route maps
- Longitudinal profiles
- Tables showing the capacity of the poles and towers related to wind and weight span for the actual conductor sizes
- Sag tables for the actual conductor types for stringing conditions and included compensation for creep
- Erection drawings for each pole and tower line formation showing, insulator sets, fittings, cross arms etc.
- Pole and/or Tower foundation.

4.1.7.1.1.3 Factor of Safety

The minimum factor of safety at assumed maximum simultaneous working loading shall be as follows:

i) Line conductors based on ultimate strength

Max tension	3.0
Everyday stress	5.0

ii) Insulator and fittings, based upon electro-mechanical test and minimum failing load

Insulators and insulator fittings	2.5
Dead-end clamps and conductor fittings	2.5

iii) Steel structures, bolts and other steel pole members based on elastic limit of tension members and on crippling loads of compression members:

Steel Structures (Including steel cross arm)	2.5
Bolts, nuts and washers	2.5

iv) Supports, stays and cross arms subjected to the longitudinal transverse and vertical loads resulting in the lading conditions stated above:

Wood supports and cross arms	3.5
Concrete structures	2.5
Steel supports and cross arms	2.5
Stay assembly and fittings	2.5
Foundation – Concrete	2.5

4.1.7.1.1.4 Working Conditions

The maximum assumed working conditions shall be as follows:-

i)	Minimum temperature of line	5^{o}C
ii)	Ambient temperature of line conductor	35^{o}C
iii)	Maximum temperature of line conductors	80^{o}C)
iv)	Wind pressure on the whole projected area of conductors	400N/m2
v)	Wind pressure on projected are of insulator	400N/m2
vi)	Wind pressure on projected are of support	400N/m2
vii)	Altitude above sea level:	0 – 2200 meters.

4.1.7.1.2 CLEARANCES AND SPANS

4.1.7.1.2.1 Medium overhead lines minimum clearances at operating temperatures:-

i)	Lines not exceeding 11kV across or along road:	5.8m (19ft)
ii)	Lines not exceeding 11kV over private land:	5.2m (17ft)
iii)	Lines not exceeding 33 kV over private land:	5.8 m
iv)	Lines not exceeding 66kV over private land:	6.2m (20ft)
v)	Lines not exceeding 132kV over private land:	7.0m

4.1.7.1.2.2 Additional Clearances

i)	11 kV line conductor to any part of the building:	2.7m (8ft. 8 inch).
ii)	33 kV line conductor to any part of the building:	5.0m
iii)	66 kV line conductor to any part of the building:	7.5 m
iv)	132kV line conductor to any part of the building:	10m

4.1.7.1.2.3 Special Clearances

a) Railway crossing clearances

i) All types of line including guard nets 8.1m (30ft)

ii) The minimum clearance of any pole or structure from the centre of a tract shall be the height of the pole above ground plus 2.1m (7ft).

iii) Where the tract is in a cutting, no such pole shall be closer to the edge of the cutting than a distance equal to the height of the pole.

iv) Angles of crossing Medium voltage, not less than 60°

b) Kenya Posts and Telecommunications Installation Clearances

i)	Guard net	–	1.3m (4ft)
	Up to 66kV conductors using cradle guard	–	1.8m (6ft)
ii)	Angles of crossing Medium voltage,	–	not less than 60°

c) Installation near Airport Clearances

i)	Guard net	–	1.3m (4ft)
	Up to 66kV conductors using cradle guard	–	1.8m (6ft)
ii)	Angles of crossing Medium voltage,	–	not less than 60°

d) Kenya Pipeline Clearances

i)	Guard net	–	1.3m (4ft)
	Up to 66kV conductors using cradle guard	–	2.1m (7ft)
ii)	Angles of crossing Medium voltage,	–	not less than 60°

4.1.7.1.2.4 Environmental Requirements

The Contractor shall undertake to complete all works in accordance with statutory requirements including those of:

i) i) The Kenya Wildlife (Management and Conservation Act) Applicable for all works inside National Parks.
ii) ii) The Kenya Agricultural Act - Concerning protection against soil erosion.
iii) iii) Public Health Act – Concerning with noise, water and air quality as they relate to human health.
iv) iv) Chief Authority Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.
v) v) The County Government Act – Section 145 for preservation or protection of wildlife and Section 163 regarding noise disturbance controls.
vi) vi) Kenya Forestry Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.

The Contractor shall take reasonable precautions to avoid damage to land, property, crops, etc. and shall ensure that the work is adequately supervised so that damage is reduced to the minimum. All surplus material shall be removed after erection and site shall be left in a clean and tidy condition, to the satisfaction of the Purchaser.

Where the Contractor considers that damage cannot be avoided if the work is to proceed normally, he shall notify the Employer accordingly. The Employer will coordinate and facilitate assistance with the landowner concerned during negotiations for compensation. The Contractor will be responsible for compensation in respect of damage and the Contractor shall proceed with the work within the limits indicated by the Purchaser.

Where temporary removal of bound, wall or similar obstacles is necessary for the purpose of foundation installation or support erection, the cost of removal and subsequent reinstatement shall be deemed included in the Contract rates for foundation and support erection.

Where it is necessary to provide scaffolding over roads, railways or telecommunication lines in order not to interfere with the passage of traffic, this shall be carried out by the Contractor at such times as may be convenient to the Authority concerned. Flagman and approved types of danger and warning notices shall be provided by the Contractor to ensure safety of the public.

4.1.7.1.3 WAY LEAVES

Way leaves shall be provided by the Purchaser to enable the Contractor to carry out the Works. In order to provide way leave the Purchaser has to obtain approvals from Government and other statutory authorities and also consents from owners and occupiers of property which will be affected by the lines.
The procedure for obtaining approvals and consents is dependent on preliminary profile survey, as described below:

a) Representatives of the Purchaser will accompany Contractors staff during preliminary survey. The Purchaser's representatives will issue notices to and liaise with landowners and occupiers in order to establish rights of entry for survey and agreement to limited cutting of vegetation as specified.

b) Upon approval by the Purchaser of preliminary survey the Purchaser will initiate procedures for obtaining way leave, and when necessary approvals and consents have been granted the Purchaser will arrange for trees etc. to be cleared from the line route as specified.

c) Upon approval by the Purchaser of the position of support centre pegs the Contractor shall submit access maps as specified and the Purchaser will obtain the necessary rights of construction access for the Contractor.

d) Way leaves procedures as described above will take place concurrently with profile survey, approval of centre pegs, etc. The Contractor shall allow in his programme for a period of up to two months from approval of preliminary lines to the grant of right of access for its construction.

e) Any conditions for the way leave should be made known to the Contractor.

f) The way leave procedures shall lead the construction programme for each section of the Contract.

4.1.7.1.4 STANDARDS

Unless another standard is mentioned in this Specification, all materials used and provided under this contract and all services performed must be in accordance with the latest amendments of the Standards of the International Electro-technical Commission (IEC) or British Standards (BS), applicable Kenyan Standards and the attached Material Specifications.

Suppliers who do not normally manufacture to IEC or BSI Standards may offer equipment in accordance with other recognized national Standards provided that they draw attention to any essential differences between their Standards and IEC/BSI Standards and Subject to the satisfaction of the Employer that the quality, finish and performance of the equipment complying with such standards shall be comparable to that complying with IEC or BS.

4.1.7.1.4.1 Units of Measurements

SI units (System International) shall be used in all the technical schedules and drawings.

4.1.7.1.5 MATERIALS

Each of the several parts of the line shall be of such construction and design as to give long and continuous service with high economy and low maintenance costs.
All material used and equipment provided under this contract shall be new and of the best quality and workmanship and shall be of the highest class throughout with the designs and dimensions of all parts such that mechanical and electro-mechanical stresses which they are subjected shall not render them liable to distortion or damage under most severe conditions encountered in service. Repair of any defective parts shall not be permitted without the sanction in writing of the Project Manager.

The detailed design shall be carried out in manner to facilitate inspection, repairs and simplicity of operations and maintenance. All materials shall ensure satisfactory operations under the atmospheric conditions prevailing in the area where the lines are to be built, irrespective of season and under such variations of load and voltage as may occur under working conditions of the system. Line supports, conductors, insulators and fittings shall be such as to minimize the risk of damage due to deterioration, or damage in service of any part of the line. The design shall incorporate any reasonable precaution and provision for the safety for those concerned in the maintenance of the Contract Works and all associated works supplied and executed under other contracts.

All corresponding parts shall be made to gauge, shall be inter-changeable wherever possible throughout the Contract Works and are to be such as will facilitate the fitting of replacement.

4.1.7.1.5.1 Line Supports and Foundations

The network shall be supported on concrete and steel structures.
The wood poles shall meet specifications set in Kenya Power and Lighting Co Ltd: Specification for Wood Pole and Kenya Standard KSO2-516: Poles for power and telecommunications lines. The concrete poles shall meet the specifications set in Kenya Power and Lighting Co. Ltd; Specifications for Concrete Pole Kenya Standard DKS 1933.

The poles can be of single pole type or H-pole type, with or without stay wires, with insulator chains or pin or post insulators, depending on the actual conditions and the approved design.

4.1.7.1.5.2 Physical and Mechanical Properties of Wood poles (Not Applicable)

The wood poles (Eucalyptus Salina) used shall have the following properties:-

Nominal length	10	11	11	12	12	14	14
Category	Medium	Medium	Stout	Medium	Stout	Medium	Stout
H(mm)	1.8	1.8	1.8	1.8	1.8	2.0	2.0
D_c(mm)	220	230	295	240	305	248	310
D_m(mm)	150	160	200	160	200	160	200
D_g(mm)	220	230	295	240	305	270	335
D_e(mm)	175.9	185.6	234.8	189	238.1	199.4	248.4
F(kN)	5.90	4.94	13.05	4.03	10.37	3.45	8.23
Ultimate load (kN)	8.64	8.73	18.42	8.89	18.24	10.46	20.02
Crippling load (kN)	59.4	58.6	149.8	51.2	128.9	45.9	110.3

H Ground position from butt
d_c Critical diameter
d_g Minimum groundline diameter (mm)
d_m Minimum top diameter (mm)
d_e Effective diameter
f Load per mm of deflection at point of application of load

Note that the mechanical properties used in the mechanical calculations are those stated in the Kenya Standard KSO2-516.

4.1.7.1.5.3 Strength and Species

Wood poles shall be of eucalyptus timber and shall belong to the strength groups Light, Medium or Stout as specified. The treatment shall be creosote pressure-treated wood, or Chromated copper arsenate (CCA).

4.1.7.1.5.4 Pole Caps

Pole caps of approved type shall be used.

4.1.7.1.5.5 Safety

All poles shall have a DANGER/HATARI warning plate, placed at a visible point in the pole at a height of 1.7m and legible from a distance of at least 2m.

4.1.7.1.6 EXCAVATION

The hole for the pole shall be excavated to a minimum of 1.8m for the 11m pole. If the base of the hole is not firm ground, the hole shall be excavated until firm ground is reached, otherwise the pole has to be placed on a flat rock block, min. 40 x 40 cm or a timber raft, min 80 x 80cm. depending on the conditions.

Minimum hole depth for wood poles shall be defined in the table:-

Pole Height H (m)	Size	Hole Depth Minimum (m)
10	Medium	1.6
11	Medium	1.8
11	Stout	1.8
12	Medium	2.0
12	Stout	2.0
14	Medium	2.2
14	Stout	2.2
15	Stout	2.4
17	Stout	2.6

The hole shall be dug to the required depth. Any holes left overnight must be covered in such a way that they do not pose any danger to persons or animals. A suitable method of warning shall be used to identify positions of the holes.

4.1.7.1.7 ERECTION

The butt of the pole is laid over the hole with the length in the direction of the line. A skid board is placed against the hole to facilitate the entry of the butt when the pole is raised and prevent earth breaking into the hole during the process of erection.

Erection of the poles shall be done using any of the following methods:

i) Erection ladders
ii) Truck mounted hydraulic lifts
iii) Guy ropes shall be used to prevent accident and to hold pole in a true vertical position. The pole is gradually raised to the vertical position and the butt guided into the hole.

4.1.7.1.8 POLE DRESSING

Partial dressing can be done while the poles are lying on the ground; in this case care must be taken during erection to avoid the fittings being damaged. The fitting of the insulator shall be done after the pole has been erected.

4.1.7.1.9 BACK FILLING

After erecting the pole and positioned it vertically, the pole shall be secured in this position by help of stones blocks placed in 2 or 3 layers, one layer at the bottom of the hole, and one to two layers at the top. The stones shall fill out the area between the pole and the wall and will secure that the pole remains vertical during the pole's lifetime.

Between the layers of stone and above the top layer, the excavated soil can be used as backfill material if the origin soil is appropriate for tamping.
The soil should be wet and backfilled slowly and each layer thoroughly tamped until the tamp makes a solid sound as the earth is stuck. Each tamping layer should not exceed 150 mm. If small stones or gravel are readily available, these should be mixed with the soil used in backfilling.

In areas where the ground is unsuitable for firm erection of poles i.e. swampy areas with black cotton soil etc the pole has to be placed on a flat rock block or on timber raft as described under **Clause 4.1.7.1.6**. It may also be necessary to change out the soil material around the pole.

4.1.7.1.10 DESIGN, MATERIALS AND CONSTRUCTION OF CONCRETE POLES

The concrete poles shall be designed and manufactured in accordance with Kenya Standard DKS 1933.

The poles shall be round, Prestressed or Reinforced Concrete Poles as per DKS 1933.

The materials used shall be in conformity with the design standard (DKS 1933) and shall be selected to suit intended application.

The pole shall be so designed that its strength in transverse direction shall be sufficient to take the load due to wind on conductors, fittings and the pole.

In accordance with Annex A of DKS 1933, the aggregates used in the manufacturer pf the pole shall be free from veins and adherent coating and free from injurious amount of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky, sconaceous and elongated pieces shall be avoided.

The surface of all reinforcement shall be free from loose scale, oil, grease, clay or other material that may have deleterious effect on the bond between the reinforcement and concrete.

The mix design, mixing and compaction of the concrete shall be such that the necessary strength in the pole is obtained after curing in accordance with DKS 1933.

Concrete shall be compacted by vibration, centrifugation or other efficient means. Hand compaction shall not be permitted.

The finished pole shall have a smooth external surface that is free from honeycombing.

A quarter (¼) of the poles supplied for each consignment shall incorporate an integral Earthing system comprising a non-stressed internal Earthing copper conductor (at least 70mm² stranded conductor) running the length of the pole and the ends of the conductor shall be left projecting from the pole to a length of 100mm at 200mm from top and 150mm below ground level. Manufacturer may offer alternative suitably designed Earthing termination for consideration.

4.1.7.1.10.1 Physical and Mechanical Properties of Concrete Poles

The concrete poles shall conform to the following standard sizes:

Nominal Length (m)	Top Diameter (mm)	Working Load (kN)	Ultimate Load (kN)	Strength Class (as per DKS 1933)	Minimum Depth in Ground (m)
10	190	2.5	5	50	1.8
11	190	2.5	5	50	1.8
12	190	3.0	6	50	1.8
13	190	3.0	6	50	2.0
15	190	3.0	6	50	2.1

The required safety factor is 2.5 and pole taper for the Pre-stressed Concrete Pole shall be at least 13mm per meter.
Poles shall be supplied complete with suitably designed fittings for conductor and stay wire characteristics.

4.1.7.1.10.2 Marking

Each concrete pole shall be marked permanently by impressing on the pole (or by use of a permanently secured plate) at a position 1.5m above the pole Ground line with the following details:

- Manufacturer's name
- Date of manufacture (mm/yy)
- Length of pole (meters) and Tip dimensions (mm)
- Ultimate/Working load/Strength Class
- Type of pole
- Weight of pole
- Standard to which the pole complies
- The words "PROPERTY OF KPLC"

Ground line reference mark shall be conspicuous on the pole.

Where a plate is used it shall be made of stainless steel, securely affixed to the pole. In all cases the lettering shall be not less than 5mm high legibly impressed.

4.1.7.1.10.3 Bolts Nuts and Washers

All bolts and nuts shall confirm to BS 4190 and shall preferably have screwed threads of I.S.O. form. Nuts and heads of all bolts shall be of the hexagonal type. All bolts and screw

rods shall be galvanized including the threaded portion. Al nuts shall be galvanized with the exception of the threads, which shall be oiled.

4.1.7.1.11 INSULATORS AND FITTINGS

4.1.7.1.11.1 Insulators

Insulation between conductors and support shall be polymeric for tension, suspension, pin and post insulators, and shall comply in all respects with IEC 305, 383 and 120, 1109 and 815 or such other standard as may be approved and with the requirements set out in this Specification and in the Technical Schedules.

Insulators polymeric type from approved manufacturers who shall have had at least ten years' experience of supplying complete insulator units to international purchasers. Technical particulars and service histories must be submitted for the type of insulator offered. Insulator units shall where possible be interchangeable with units already in use on the Employer's system.

All insulators shall be designed with a view to service in a tropical climate in an area subject to lighting storms, at an altitude of about 2200 m above sea level.

Glass Insulator strings, where specified in scope of work, shall consist of minimum quantity of 12 units for 132kV, 6 units for 66kV, 3 units for 33kV and 2 units for 11kV at 146 mm Centre distance between each disc. The actual numbers and types of discs shall be selected to suit the requirements set out in the technical schedules.

Locking devices for the insulator units themselves and for associated ball and socket and fittings shall be of stainless steel and shall comply with IEC 372. The assembly shall be such as to allow easy removal for replacing of insulator units or fittings without the necessity to remove the insulator string from the crossarms.

All ball and socket joints on insulator sets shall be lightly coated with approved grease before erecting.
Each insulator shall be marked with the name or trademark of the manufacturer and the year of manufacture in accordance with IEC Publication 60383. In addition, each insulator shall be marked with the specified electromechanical or mechanical failing load in conformity with IEC Publication 60383.

4.1.7.1.11.2 Insulator Fittings

Fittings shall comply with BS.3288: Part 1 or such other standard as may be approved and shall be so designed that replacement of string insulator units and the arcing protection system can easily be performed during maintenance or repair under outage or live-line conditions.

All clamps shall be as light as possible and shall be designed to avoid any possibility of deforming the stranded conductors and separating the individual strands.

Bolts and nuts shall be in accordance with an approved specification. Bolt threads shall be coated with approved grease immediately before packing. Split pins for securing attachment of fittings of insulator sets shall be of stainless steel and shall be packed by washers of approved size and gauge.

All insulator strings shall be attached to crossarms by means of shackles or swivels. Hooks shall not be used.

4.1.7.1.11.3 Pin Insulators

Pin insulator shall be used for intermediate line poles and for small angles up to 20°.

On pin insulators, the conductor shall be bound in on top of the groove, using two suitable stirrups in each case. The bind shall be formed of a single layer of closely wound wire, extending at least 25 mm beyond the stirrups. The bind shall be wound on opposite directions, on each side of the insulator.

With aluminium conductor, the bind shall be formed of two stirrups, with 2.5mm diameter aluminium binding wire. In addition, aluminium amour tape shall be used, wrapped in a direction opposite to that of the conductor lay. The amour tape shall cover the portion of the conductor that is in contact with the insulator, and extend at least 40 mm under the bind.

4.1.7.1.11.4 Tension and suspension Insulators

These Polymeric Insulators shall be used where increased tensile strength in the conductors is envisaged i.e. flying angles, section and terminal poles.

The table below gives creepage distance requirement in relation to pollution.

Type of pollution	Creepage distance
Low	18-22 mm/kV
Medium	25-31 mm/kV
Extreme (Coastal/industrial area)	35 mm/kV

Where there is severe lightning activity, high insulation and creepage values are necessary

4.1.7.1.11.5 Post Insulators

In high pollution areas (Coast region) 33kv line shall use Post insulators for 66 kV line and 11kv lines shall use 33kv line post insulators.
All insulators to be used shall be composite polymeric insulator unless stated in the general technical specifications.

4.1.7.1.11.6 Cross Arms

The following types of cross-arms shall be used for 33kV and lower voltage lines depending on the limiting factor. 66kV lines and above shall not use Cross Arms, instead they shall use composite post insulators.

4.1.7.1.11.6.1 Steel Cross Arms

Steel crossarms shall be used in all cases as required.
Steel Crossarms shall be used extensively in the line making different formations. The choice of the formation will be determined based on the following:

i) Environmental conditions
ii) Landscape
iii) Available space

The steel cross arm shall be suitable for continuous operation outdoors in tropical areas at altitudes of up to 2200m above sea level, humidities of up to 90%, average ambient

temperature of +30ºC with a minimum of -1ºC and a maximum of +40ºC and saline conditions along the coast.

4.1.7.1.11.6.2 Materials

Structural steel used, shall be grade 43A as specified in the BS 4360: “Specification for weld able structural steel”.

The tensile strength and yield stress of the steel shall be not less than 430/510 N/sq. mm and 255 N/sq. mm respectively.
Angle sections shall be as per BS 4848
Channel sections shall be as per BS4

4.1.7.1.11.6.3 Welding

Welding where specified shall be by metal-arc welding and shall be as per BS 5135.
After welding and before galvanising, welds shall be thoroughly cleared to remove slag and spatter, preferably by sand blasting.

All materials before and after fabrication shall be straight and free from twists. The material shall be free from blisters, scale and other defects.

All dimensions specified shall be subject to the following tolerances, unless otherwise stated.

(i) Dimensions up to and including 50 mm: ±1 mm
(ii) Dimensions greater than 50 mm: ±2 mm

Erection clearance for cleated ends of members connecting steel to steel shall not be greater than 2mm at each end.

Bolt holes shall not be more than 2mm greater than the diameter of the bolt for bolts up to 24mm diameter.

Cutting may be by shearing, cropping, sawing or machine flare cutting. Sheared or cropped edge shall be dressed to a neat finish and be free from distortion where parts are to be in metal contact.

All holes shall be drilled in one operation and burrs shall be removed. Holes shall not be formed by a gas cutting process. All matching holes for bolts shall register with each other so that a gauge 2mm less in diameter than the diameter of the bolt shall pass freely through the assembled members in a direction at right angle to such members.

4.1.7.1.11.6.4 Galvanizing

All materials to be galvanized shall be of the full dimensions shown or specified and all punching, cutting, and the removal of burrs shall be completed before the galvanizing process commences.

All galvanizing shall be done by the hot dip process with spelter, not less than 98% of which must be pure Zinc and in accordance with BS 729.

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

Galvanized steel structures shall be treated after galvanizing with Sodium Dichromate Solution.

Galvanizing	Steel Structures for Inland installations
Minimum Average Coating Weight	610 g/m²

Bending of flat straps shall be carried out cold.

4.1.7.1.11.6.5 Standard Sizes

The standard sizes of the different Cross Arms shall be as shown on the table below:-

Application	Standard Length (mm)	Cross Section		
		Height (mm)	Width (mm)	Thickness
11kV Inter pole. Upto 150mm^2 conductor.	1626	70	70	9.5
11kV Section/Angle/Terminal Upto 60^o 150mm^2 conductor.	2290	125	70	9.5
33kV Inter pole	2400	100	76	9.5
33kV Section/Angle pole/ Terminal	2400	125	76	9.5

4.1.7.1.11.6.6 Markings

The cross arms shall be marked legibly and indelibly with the words “Property of KPLC”.

4.1.7.1.11.6.7 Line Formation

The following is a recommendation for the use of the different common line formations:

i) Line poles for deviations 0°-10°, Steel cross arm will be used for horizontal and delta formations.
ii) Line poles for deviation 20°-60°,, double cross-arms or vertical flying angle shall be used.
iii) Line poles for deviations greater than 60°,, vertical sections shall be used.

4.1.7.1.11.7 Stay, Stay Insulators and Stay Blocks

4.1.7.1.11.7.1 Stay

Stay wires shall be in conformity with the attached Specification for Stay Wires and Guy Grips.
The dimension of stay wires used shall be in accordance with the actual load taking into consideration the Safety Factor given.
The stay wires shall with first-class workmanship be fastened to the pole to assure that they are keeping the pole in a vertical position during the pole’s lifetime.

4.1.7.1.11.7.2 Stay Insulator

A sling type strain insulator shall be inserted in each stay 1.6m from the top.

4.1.7.1.11.7.3 Stay Block

A reinforced concrete stay block buried to the depth of 1.6m shall be used as the stay anchor.

4.1.7.1.11.8 Conductor

Phase conductor to be used shall be Aluminium Conductor Steel Reinforced (ACSR) or All Aluminium Alloy Conductors (AAAC) and shall consist of steel strands together with aluminium strands or aluminium strands. The specific conductor to be used shall be described in the definite scope of work.

The outermost layers of the conductors shall be stranded with right hand lay. There shall be no joints in the individual wires of the outer layers of the aluminium wire.

The requirements for the conductors are specified in the attached Specification for Aluminium Alloy Conductors and Specification for Aluminium Conductor Steel Reinforced.

4.1.7.1.11.8.1 Conductor Characteristics

The conductors shall conform to the following:

a) Physical characteristics

Nominal Al. area (mm^2)	Code Name	Steel No./mm^2	Alum. No/mm^2	Overall dia. (mm)	Calculated Al. equ. Area (mm^2)	Total cond. Area (mm^2)	Weight Kg/Km	Copper Equiv. Area (sq.in)
150	Wolf	7/2.59	30/2.59	18.1	154.3	195.0	727	0.15
175 ACSR	Lynx	7/2.59	30/2.79	19.53	183.4	226.2	842	0.19
300AAA	Upas		37/3.53	24.71		362.1	997	0.3

b) Electrical characteristics

Nominal Al. area (mm^2)	Tensile Strength kgs	Resistance at 20 °C Ohm/Km	Current Rating Amp	Inductive reactance ohm/Km Spacing	
				30cm	50cm
150	6880	0.1844	430	0.235	0.266
175	7880	0.1576	470	-	-
300	10600	0.09155	610	-	-

The current ratings are based on the following operating conditions:

- Ambient temperature : 35°C
- Maximum conductor temperature : 80°C
- Intensity of solar radiation : 0.089 w/cm^2

4.1.7.1.11.8.2 Joints, Clamps and Connectors

Conductor fittings shall be designed in accordance with BS.3288. The electrical conductivity and current capacity of each joint or clamp shall be not less than those of the equivalent length of conductor.

Dead end clamps and tension joints shall be of the wedge clamp type and shall be so as not to permit slipping of or cause damage to or failure of the complete conductor at a load less than 85 per cent of the ultimate strength of the conductor. (Refer to the safety factors: 3.0 for conductors, 2.5 for clamps/fittings))

The design of joints and any tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly. All external nuts shall be locked in an approved manner. There shall be no relative movement within the clamp between individual layers of the conductor itself.
Mid span joints shall comply with the mechanical requirements of the Specification for line conductor joints and clamps. Compression dies shall be of a common size and dimensions for each fitting for a given size of conductor. Not more than one mid span joint will be allowed in one span in one conductor.
Parallel Groove (PG) clamp can be applied to joint conductors where there is no mechanical load.

4.1.7.1.11.8.3 Conductor Terminations.

Ball ended hook, Socket clevis and Socket tongue shall be suitable for use on Aluminium conductor steel-reinforced (ACSR) of outer diameter between 7.0mm and 25mm (25 sq. mm and 150 sq.mm) and standard disc insulator of ball and socket type with the ball pin diameter of 16mm.

Ball ended hook, socket clevis and socket tongue shall be of malleable iron or ductile iron, hot dip galvanised to BS 729.

Tension clamp shall be bolted type and shall be suitable for use on aluminium conductor steel-reinforced (ACRS) of outer diameter between 7.0mm and 25mm (25 sq.mm and 150 sq.mm).

The clamp body and keeper piece shall be of high strength and heat-treated cast aluminium alloy.

The clamp cotter bolts, and U-bolts shall be galvanised steel and the pin shall be stainless steel.

The clamp shall have slip strength of not less than 85% of the rated ultimate strength of conductor it is intended for use with.

4.1.7.1.11.8.4 Joints (Non-tension)

Parallel groove clamp (PG Clamp) shall be suitable for use on aluminium conductor steel-reinforced and all aluminium conductors of outer diameter in the range of 7.00 mm to 18.2 mm for ACSR conductors 25mm for AAAC conductors (300 sq. mm).

(a) The groove of the PG clamp shall correctly fit the conductor it is intended for use with. It shall have adequate cross sectional area and length.
(b) The PG clamp shall be of electrolytic, high strength, corrosion resistant aluminium alloy.

4.1.7.1.11.8.5 Suspension Clamps

Suspension clamps shall be suitable for use on aluminium conductor steel-reinforced (ACSR) of up to 18.2 mm diameter (150 sq. mm) and All Aluminium Alloy Conductor (AAAC) of up to 25mm diameter (300sqmm) shall be of the following types.

(a) Clevis ended hook type and pivoted type (similarly known as envelope type and trunnion type respectively).
    (i) The clamp body and keeper piece shall be of high strength, heat-treated cast aluminium alloy.

(ii) The clamp cotter bolts, hangers, brackets and U-bolts shall be of galvanized steel and the cotter pin shall be of stainless steel.

(b) Angle suspension clamp type (similarly known as side opening type).

(i) The clamp shall be suitable for use on turning angles from 10 to 120 degrees.
(ii) The clamp body and keeper shall be of malleable iron or ductile iron; hot dip galvanised to BS 729.
(ii) The clamp cotter bolts and bolt shall be galvanised steel and the cotter pin shall be stainless steel.

4.1.7.1.11.8.6 Connectors

The connectors shall be suitable for use on stranded bare conductors and shall correctly fit the conductor it is intended for use.
The connector shall have adequate cross sectional area and dimensions and shall have current carrying capacity at least equal to the capacity of the conductor it is intended for.

(a) Aluminium connectors
(i) Aluminium connectors (line taps) shall be suitable for connecting stranded aluminium conductors
(ii) The connector shall be manufactured from electrolytic, high strength aluminium.

(b) Copper connectors

Copper connectors shall be suitable for connecting stranded copper conductors.

(c) Bi-metal connectors
(i) Bi-metal connectors shall be suitable for connecting stranded aluminium conductors to stranded copper conductors.
(ii) The bi-metal connector shall be designed to provide an effective corrosion barrier between the dissimilar metals (aluminium and copper).

4.1.7.1.11.8.7 Drums

Drums for conductors shall be stoutly constructed of good quality timber or steel and clearly marked with length and type of conductor in a manner not easily removable. Drums shall be securely battened around the perimeter and shall be lined with approved impervious material to prevent contact between the contents and both the drum itself and any chemicals with which the drum has been treated.

All timber drums and battens shall be protected from deterioration on site by termite or fungus attack by an approved impregnation treatment at the works before dispatch. Such substance shall not be harmful to the conductor.
All drums shall have spindle holes of adequate diameter and be stoutly reinforced with steel plate.

The cut ends of the conductor shall be properly secured to the flange of the drum and shall be treated in an approved manner to prevent the ingress of moisture during transit or storage.
The Contractor shall deliver all empty drums to the employer's store. All drums are non-returnable and shall remain the property of the Employer.

4.1.7.1.11.8.8 Markings of Drums

The following particulars will be indelibly stencilled on both flanges of every drum:
(i) Contract title and reference number
(ii) Manufacturer's name
(iii) Direction of rolling

(iv) Lifting instructions and limitations.
(v) The words “Property of KPLC”

An aluminium nameplate shall be fixed to each drum clearly showing the following:-
i) Conductor materials and stranding
ii) Length of conductor
iii) Net weight
iv) Gross weight
v) Manufacturers batch number
vi) Manufacturers drum number
vii) Winding date
viii) Approximate measurements

4.1.7.1.11.8.9 Conductor Stringing

All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

Every precaution is to be taken to prevent damage to the conductor. Clamps and other devices used for handling the conductor during stringing shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor. Conductor grooves in sheaves and tensioner shall be lined with neoprene or rubber.

Conductors shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

Conductor drums shall be closely examined before conductor pulling commences and all nails and other things that could damage the conductor shall be removed.

4.1.7.1.11.8.10 Re-Conductoring

Where applicable before the re-conductoring commence, the Contractor shall inspect the line and check that the clearances to ground, trees, houses, roads etc. meet the requirements. He shall also check that:

- The capacity of poles, cross arms and stay wires is sufficient for the new conductor
- The quality of poles, cross arms and stay wires is satisfactory
- The pole heights are sufficient for the new conductor
- The poles are in vertical position

Where the existing installation does not meet the above requirements, change out of material or aligning work of poles have to be carried out.

When re-conductoring, the Contractor has to handle all tilted poles with outmost care. Before loosen the existing conductors, the poles have to be secured with stay wires. Climbing the poles has to be done by use of ladders placed against the tilted direction.

All tilted poles has to be corrected to a vertical position before the stringing work of the new conductors starts. Poles that do not meet capacity- or quality-wise meet the new requirements have to be changed out.

After aligning the poles, the top of the pole shall not be out of the vertical axis by more than the top pole diameter.

All clamps, fittings and details not suiting the new conductors or quality-wise not meet the requirements, shall be changed out.

4.1.7.1.11.9 Safety

Personnel shall be required to use necessary protective gear, which conform to applicable codes.
Personnel working near high voltage areas shall be required to use non-slip footwear, gloves, safety glasses, helmets, etc. They shall also be required to observe stipulated safety clearances.

Fire prevention and safety programmes shall also be observed.

4.1.7.1.11.10 Operation Devices and Protection Systems

Operation devices consisting of single and three pole disconnectors shall be installed at locations specified by the designer. The disconnectors shall be easily accessible during normal conditions. They will be fixed in such a way that they cannot be closed by the action of gravity. Their characteristics shall be capable of meeting the maximum rated current of the circuit.

4.1.7.1.11.10.1 Isolation

4.1.7.1.11.10.1.1 Air break Switches

Air break switches shall be used to interrupt small currents (up to 10% of rating of ABS).

4.1.7.1.11.10.1.2 Protection against over Voltages

Protection against overvoltage will consist of surge diverters at locations specified by the designer.

4.1.7.1.11.10.1.3 Protection against Overcurrent

The network comprises main line and spurs.
Circuit breakers shall be installed at the beginning of the main line at the primary substation.

Short circuit fuses shall be installed at the beginning of the primary spur.
Autoreclosers and Sectionaliser shall be located as specified by the designer.

4.1.7.2 PARTICULAR TECHNICAL SPECIFICATIONS FOR TRANSMISSION LINES

4.1.7.2.1 DESIGN REQUIREMENTS

4.1.7.2.1.1 Philosophy of Design

The philosophy of design contained within this specification is based upon deterministic principles whereby the applied loading multiplied by the appropriate safety factor must be less than the ultimate strength of the component.
In tendering the Contractor will be deemed to have concurred as a practical manufacturer with the design and layout of the works as being sufficient to ensure reliability and safety in operation freedom from undue stresses and satisfactorily performance in all other essentials as a working plant.
The transmission lines shall be designed with high reliability and low cost of maintenance as the primary consideration in accordance with the relevant sections of the specification.
The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the erection and subsequent maintenance of the contract works.

4.1.7.2.1.2 Units of measurement

In all correspondence, technical schedules design calculations and drawings the metric (SI) units of measurement shall be used. Angular measurements shall be degrees with 90^0 comprising a right angle.

4.1.7.2.1.3 Design Calculations

All sets of calculation shall be complete, bound titled and given a unique drawing number The binding shall be such as to allow the easy introduction of subsequent pages if necessary.
Bound into each set shall be fully detailed index. Following this shall be a design information sheets which incorporates the following details: -

a) The design concept shall be summarized
b) Full details of manual design papers or other aids referred to in the text shall be given with photocopies of relevant sheets if appropriate.
c) Full loadings shall be reiterated with their deviations if appropriate
d) Design stresses shall be reiterated
e) Code or standard references should be quoted and equation written out in full for initial calculation

Should the Contractor be required to re-submit amended calculations or additional sheets the following annotation shall be adopted:-

a) Amended sheets should retain the same sheet number but have a lower case revision letter suffix i.e. sheet 14 when amended becomes 14a then 14b.
b) Additional sheets that needed to be inserted shall be given the sheet number they are added to plus an upper case letter prefix i.e. additional sheets to page 60 become A60, B60 and if subsequently amended A60a etc.

Where a computer program is used for design calculations a full explanation in the English language shall be provided to assist the Employers approval of the calculations for each and every program used. Details must include name of program author source, comprehensive description of theoretical basis including all references to relevant documentation, checks undertaken on program and list of projects on which the program has been used.

4.1.7.2.2 DRAWINGS

4.1.7.2.2.1 General Requirements

- Drawings shall be to scale fully detailed and all dimensions shall be in Metric Units.

General arrangements drawings submitted shall be to scale of not less than1 to 50 and all detail drawings not less than 1 to 20. Profile drawings shall normally be drawn to a vertical scale of 1 to 200 and a horizontal scale of 1 to 2,000.

- Drawings sheets shall conform in size to BS 3429, mainly A0, A1, A2, A3, and A4. A3 drawings shall be used as much as possible for construction drawings.
- The sheet size is to be stated on the drawing within or adjacent to the title block.
- Drawings shall conform to BS 308 or equivalent.
- The scale used shall be stated on the drawing as a ratio together with linear scale at a convenient position along the margin of the original drawing sheet.
- The physical draughting requirement in respect of line density, strength, contrast, contrast, spacing and character legibility shall be met to ensure drawings are suitable for microfilming in accordance with BS 5536 and the specification for micro-copying of drawings to BS 4210.
- All drawings shall bear in English, serial number of the project, drawing number, which shall be unique to this project and scale. The system of numbering and layout of the title block will be to the approval of the Employer. The title block shall include the name and address of the Employer. The revision notes shall detail the nature of each revision. The revision shall be enclosed in a cloud with the revision letter indicated.

4.1.7.2.2.2 Computer Generated Drawings

The submissions generated drawings by electronic transmission or any other electronic form shall be subject to agreement by the Employer.

4.1.7.2.2.3 Contract Drawings List

At defined interval the Contractor shall submit the requisite number of copies of the contract drawing list.
The list shall contain the following information:

a) Drawing number,
b) Drawing title
c) Revision status
d) Approval status

All changes since the previous issue shall be clearly indicated and when agreed only the front (index) revised sheets need to be submitted.

4.1.7.2.2.4 Contract Record Drawings

The Contractor shall submit to the Employer:

a) A final issue of the contract drawing list indicating which of the drawings design calculations, methods statements etc that they propose to issue as final contract drawings. These drawings shall be updated to incorporate all modifications made during erection and commissioning.
b) Requisite number of prints of each schedule, including where appropriate the supply and installation material manual.
c) Requisite number of drawings including design calculations schedules including the supply and installation material manual in diskette format in either WPG or DXF format.
d) Requisite number of polyester/transparency film copy of each drawing, including design calculations, profile and route maps.

The distribution of the contract record drawings will be advised by the Employer.

4.1.7.2.2.5 Route Maps

During the progress of the work the Contractor shall record on profiles, supply and install material manuals (SIMMs) and on a set Survey Maps of approved scale such particulars as will allow an accurate reference to be made afterwards in case of any faults or projected modifications to the line.
The map and/or profile sheet shall show the exact position of every support with approved reference marks. The maps shall be supplemented or profiles marked by sketches where necessary to delineate boundary position of support which cannot be clearly indicated on the maps.
The date included on the maps profile sketches and SIMMS shall be submitted to the employer to whom facilities shall be given for examining such records during the progress of the work.

4.1.7.2.2.6 Sag Templates

The Contractor shall supply the specified sets of templates in strong stable colourless plastic or similar material not less than 3mm thick. Engraving shall be on the back face of the templates. The templates shall be for the specified equivalent spans.

Each template shall be accurately shaped to provide the sag curve; the same curve shall be engraved on the template at a distance below representing the minimum allowable vertical clearance to normal ground. A further sag curve in still air at minimum temperature shall also be shown. Each template shall be clearly endorsed with the sagging basis, conductor particulars equivalent span and unless otherwise specified to a scale of 1:200 vertical and 1:2000 horizontal.

Templates shall be supplied to the Employer before the submission of the profiles. Failure to do so may result in delay which will be responsibility of the Contractor.

4.1.7.2.3 MATERIALS SUPPLY AND INSTALLATION MANUAL

As soon as final support positions are approved, the Contractor shall provide the requisite copies of the A4 size Supply Install Material Manual (SIMM).
Each support position shall be represented by one of the manuals with the following information recorded:

a. Provisional and final support numbers.
b. Profile and record map reference drawing numbers.
c. Span
d. Wind span
e. Weight Span
f. Angle of deviation
g. Support type, leg and body extensions and General Arrangement (G.A.) drawing reference numbers
h. Foundation type and G.A. drawing reference number
i. Earthing details and G.A. drawing reference number
j. Insulator set details and G.A. drawing reference number
k. Sag adjustment setting and linkage requirements – (where appropriate)
l. Phase conductor jumper details including spacer and general arrangements drawing reference number – (where appropriate)
m. Earth wire set details and G.A. drawing reference number
n. Earth wire vibration damper G.A. drawing reference number
o. Aircraft navigator (obstruction aids) drawing reference number – (where appropriate)
p. Fibre optic junction boxes and cabling G.A. drawing reference number – (where appropriate)

In addition, the following schedules shall be included: -

i. Phase conductor and OPGW sags and tension (erection and final)
ii. Suspension insulator sets off-sets
iii. Location and spacing of all phase conductor spacers dampers – (where appropriate)
iv. Location of all phase conductor and earth wire tension and non-tension joints
v. Location and spacing of all aircraft warning spheres (where appropriate)
vi. Location of all fibre optic joint boxes – (where appropriate)

The appropriate reference drawing numbers shall also be included. Preliminary copies of SIMMs shall be available prior to any site work commencing, together with materials summaries. This is Hold Point.

4.1.7.2.3.1 Maintenance Manual

The Contractor shall provide at the specified period before the end of the construction period of the contract, a maintenance manual covering the following information: -

a) Type, code numbers and description of all plant erected, together with names and addresses of manufacturers
b) Methods of assembly of all fittings
c) Method of replacing any part of the plant including the use of maintenance holes provided on the support access provisions and where appropriate the application of “live - line’ maintenance techniques.
d) Recommendations of preventive maintenance including frequency of inspection.
e) List of recommended maintenance equipment with a description of its use and limitations
f) Type and application of temporary Earthing equipment.
g) Personal safety equipment requirement and any risk assessment required.

The above information must be specified to this contract and entirely in the English language.
Drawings and diagrams shall be used where necessary to enable the Employer/Purchaser to properly maintain the whole of the works.
The manual shall be suitably bound within a hard cover and all materials used shall be reasonably hard wearing.

The manual shall be submitted to the Employer. This is Hold Point.

4.1.7.2.3.2 Samples And Models

If the nature of the works makes it desirable the Contractor/ supplier may be asked to submit or prepare for the Employer such samples, patterns and models as the Employer may reasonably require for the purpose of design approval at the expense of the Contractor/supplier.

4.1.7.2.3.3 Photographs

The Contractor shall make all arrangements to provide progress photographs of all tests and such sections of the work in progress as directed by the Employer. Each photograph shall be suitably entitled, in digital format. The photographs shall be the property of the Employer and no copies of the photographs shall be released without the authority of the Employer.

The Contractor will normally be required to provide every month at his own cost the specified number of sets of un-mounted progress photographs suitably inscribed of potions of the work in progress throughout the period of construction. Any variation to these quantities will only be with the permission of the Employer.

4.1.7.2.4 TRANSPORT, ACCESS AND SERVITUDE

4.1.7.2.4.1 Wayleaves

4.1.7.2.4.1.1 General

Way leaves and access facilities, subject to the requirement of landowners and occupiers, will be provided by the Employer to enable the Contractor to carry out the erection of the contract works. Such facilities will not necessarily include facilities for storing materials nor necessarily include access for wheeled vehicles.
The Contractor shall satisfy themselves that the necessary rights of entry and access have been obtained before
The contractor shall indicate to the employer such pipes or other obstructions telephone telegraph and power lines which infringe the clearance specified or otherwise fail to satisfy the requirement of the specification.
The necessary agreement for the removal of obstruction such as trees and for the permanent removal or guarding of pipes telegraph telephone and power lines, will be obtained by the Employer.

4.1.7.2.4.1.2 Way leaves Schedule

Before the Contractor commences work on any property, he shall obtain the way leaves schedule from the Employer, including details of any special requirement of the occupiers concerned. This is a hold Point.

4.1.7.2.4.2 Access to Site, Notice of Entry

4.1.7.2.4.2.1 Access Routes – General

The Employer may indicate to the Contractor the general route for access to each or any position as agreed by the Employer, otherwise the Contractor shall make all necessary arrangements (other than questions of way leaves) with the occupier.
Subject to the provisions of the preceding paragraph before commencing work, the Contractor shall at his own expenses do what is necessary to make the access suitable for his use and shall take all reasonable precautions to avoid damage, including if required erection of temporary fences or gates where permanent fences, hedges or gates have been removed. The Contractor shall not be entitled to any additional payment in the event of a particular access being difficult.
The Contractor shall be responsible for maintaining agreed access routes in a usable condition without undue widening for the duration of the contract. The occupier shall not be put to any inconvenience in gaining access to his land or buildings. No unauthorized access routes shall be taken by the Contractor.

4.1.7.2.4.2.2 Commencement of work

Before beginning on any property, the Contractor shall be responsible for obtaining confirmation from the Employer that way leaves are in order and any agreed accesses have not been altered and for giving not less than 48 hours' notice to the occupier that work is to begin. Work shall proceed on any land within the requisite period of such notice being given to the occupier.

4.1.7.2.4.2.3 Suspension of work

Where work is to be suspended without the expectation of it being resumed within the specified period, the Contractor must notify the occupier of such intention and shall similarly give the occupier prior notification of the resumption of work. The purpose of this Clause is to assist in maintaining good relations between the occupier, the Contractor and the

Employer and to keep the occupier informed of what is going to happen on or across his land.

4.1.7.2.4.2.4 Compliance with occupier's requirements

At all times during the execution of the works, the Contractor shall ensure compliance with all such reasonable requirements of the occupier as are brought to the Contractor's notice by the Employer. The Contractor shall not be entitled to any additional payment in respect of his compliance with the reasonable requirements of the occupier.

4.1.7.2.4.2.5 Notice to Authorities

Before the Contractor carries out the stringing of conductors along or across power or telecommunication circuits, public roads, etc, he shall give the requisite notice to the appropriate Authorities of the time and date when he proposes to perform the work and shall send a duplicate copy of each notice to the Employer.

4.1.7.2.4.2.6 Route Clearance

For details of the clearance requirements for survey, access routes, line route, support locations and conductor stringing, reference shall be made to **Clause 4.1.7.2.4.6** on route selection and clearance

4.1.7.2.4.2.7 Access Roads

For details of the access road requirements reference shall be made to **Clause 4.1.7.2.4.6** on route selection and clearance

4.1.7.2.4.3 Crossing Of Obstacles

4.1.7.2.4.3.1 General

The Contractor shall, at his own expense, make any necessary arrangements and take the necessary precautions where the route crosses buildings, telecommunication, power or pipelines, orchards, gardens, railways, antiquities or other obstructions or ground over or across which erection cannot be carried out in the normal manner or has to be avoided. These arrangements must be submitted to the Employer. This is a Hold Point.

Where a support is set across a fence, hedge, bank or wall, the Contractor shall remove and reinstate the fence, hedge, bank or wall at his own expense and he shall be responsible at his own expense for making good to the satisfaction of the Employer, owners and tenants concerned, all land, property, roads, drains, fences, walls hedges, gates and the like which he has damaged or disturbed during the execution of the contrast works and shall remove all surplus material after erection. The Contractor shall take proper precautions to prevent the straying of and damage to livestock until after the backfilling of excavations and permanent reinstatement of fences, walls, hedges, gates and the like are completed.

4.1.7.2.4.3.2 Public Utilities

The Contractor shall ensure that the erection of the contract works does not cause damage to or interference with existing telecommunication, power or pipelines.
Where appropriate Authorities affected deem it necessary for the protection of their employees, property, or the public, or for the assistance of traffic, to provide flagmen and watchmen, the cost of such provision shall be borne by the Contractor. Where required by the appropriate Authorities work shall be carried on outside normal hours and at the Contractor's own expense.

The Contractor shall also be liable to make good at least to the original condition or compensate the owners, operators and users or any public undertaking in respect of any damage however caused to their property, lands or roads arising out of or in consequence of the execution of the works.

4.1.7.2.4.4 Scaffolding

The Contractor shall provide all necessary scaffolding and the like for the crossing of telecommunications or power lines, roads, railways building or other obstacles. The Contractor shall advise the Employer in each instance of the scaffolding he proposes to use. Drawings of the proposed scaffolding shall be submitted to the Employer, and the appropriate regulatory authorities. This is Hold Point.

4.1.7.2.4.4.1 Live Line Scaffolds

The scaffolding which is used to cross specified low, medium and high voltage power lines shall be of such dimensions and allow such clearances that the power lines being crossed may remain in commission during construction of the new transmission line. It may only be possible to have shutdowns on the lines to be crossed for sufficient periods of time to top out and net the scaffolds. Such restrictions in building and use of the scaffolds will not be grounds for claiming additional costs. Design and construction of the live scaffold shall not be inferior to the minimum standards outline in the following clause.

4.1.7.2.4.4.2 Live Line Scaffold-Construction

The scaffold shall be designed to withstand the maximum design wind speed, except that a reduced return period will be accepted. Consideration shall also be given due to impact loading, due to dropping of the upper phase conductor.
The scaffold shall, unless otherwise approved by the Employer, consist of 3m wide 300mm squire mesh nylon nets attached to steel wire ropes running perpendicular to the lower line route, carried by metal scaffolding at 3m intervals. The nets shall be attached to the catenary wires by means that do not require the presence of any persons on the net or the catenary wires whilst the lower line is alive. An additional movable 3m by 50 mm mesh walk net laid over the 300 mesh nets may be used whilst the lower line is dead.
Normally, steel or aluminium tubular scaffolding to BS 1139 and BS 6323 should be used. The use of pre-formed units or frames shall be subject to the Employer's approval.

The mechanical construction shall be in accordance with BS 5950. Reference shall also be made where appropriate to BS 5973.
The design of the scaffold shall have due regard to the requirements of safety with particular respect to accidental contact with live conductors during construction, use and removal.
The scaffold, including foundations, shall be designed and constructed to ensure stability during the process of erection and removal, and also at times when work has caused for any reason including adverse weather conditions. The foundations shall be suitable for the ground concerned.

The base width of any tubular steel supporting structure shall not be less than 25 percent of its height. Lighter materials (e.g. Aluminium) shall be used with caution. Adequate diagonal bracing shall be provided.
The scaffold shall extend at least 5m either side of the outermost conductors of the upper line. A maximum of 2m of this distance may be provided by means of catchers.
Catchers shall be provided at each end of each scaffold support. The catcher may be vertical or inclined to a maximum angle of 45^0 from the vertical. They shall be capable of

withstanding the specified impact loads without excessive distortion that would permit a falling conductor to approach or touch a live line.

The upper parts of the scaffold shall be provided with soft wood rubbing boards or otherwise protected in an approved manner to prevent damage to the conductors resting on or being drawn over the guard. Soft wood poles may be used for this purpose. The height of these boards shall be sufficient to prevent the conductor damaging the nylon net. To avoid damaging the conductors no object other than non-metallic lashing or the catchers shall protrude above the rubbing boards.

Sufficient endless or double ended lead lines for hauling over pilot wires shall be placed over the scaffold prior to re-energization of the lower line.

The side supports shall have working platforms to facilitate the required running of conductors and prior wires. Working platforms shall be provided with handrails, toe boards and notices warning of the danger of live conductors. The heights of handrails shall be 1m and the toe boards 230 mm. Each working platform shall have a notice plate indicating the “Safe Climbing Height”.

The scaffold shall be fitted with danger plates at intervals of not more than 6m along the anti- climbing device with at least one plate on each face of the structure.
The scaffold shall be constructed to prevent unauthorized access or climbing by the use of barbed wire anti-climbing devices, fences or other means approved by the Employer.

The scaffolding shall be lit with red warning lamps from ½ hour before sunset to ½ hour after sunrise if erected within 2m from a highway or footpath without an intervening fence. The scaffold the Contractor shall provide or arrange for the supply and maintenance of these lamps (e.g. with the line Contractor).
If the scaffolding is constructed adjacent to a roadway, a guard constructed from steel drums filled with soil or a soil bund shall be provided and suitably lit.

Where possible the resistance to earth of the scaffold shall be less than 10 Ohms. Special consideration by the Employer and the lower line operator shall be given in cases where this is not attainable with a reasonable number of driven earth rods.

Bonding the scaffold to the earthing systems of either the live-line, or the line under construction is not normally acceptance. In the former case a nearby line fault could cause the scaffold to become live. In the latter case a fault between the live-line and the scaffold could cause components of the line under construction to become alive, particularly as its earthing system may not be complete.

The earth rods should normally be driven into the ground around the outside and approximately 1 m from the scaffold structure. The rods should be securely connected electrically and mechanically to the scaffold structure by flexible copper or aluminium leads with minimum across-sectional areas of 64 mm^2 or 100 mm^2 respectively.

Drawings of the scaffold complete with details of the clearance plates and earthing arrangement, together with supporting calculations shall be submitted to the Employer and appropriate regulatory authorities. This is a Hold Point.

4.1.7.2.4.5 Damage

4.1.7.2.4.5.1 General

The Contractor shall take all reasonable precautions to avoid damage to land, property, roads, crops, fields drain, fences walls, hedges, gates, trees and the like and shall ensure that the work is adequately supervised so that any damage is reduced to the minimum. Save as otherwise provided, the Contractor will be liable for all damage arising by or in consequence of the works except unavoidable damage to crops and shall pay compensation or make good at the option of the Employer.

4.1.7.2.4.5.2 Contractor's Responsibility

The Contractor's liability for loss or damage shall extend to any such loss or damage resulting from the employment of a Subcontractor. This does not relieve the Contractor of his liability for all actions of his Subcontractor.

4.1.7.2.4.5.3 Livestock

Adequate provision shall be made by the Contractor to prevent the straying of or injury to livestock during the execution of the work and until the permanent reinstatement of fences, wall, hedges, gates and the like is completed.
The Contractors shall be liable for any injury to or loss of livestock due to failure to comply with the above requirements.

4.1.7.2.4.6 Route Clearance

Where clearing is required, the following requirements shall be observed:

a) Tree and tall scrub shall be cleared to a distance of 15m on either side of the centre line of the route. Trees and bushes shall be cut down to a height of not more than 1.25m above ground level. In addition, tall trees outside the cleared area, of such height that could fall within 3m of the conductors, shall be trimmed by the Contractor. No tree may be felled without the express permission of the Employer. This is a Hold Point.

b) Felled trees and scrub shall be removed from a path 2.5m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and roots from this track and leave a graded way for negotiation by Land Cruiser or similar four-wheeled drive light vehicle for patrolling and maintenance by the Employer.

c) The Contractor shall clear a 4 m wide agreed construction track from public roads, of all trees, stumps, scrub and vegetation to tower positions as required by the Employer. Such tracks need not be surfaced but shall be graded and shall include culverts to prevent wash-way.

d) All felled trees and tree trimmings shall remain the property of the landowner.

4.1.7.2.5 SURVEY AND GEOTECHNICAL INVESTIGATIONS

4.1.7.2.5.1 Route Selection

The Employer will indicate to the Contractor either on maps or during visits to the sites the proposed route of the transmission line, with approximately positions of the angle and terminal support and the position of such intermediate supports as it may have been desirable to determine during preliminary way leaves negotiations. The Contractor shall give the Employer the requisite period of notice prior to commencing the survey. This is Hold Point.

4.1.7.2.5.2 Contractor Survey

4.1.7.2.5.2.1 Access for Survey

The Contractor's surveyors shall in all cases announce himself to the occupier/landowner immediately before entering any private property for the purpose of survey.

4.1.7.2.5.2.2 Accuracy

Profiles shall be produced as a result of a precision ground or aerial survey, the accuracy of which shall be such that the vertical tolerance between levels forming the profile and actual ground level shall not exceed 300 mm, and the measured to an accuracy of not less than 0.2 percent. All levels shall be related to the specified national datum.

4.1.7.2.5.2.3 Profile Drawings – Size & Scales

Computer plotted profiles on plain plastics drawings sheets will be accepted by the Employer.

The profile shall either be drawn on a mixture of a melinex type material or as otherwise approved with printed grid lines of increasing thickness in 1, 5, 10 and 50 mm squares and shall be drawn on the reverse side of the melinex to the grid lines.
However, the format of the profile shall not differ from the details specified in the following clauses.
Unless specified to the contrary the scale of the profile shall be:

- 1:2000 horizontally and
- 1:200 vertically

The profile shall be plotted with the direction of the line route left to right on profile sheet. In general, individual profile sheet shall commence and finish at tension supports but where this is not practicable and continuation sheets are found to be necessary the ground line is to be drawn so that there is an overlap of at least 300 mm between adjacent sheets. The chainage of each section between tensions structures shall start at zero, be on 50mm printed grid line and not less than 150mm from the left-hand margin. Each section shall normally be started on a new sheet. The date of survey of each section shall be added.
If more than one section is drawn on one sheet a gap shall be left in the ground line of not less than 150mm.

4.1.7.2.5.2.4 Profile Drawings – Details

The following details and information are to be included on the profile drawings:

a. At each angle position "tie– in" sketch shall be provided on the profile sheet. This sketch shall show clearly the location of the support using as reference where possible points which can be located on the ground and on the 1:5,000 or closest available scale of survey map. The direction of the line and angle of deviation are to be shown stating also whether the deviation is left or right. Where reliable maps of reasonable scale and accuracy are not available for locating and plotting support positions survey methods acceptable to the Employer shall be employed to establish grid co-ordinates supports and ground features shall be related to these.

b. Where ground slope across the line route exceeds 1 in 25 the level of ground left and right of the centre line shall be recorded at specified horizontal offset distances where the side slope is uniform. Where the slope breaks upwards beyond this distance levels will be recoded up to a specified horizontal offset distance. The

offset levels shall indicate on the profile as broken and/or chain lines and the distance off-line started.

c. The profile shall show all changes of level of 300 mm or more along the route centre line and along the off-set lines. All features such as hedges, fences, graves, ditches, roads, railways, rivers, buildings, canals, telephone and railway lines and all power lines shall be shown. Route numbers or name of roads shall be stated or, if unclassified the destination. Railways are to be given the destination, number of tracks, whether or not electrified and the level at the top of rail stated.

d. The chainage is to be shown at each 300 m and at every geographic feature or obstruction. Chainage shall also be given to all pegs.

e. The specified Datum shall be the basis for all levels and the levels above the specified Datum shall be shown at 10 m vertical interval at the beginning and end of each profile sheet. Levels shall be shown at each peg on line and at every obstruction or geographical feature.

f. The visual nature of the ground shall be noted whether cultivated, woodland, etc, with special reference to marsh soft ground or rock and other relevant information such as soil instability.

g. All buildings or high obstruction within 30 m of the centre line shall be shown dotted at their measured height with the distance left or right of line indicated.

h. Where the ground contour rises to a point which would be less than 100 mm from the top of the profile sheet, the ground line shall be terminated and continued on a new sheet with an overlap of 300 m of line route.

i. The following detail shall be shown for crossing of power lines: -
   - Voltage and type of construction
   - Ground levels at point of crossing and support structures.
   - Height of top conductor and earth wire at point of crossing and at point of support.
   - Distance from crossing point to support structures along route of line to be crossed.
   - Angle of crossing.
   - Temperature at time levels were taken (state date and time);
   - Support structures members.

j. Along the bottom of the profile sheet a route map shall be drawn, to the same scale as the horizontal scale of the profile, showing all relevant details, within a distance of 30m each side of the route centre line. All items covered by **Clause 4.1.7.2.5.2.4 paragraphs (a) and (i)** above as appropriate shall be included

k. On tower spot locations, local profile for each tower shall be provided. Stub length and foundation depth design shall refer local profiles as much as possible.

4.1.7.2.5.2.5 Support Location on Profiles

The Contractor shall submit to the Employer the requisite copies of the profile drawings upon which shall be indicated the proposed location and type of each support, spans, section lengths, (i.e. distances between tension supports), equivalent spans, wind and

weight span, phase conductor swing angles, difference in level between adjacent phase conductor attachment points and the sag templates used. This is a Hold Point.
In addition, the relevant position of the bottom or lowest phase conductor at the specified maximum conductor temperature, together with another line parallel to the phase conductor at the minimum statutory ground clearance, shall be shown on the profile.

4.1.7.2.5.2.6 Check Survey

The Contractor shall carry out a check survey. Profile drawings/preliminary profile will be made available to the Contractor, who will be required to check the profile survey and survey and design final route for approval.

The Contractor is required to check thereon the proposed support positions and submit the profile to the Employer. Profile details and support locations shall be in accordance with the preceding clauses. Check survey shall include Contractor notes on final route selected and shall be approved by Employer; approved centre shall be the transmission line approved design centre. Design and construction set out will be based on this without changes, and any deviation shall be reported immediately to the Employer with the proposal for restoring design centre.

4.1.7.2.5.3 Geotechnical Investigation

4.1.7.2.5.3.1 General

Geotechnical investigations shall be undertaken in accordance with the technical requirements detailed in the following clauses.
Where required by the Employer, the Contractor or his appointed geotechnical consultant shall undertake the specified slope stability analysis and design. The Contractor shall give the Employer the requisite period of notice prior to commencing the geotechnical investigation. This is a Hold Point.

4.1.7.2.5.3.2 Level 1

Level 1 geotechnical investigations shall be based on a visual-tactile examination or disturbed soil samples for the determination of both soil classification and strength.

4.1.7.2.5.3.3 Level 2

Level 2 geotechnical investigations shall be based on in-situ testing for the determination of the soil strength and visual tactile examination of disturbed samples for the determination of soil classification

4.1.7.2.5.3.4 Level 3

Level 3 geotechnical investigations shall be based on in-situ testing (as level 2) for the determination of the soil strength and the recovery of disturbed soil samples for the subsequent laboratory testing. Laboratory soil classification tests for non-cohesive soils shall be article size distribution, moisture content and relative density, whilst those for cohesive soils shall be moisture content and Atterberg limits.

4.1.7.2.5.3.5 Level 4

Level 4 geotechnical investigations shall be based on a combination of in-situ testing (as level 2) and the recovery of disturbed/undisturbed soil samples for the subsequent laboratory testing.

4.1.7.2.5.3.6 Soil and Ground Water Samples

Where specified, soil and ground water samples shall be obtained for determination of the chemical content i.e. organic matter, sulphate, pH and chloride content.

4.1.7.2.5.3.7 Geotechnical Investigation Criteria

Geotechnical investigation shall be undertaken to the following criteria:

a) Geotechnical investigation shall be undertaken as near as possible to the tower site. For test foundations the investigation shall be undertaken as near as possible to the test site and shall take account of the theoretical failure surface of the foundation.

b) Time lapses between the investigation and foundation installation shall take into account any noticeable effect on the geotechnical properties due to rainfall or seasonal variations in the groundwater level.

c) Depth of investigation shall be:
   i. For trial pits 2m; or
   ii. the foundation depth plus 1.5 times the maximum base width dimension for concrete pad and chimney or steel grillage foundations; or
   iii. 3m or 5 times shaft diameters (whichever is greater) below the foundation depth for drilled shaft, piled foundations; or
   iv. at least 2m into rock or hard dense stratum (N_{SPT} > 50) if this occurs before the recommended depth; or
   v. for uplift or lateral foundation tests not less than 1m below the base of the test foundation.

d) SPTs (standard penetration tests) should be undertaken at the top of each stratum and then at 1m intervals in soil or weak rock.
e) PMTs (Pressure meter tests) should be undertaken in each stratum or as required.
f) CPTs (Cone Penetration Tests) should be taken continuously over depth of investigation
g) VSTs (Vane Shear Tests) should be undertaken at top of each stratum and then at 1m intervals.
h) Soil/rock description should be based on disturbed samples taken in each stratum and thereafter at 1m intervals.
i) Highest ground water level and variation in water level

4.1.7.2.5.3.8 Geotechnical Investigation

Geotechnical Investigation Level	**Frequency**
Level 1 and 2	Every tower site
Level 3	Every tower site
Level 4	Every tension, Angle and terminal tower
Electrical resistivity	Every tower site

Ground water samples shall be taken at every tension/angle/Terminal and 5% suspension monopole position for chemical analysis.

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4.1.7.2.6 CONDUCTORS AND FITTINGS

4.1.7.2.6.1 Power Conductor – ACSR

The power conductor shall be Aluminium Conductor Steel Reinforced (ACSR) and shall comply with IEC 60889. The outermost layer of the conductors shall be right-handed lay (z-lay). The Aluminium shall be of the highest purity commercially obtainable and shall not be less than 99.5%. The Contractor shall submit certificates of analysis giving the percentage and nature of impurities in the metal from which the wires were made. There shall be no joints in the individual wire of the outer layers of aluminium wires. All steel core wires unless specified to the contrary shall be hot-dipped galvanized to comply with the requirements of IEC 60888.

Unless specified to the contrary all conductors shall be uniformly covered with neutral grease as per IEC 61089. The minimum fill factor of grease shall not be less than 70 percent. Each layer of wire except the outer layer shall have, both lengthwise and peripherally, an even and continuous coating of grease. Wax thickened greases shall be applied at a temperature above the dropping point and shall be substantially free from contaminants.
The grease shall protect the conductors from corrosion in service, not corrode the steel or aluminium, be compatible with any wire drawing lubricant that might be applied on the conductor, not flow nor exude from the conductor during storage, transport, erection or service at temperatures of up to 100 degrees celsius. In addition, the grease should have adequate resistance to oxidation and conform to relevant current health and safety requirements.

4.1.7.2.6.1.1 Technical Details of ACSR Conductor

NO	PROJECT	CONDUCTOR TYPE	KPLC SPECIFICATION
1	Rongai 132/33kV Substation	Lynx 175mm2	KP1-13D-4-1-TSP-06-022-3 SPECIFICATION FOR ALUMINIUM CONDUCTORS STEEL REINFORCEMENT - ACSR - PART 3 -175MM^2 BARE
2	Kathwana 132/33kV Substation		

4.1.7.2.6.1.2 Conductor Sag Design

Sags shall be computed under the following conditions:

Most severe design conditions:	Max. Wind pressure under min temperature
Max. wind pressure on conductor	385 N/m^2
Max air temperature	35^0 C
Min. air temperature	10^0 C.
Min. conductor temperature	0^0 C
Max. conductor temperature (continuous loading)	75^0 C
Max. conductor temperature (fault conditions)	200^0 C
Average conductor temperature	40^0 C

Factor of safety	
- Max. Working tension to UTS	more than 2.5
- Everyday stress to UTS	more than 5.0
Young's modulus of aluminium	6,300kg/mm^2
Young's modulus of steel	21,000kg/mm^2
Linear expansion coefficient	17.8X 10^{-6}/^{0}C

4.1.7.2.6.2 Drums

The conductors shall be supplied on impregnated drums of approved materials constructed so as to enable the conductors and OPGW to run smoothly and those as spare materials shall be supplied on steel drums of approved materials for storage for long duration. Length of conductors on one drum shall not be less than 2,000m.

4.1.7.2.6.3 Joints And Repair Sleeves

Tension joints of the conductors shall be of compression type and shall be free from slipping off, causing damage to or failure of the complete conductors, OPGW or any parts thereof at loads less than 95 per cent of the ultimate breaking strength of the conductors and OPGW. Electrical conductivity and current carrying capacity of the tension joints for the power conductors shall not be less than those of equivalent length of the conductors.
The cut ends of steel wires and steel component inside the joint shall be protected from the weather in an effective and permanent manner.

Aluminium sleeves shall have plugholes for injecting compound.
All tension joints shall be supplied with aluminium fool-proof gauges or anti-displacement pins for correct positioning, adequate quantity of filling compound in injectors and aluminium collars for gap filling.

Full details of the joints including an illustration of practices for filling the air gap between sleeves, method of correct positioning of steel sleeves, gauges for ascertaining the compressed size, etc. shall be submitted with the tender.

Repair sleeves for the power conductors shall be of the compression type and the conditions stated above for the tension joints shall apply to the repair sleeves where applicable.

4.1.7.2.6.4 Accessories For Power Conductors and OPGW

In order to prevent fatigue of power conductors and earth wires due to repeated vibrations caused by breeze, the following countermeasures shall be applied.

a) Trunnion type suspension clamps
b) Vibration dampers
c) Armour rods.

4.1.7.2.6.4.1 Trunnion type suspension clamps

Suspension clamps shall be of trunnion type, made of aluminium alloy and as light as possible. They shall be designed to avoid any possibility of deforming the stranded conductors and earth wires and of separating the individual strands and shall be free to pivot in the vertical plane containing the conductors and earth wires.

Suspension clamps except jumper suspension sets shall have a suitable dimension for clamping the conductor with preformed armour rods; and shall not permit the complete conductor with armour rods to split at load less than 2,250kg for ACSR. Particular attention shall be paid to the elimination of corona emission from all parts of the suspension clamp.

4.1.7.2.6.4.2 Vibration Dampers

Vibration dampers shall be of Stockbridge type for both conductors and OPGW. The dampers shall be applied in all conductors and OPGW in every span except slack spans into the substations. The dampers shall be designed to be attached to the conductors and OPGW in a manner, which will prevent damage thereto and free drop of the weight in service. Clamping bolts shall be provided with domed self-locking nuts designed to prevent corrosion to the thread.

The nominal weight of damper shall be 12 pounds (5.44kg) for the conductors and 4 pounds (1.81kg) for the OPGW. The numbers of the dampers to be installed per span shall be:

a) 2 pieces per conductor or OPGW for spans up to 600 m and,
b) 4 pieces for the spans longer than 600 m.

First and second dampers will be positioned at 1.1m and 2.2m for power conductors and 0.6m and 1.2 m for OPGW respectively from the centre of suspension clamps or from the mouth of tension clamps.

4.1.7.2.6.4.3 Armour Rods

Preformed armour rods shall be applied to all suspension points of the power conductors except jumper suspension points.

Suspension clamps for those conductors protected by armour rods shall be suitable for the enlarged conductors.

4.1.7.2.6.4.4 Corona and Radio Interference

The design of all line conductor fittings, vibration dampers, etc., shall avoid **sharp corners** or **projections** which would produce high electrical stress in normal working. The design of adjacent metal parts and matching surfaces should be such as to maintain good electrical contact under service conditions. Particular care shall be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

4.1.7.2.7 LINE INSULATION

The transmission line for the project is aligned on an elevation level of 1500-2500m above sea level. The area has high humidity levels, tropical sunshine and prone to medium pollution by agricultural activities.

Silicon-rubber long-rod type Composite Insulators of the approved type shall be used to support the power conductors of the Transmission line. All insulator units will be composed of top and bottom arcing rings to equalize the voltage distribution over the insulator. The top shed of the insulators shall also have a larger diameter to prevent waste from birds and animals tracking down along the insulator.

4.1.7.2.7.1 Insulators Design

The insulator units shall be designed to withstand the design service voltages including lightning, switching and power frequency, the mechanical loads relevant to the installation-service-maintenance conditions, the service temperature and environmental effects.

Internal stresses due to expansion and contraction of any part of the insulator unit shall not lead to deterioration.

The insulators should withstand wind pressures of up to a maximum of 385N/ m2.
The design of insulator units shall be with end over mould or such as to avoid local corona formation and no significant radio interferences shall be exhibited. The long rod Insulator units shall comply with the requirements of IEC 61109.

4.1.7.2.7.2 Fittings

All fittings to make each composite insulator set complete for beneficiary use shall be supplied and included in the rate for each insulator unit. Such bolts, nuts, washers, cotter

pins and retaining pins with necessary spares as may be necessary for the use for erection shall be deemed to be included in the appropriate items.

Ball and socket couplings shall be in accordance with the requirements of IEC 60120/16. Sockets shall have “R” type security clips in accordance with the requirements of IEC 60372.

Clevis tongue couplings shall be in accordance with the requirements of IEC 60471.
All ferrous fittings shall be made of steel, ductile iron or malleable iron hot dip galvanized, and shall have sufficient strength for abrasion and weariness produced by repeated vibration. Cotter pins shall be made of non-ferrous metal or stainless steel and designed as the self-locking type.

The arcing ring shall be provided for the top and bottom of each insulator string and shall be of such design and shape that it reduces the voltage across the part of the insulator adjacent to the conductor for each insulator string, to a value which prevents visual corona formation on the metal caps and pins of the insulators and shall minimize the Radio / Video interference voltage from complete insulator and hardware assemblies when operated at the voltage up to 420 KV.

The arcing rings shall be of such design that when added to suspension and tension assemblies, the resulting flash-over values of the complete insulator string shall not be reduced below the percentage indicated hereunder, of corresponding flash over values with the rings omitted.

The percentages are:
a) Wet 50 Hz: 100%
b) 1.2 / 50 Impulse: 96%

The rings shall be of hot dip galvanized steel or Aluminium tube having outside diameter as required for corona control and minimum thickness of 2.5mm. Both inner and outer surfaces shall be galvanized to the required specifications (BS 729). The details of the rings, brackets and methods of mounting shall be of such design that the rings may be readily replaced under ‘hotline’ maintenance.

The horizontal distance between corona rings at suspension rings at suspension insulator strings shall be kept as small as practicable to accomplish the required reduction in Radio/ Video Interference (RVI).

All the accessories and the fitting offered against this specification shall be subjected to corona test. The corona shall not take place and shall extinguish at the voltages specified i.e. when a voltage of the specified value applied (Phase to Neutral i.e. RMS) the corona shall appear and shall disappear again at the specified value of voltage.

4.1.7.2.7.3 Pollution

The design of insulator units should take into account the principles contained in the IEC 60815 for medium pollution environment. For this project the minimum creepage value of 25mm/kV shall be applied (Creepage distance of 3700 mm).

4.1.7.2.7.4 Zinc Collars

The insulator unit cap and pin shall be fitted with zinc-collared pins to prevent cracking due to pin corrosion caused by the effects of pollution and high humidity in the project area.

4.1.7.2.7.5 Insulator Protective Device

The design of insulator fittings including corona shields shall comply with the following requirements:

a) Shall effectively protect the insulator unit and fittings from damage caused by power arcs.
b) Shall effectively improve the voltage distribution along the insulator unit.
c) Shall effectively improve the corona performance of the insulator unit.
d) Shall be designed in such a way as not to subject to breakage fatigue due to wind induced vibration.
e) Shall withstand the specified mechanical load
f) Shall be suitable for live line maintenance

4.1.7.2.7.6 Materials

The silicon rubber composite insulator shall comply with requirements of IEC 61109. The tension bearing material shall be E-CR Fibre Glass and the housing and sheds made of HTV silicone rubber.
Insulator caps and pin bases of malleable cast iron shall be manufactured from a suitable grade of MCI complying with the requirement of BS EN 1563 for spheroidal graphite or BS EN 1562 for white heart and peralitic.

Insulator end fitting of forged or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS 1472 or BS 1490 and/or BS EN 1676 respectively.
Security ‘R” clips shall be of phosphor-bronze composition in accordance with the requirements of BS 2870 and supplied in the half-hard condition with a minimum harness of 155 VPN

Zinc collars shall have a total impurity not greater than 0.05 percent and shall comply with the requirement of BS EN 1179.

All insulator caps, bases and pins shall either be inherently resistant to atmospheric corrosion or a suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in the appropriate grade of stainless steel, shall be protected by hot-dipped galvanising to comply with the requirements of BS 729.

4.1.7.2.7.7 Tests

Type, sample and routine tests shall be undertaken on the insulator units in accordance with the IEC 61109.

4.1.7.2.8 MINIMUM CLEARANCES

Minimum Clearance of Live Parts to towers shall be as per **Appendix 9.A.2**

4.1.7.2.9 APPENDIX 9.A.1

Specifications for the Composite Insulators (as per KP1-3CB-TSP-04-018-1)

No	Specifications	Suspension	Tension
1	Maximum System Voltage (kV)	145	145
2	Pollution Category	Medium Category -II	Medium Category -II
3	Dielectric	Silicon rubber	Silicon rubber
4	One-minute power frequency withstand voltage, 50 Hz, wet. (kV)	275	275
5	Lighting impulse withstand voltage, 1,2/50 pos. (kV)	650	650
6	Power arc current	25 kA, 0.5 sec	
7	Minimum creepage distance (mm)	3700	3700
8	Specified mechanical load, tension (KN)	70	100
9	Minimum Arc Gap (mm)	1250	1250
10	Material fittings	Steel h.d.g	Steel h.d.g
11	Material of rod	E- CR Glass	E- CR Glass
12	Material of housing and sheds	HTV- Silicone	HTV Silicone
13	Socket	IEC 60120/16	IEC 60120/16
14	Ball	IEC 60120/16	IEC 60120/16
15	Arcing Rings material	Steel h.d.g	Steel h.d.g
16	Arcing rings	IEC 61284	IEC 61284

APPENDIX 9.A2

Minimum Clearances of live parts to towers

The minimum electrical clearances of live parts to earthed monopole structures shall be as follows:

Minimum clearances		
a) In still air (vertical position)	:	1370 mm
b) Under 15^0 swing of suspension insulator set or jumper conductors		:1370 mm
c) 20^0 swing of suspension insulator set or jumper conductors	:	1350 mm
d) 30^0 swing of suspension insulator set or jumper conductors	:	1200 mm
e) 45^0 swing of suspension insulator set or jumper conductors	:	1220 mm
f) 60^0 swing of suspension insulator set or jumper conductors	:	1070 mm

APPENDIX 10.A2

Minimum Ground clearances of lowest conductor on tower

Above general terrain	7.1m
Above main roads	7.5m
Above other Power lines	3.2m
Above other Telephone lines	3.2m
Above railways, SGR	8.5m, 15m

4.1.7.2.10 TRANSMISSION LINE TOWERS

4.1.7.2.10.1 Types of tower

Towers shall be self-supporting and broad base galvanised steel lattice type with body and hillside extensions. The hillside extensions shall be applied for tower legs on the slope so that legs are suited to the original slope of tower site and that excessive land cutting around foundations and land collapse is prevented.

The following monopole tower types shall be designed for the project in order to meet various tower positions and loadings economically.

(a) Type-S: Use at tangential positions or angle points up to 5 degrees of horizontal deviation, provided with suspension type insulator sets.

(b) Type-L : Use at positions of light angle between 5- 15 degrees of horizontal angle deviation with tension type insulator sets.

(c) Type-M: Use at positions of medium angle between 15-30 degrees of horizontal angle deviation with tension insulator sets.

(d) Type-H: Use at positions of heavy angle between 30-60 degrees of horizontal angle deviation with tension insulator sets.

(e) Type-HS: These are heavy suspension towers to be applied to zero degree line horizontal angle deviation, with tension type insulator sets.

(f) Type-T : Use at positions of line termination or ≥ 90 degrees of horizontal angle deviation with tension type insulator sets.

4.1.7.2.10.2 Tower design general arrangement

Towers shall have the general arrangements and configurations shown in the drawings included with the specification. They shall be designed to resist the specified ultimate system loading. Clearances between live parts and supporting steelwork and between the phase conductors and ground or other obstacles shall be as specified in Appendix **10.A2**.

All tower designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

The design shall be such that the number of different parts shall be as few as possible to facilitate transport, erection and inspection. The maximum weight of the heaviest single member should be limited to that within the normal lifting capability of the proposed erection equipment.

Main leg members of lattice steel towers shall be formed of the maximum single lengths appropriate to the body or leg extensions and shall not without the Employer’s approval incorporate additional spliced sections.

For lattice steel towers a fully triangulated system of bracings shall preferably be adopted. If full triangulation is not adopted, the overall stability and secondary bending stresses must be considered in the design.

Where fabrication processes employed adversely affect the material properties or introduce zones of high stress concentration the overall design of the structures shall take such factors into account.

Cross arm design for polymeric insulators shall be so arranged that they can be disconnected in the plane of the longitudinal face of the support without disturbing any section forming part of the monopole body.

For Lattice towers Cross-arms shall be so arranged that they can be disconnected in the plane of the longitudinal face of the support without disturbing any members forming part of the support body. The cross-arms should be designed to take and be compatible with the Live Line maintenance tools and equipment.

Appropriate bird guard protective devises shall be installed to keep away birds from roosting directly over the insulator units.

Where applicable approved anti-climbing spiked wire mesh or race wire shall be installed at appropriate height to deter Monkeys and Baboons from climbing the towers.

4.1.7.2.10.3 Tower design and technical Specifications

The towers shall be a self-supporting single-pole tubular steel monopole, designed for Mult circuit use in urban areas.
Main circuit design shall be double 132 kV top and 33 kV double circuits mounted below. It shall also have provision to carry 48 cores OPGW cable and ground Earth wire at top for lightning protection of the double circuit transmission line.

4.1.7.2.10.3.1 Tower design reference:

Towers design and manufacturing shall meet following IEC, BS, IEEE, ASTM and other internationally acceptable standards;

- Structural design -
  - IEC 60826 and 60652, ASCE10 and 48, IS875 and 1893

- Material and fabrication-
  - ASTM A123/A123M, ISO 1461, ISO12944 and AWS D1.1
  - ASCE Manual of practice N0.74: guidelines for Electrical Transmission line structural loading

- Hot-dip galvanized - BS EN 10025 / IEC 60826.
- Seismic load design - IS 1893 / IEC 60826
- Wind Load Design - IEC 60826 / IS 875

4.1.7.2.10.3.2 Tower height design

Height of monopole and lattice towers shall be determined in the under-mentioned way:

H = Gc + Sg + Li + Hc + Hg

Where,

H = total height of tower

Gc = Necessary ground clearance of power conductors above ground or other objectives.

Sg = Maximum conductor sag

Li = Length of a suspension insulator set, but nil for a tension type tower.

Hc = Vertical spacing of upper conductor cross -arm spacing
Hg = Vertical spacing between upper conductor cross-arm and overhead OPGW.

Towers shall be provided with body extensions in a 3m step to a standard height for maintaining necessary conductor ground clearance mentioned in Appendix 10.A.2 on various ground profiles. In addition, in the body extensions, each leg will have hillside extensions in a 1m step to suit for the original ground slope.

4.1.7.2.10.3.3 Design Span

The design of all towers shall provide for the following basic, wind and weight spans:

This design span table shall be submitted with the bids.

Type of Tower	S	L	M	H	HS	T
Basic span (m)	350	350	350	300	500	250
Wind span (m)	350	350	350	250	450	250
Weight span (m)	500	450	400	300	300	300
Uplift Weight (KN/Phase)	25	50	60	110	150	250

The term basic span means the horizontal distance between centres of adjacent supports on the level ground which the height of standard towers is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term wind span means half the sum of adjacent horizontal span lengths supported on any one tower.
The term uplift weight means the weights of conductors and overhead OPGW supported upwards at any one tower for reinforcing strength of cross arms.

4.1.7.2.10.3.4 Minimum design Loads

For structural loading shall refer to ASCE Manual and Report on Engineering Practice No. 74 “guidelines for electrical transmission line structural loading”.
The following minimum loads shall be applied in the design of towers, actual site environmental loads (wind) with appropriate factors of safety will be used for detailed design.

(a) Wind Loads
- On power conductors and overhead OPGW : 385N/m^2 (on the projected area of conductor or wire)
- On tower structures :690N/ m^2 (on the projected area of structure members)
- On insulator sets : 385N/ m^2

(b) Maximum working Tensions of Conductor and OPGW
- Power conductor Lynx : 22,500 N
- Overhead ground wire OPGW : 14,100 N

(c) Vertical Loads
- Tower structures : actual weights of tower structures including accessories
- Power conductors : Weight of conductors of specified weight span with accessories

- OPGW accessories : weight of specified weight span with
- Erection Loads :such loads as workers' weights on tower members, reaction of temporarily backstays during stringing operation, etc

(d) Horizontal Angle Effect
-Power conductors and overhead OPGW : horizontal component of maximum working tension of conductors and OPGW due to the specified horizontal angle deviation.

The towers shall be designed for the following wind and weight spars.

Parameter	**Unit**	**S**	**L**	**M**	**H**	**HS**	**T**
Wind span — normal	m	350	350	300	250	450	250
Wind span — broken wire	m	200	150	150	100	300	250
Weight span — normal	m	350	400	400	300	550	250
Weight span — broken wire	m	250	200	200	150	300	250
Transverse wind load / phase — normal · Lynx	kN	2.63	2.63	2.26	1.88	3.38	1.88
Transverse wind load / phase — broken · Lynx	kN	1.50	1.13	1.13	0.75	2.26	1.88
Vertical load / phase — normal · Lynx	kN	2.89	3.30	3.30	2.48	4.54	2.06
Vertical load / phase — broken · Lynx	kN	2.06	1.65	1.65	1.24	2.48	2.06
Uplift weight / cross-arm (as tendered)	kN	20	35	50	100	140	250
— Uplift ÷ dead weight, Lynx	—	6.9	10.6	15.1	40.4	30.8	121.1

4.1.7.2.10.3.5 Design Conditions

(a) Assumed Normal Loading Condition:
The assumed maximum simultaneous working loading on towers shall be as follows:
(i) Vertical loads : as above-mentioned.
(ii) Transverse loads : wind loads horizontal angle deviation effects
(iii) Longitudinal loads : wind loads and erection loads but together with maximum working tensions of power conductors and overhead earth wire for their termination for Type-T tower.

(b) Assumed Broken-Wire Condition
Under the condition, any one power conductor or an earth wire is assumed to be broken at their maximum working tensions in addition to the loads under the normal condition. In the case of Type-S tower, the pull will be assumed to be reduced to 70% of the specified maximum working tensions.

(c) Factor of Safety:
The following factors of safety for tower structures shall be applied in the design.
(i) More than 2.5 for the synthetic maximum load under the normal loading condition.
(ii) More than 1.25 for the synthetic maximum load under the broken-wire condition.
Those factors of safety shall be proved under tower loading tests on the proto-type towers in the manufacturer's testing station, and there should be no failure or permanent distortion during the tests.

4.1.7.2.10.3.6 Design of Towers

Latticed steel structures shall be designed with geometric configurations based on structural strength, electrical, economic, and safety requirements. Member forces caused by the design factored loads shall be determined by established principles of structural analysis.

Each type of towers shall be designed so that no failure or permanent distortion shall occur when tested with applied force equivalent to 2.5 times the maximum simultaneous working loadings specified in the **Clause 4.1.7.2.10.3.6** [Normal Working Loading] and also equivalent to 1.25 times the maximum simultaneous working loadings resulting from the assumed broken wire condition. Design loads shall consider:

a) Minimum legislated levels
b) Client specifications including factors of safety,
c) Expected climatic conditions,
d) Line security provisions,
e) Design life of not less than 50 years,
f) Construction and maintenance operations.

The ultimate design stress, obtained from the working stress multiplied by the factor of safety of 2.5 under the normal condition and 1.25 under the broken wire condition, in tension members shall not exceed the yield point of materials. The ultimate design stress, obtained from the working stress multiplied by the above-mentioned factor of safety, in compression members shall not exceed a figure obtained from an approved formula to be entered in Tender based on the yield point of materials. Alternately, formulas in the American Society of Civil Engineers standard for the design of self-supporting lattice steel transmission structures ASCE 10- 97. Structural loading shall refer, ASCE Manual and Report on Engineering Practice No. 74 guidelines for electrical transmission line structural loading.

Tower design report shall consist of full structural analysis report showing correctness of dimensional detail calculations, tower profile/layout drawings, shop detail drawings, erection drawings and bills of materials. Shop detail drawings shall be approved by the producing utility Engineer of Record (EOR) regarding compliance with the purchaser's specifications and the strength requirements of the design.

Designed tower full size prototype proof test shall be conducted and approved before tower materials shop production and delivery to site.

4.1.7.2.10.3.7 Materials and Fabrication.

The towers shall be fabricated from high tensile steel of the finest quality or other approved materials, of which mechanical properties shall comply with Grade Fe 430 and Fe 510 specified in ISO 630-1980 or equivalent. Steel Grade shall be S355J2G3 for standard loading and S420 for heavy loading design applications

No member of the tower shall be less than 6mm in thickness and 50mm in width of flange for leg members of towers and main members of the cross-arm, and 5mm and 45mm for the web and nominal members respectively. The slenderness ratio shall not exceed 150 for the leg and arm members, 200 for the web members and 250 for the nominal members as compression member and 350 for tension only member.

All the connection shall be made by mild and/or high tensile steel bolts and nuts. No bolt shall be less than M12. All bolts and nuts shall be provided with approved spring washers. Antitheft bolts shall be used from ground level to the tower anti-climb level.

Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding diameter of bolts. Holes shall be drilled for the members not less than 13 mm in thickness. For the

members having thickness below 13 mm, holes may be drilled or punched, but the former is preferred.

Holes shall be drilled to join the flanged sections of the monopole, and bolt and nuts punching is not allowed

All the steel members or monopole sections shall have clearly identifiable part numbers which enable quick identification of similar parts. The letters 'KPLC' should also be inscribed on each member by punching or any other suitable method, with more than one inscription for parts of length greater than 0.5m.

All burs shall be removed completely by reaming and smoothing before hot-deep galvanising.

4.1.7.2.10.4 Tower Accessories

The following accessories shall be provided for every tower.

(i) **Anti-climbing device and climbing steps**: All towers shall be provided with the anti-climb device on each leg or section at height of 3 m to 5 m above the highest ground level at all tower locations. The device installed on the step-bolted legs shall be provided on all towers. Gates shall be designed to open upwards only and shall be secured with galvanised bolts and nuts. No padlocks are required.

Each tower shall be provided with step-bolts of an approved type on diagonal sides of the tower at a spacing no more than 380mm, starting immediately above the anti-climbing device and continuing to the earth wires.

Holes for removal step-bolts below the anti-climbing guards shall be provided at no more than 380mm centres on the step legs for lattice tower.

(ii) **Danger, Number and Helicopter patrol plates**: Danger plate which shows warning sign for tower climbing of other people than maintenance crew will be provided on all towers.

Number plates which show tower number set serially from Kipevu to Mbaraki will also be installed on every tower.
On the top of every section tower, and every 10^{th} tower, additional number plates will be provided to aid helicopter patrol over the transmission line. Lettering and size of plates shall be to the Employer's requirements and should be both sides of the number plate for clear identification when patrolling from either end.

All plates shall be of anti-corrosive material. If enamelled iron plates are used, the whole surface of each plate including the back and edges shall be properly covered and resistant to corrosion. On all plates the colours shall be permanent and free from fading. With enamelled plates, washers or fibre or other approved material shall be provided back and front of the securing bolts.

(iii) **Tower Earthing**: No separate earth conductor from top to bottom of towers is required and earthing continuity will therefore depend on surface contact between bolted members.

All structures shall be provided with means for connecting earthing devices at or around nominal ground level, on each leg and for connecting earth wire bonds to each top crossarm or earth wire peak.

Each leg of towers will have an earthing rod underneath its foundation to act as basic grounding required by good transmission line Engineering. Basic grounding shall be constructed in such a way that isolation from the tower and concrete foundation is possible to allow earthing survey if required during line service life.

Maximum earthing resistance of a tower is targeted on 10 Ohms, and in case of higher resistance than 10 Ohms, additional horizontal counterpoise earthing system will be added in the ground longitudinally to the line route with more than 50 cm depth. The rate entered in the schedule of prices shall include for all necessary fittings and shall be adjusted at the variation rate for increased or reduced fittings.

(iv) **Aircraft Warning Devices**: Due to the activity of aircraft in the vicinity of certain parts of the transmission line, it shall be necessary to mount warning spheres on earth wires at some locations. Aircraft warning spheres shall be capable of being clamped securely to overhead earth wire. The sphere itself shall be of plastic or fibreglass construction of at least 0.5m in diameter and coloured orange or yellow as required by local regulations. The Contractor is to enter rates against appropriate item in the schedule of prices for the above and he will be advised early in the contract of actual requirements.

(v) **Bolts:** Where appropriate all metal parts hall be secured with bolts and nuts with single spring washers. When in position the bolts shall project through the corresponding nuts by at least three threads, but such projections shall not exceed 10mm. No screwed threads shall form part of a shearing plane between members.

In order to safeguard the tower members from theft; special anti-theft bolts shall be applied from ground level up to 1 metre above the anti-climbing device. The bolts shall be approved by the Employer. The bolts are of the type that shears once the full torque has been applied.
The nuts of all bolts attaching phase conductor insulator set, earth wire sets, maintenance brackets/plates shall be locked in an approved manner preferably by locknuts.

The bolts of any one diameter in a tower shall be one grade of steel. Section members shall be joined in such a way that electrical continuity is maintained to ground.

(vi) Rectangular and Auxiliary Cross Arm

The type H, HS and T towers may be provided with rectangular arms where horizontal angle exceeds 45degrees.
The prices of the rectangular arm set shall be included in the prices for the towers.

(vii) Spare Towers

Two (2) sets of spare suspension tower of emergency type and two (2) set of the emergency type angle tower used in the line shall be provided. Spare Base plate shall also be provided, sufficient for the four (4) emergency type towers. Spare web bracings shall also be provided, sufficient for five (5) standard towers up to the anti-climbing device level in case of lattice tower.

4.1.7.2.10.5 Materials

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate, unless otherwise specified and shall be suitable for all the usual fabrication processes, including hot and cold working within the specified ranges.
The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, laminations, segregations and other defects. There shall be no rolling laps at toes of angles or rolled-in mill scale.

Unless specified to the contrary the following grades of steel shall be applicable for tower design:

a) Mild steel shall be either grade S235JRG2
b) High tensile steel shall be grade S355JR for sections less than 20mm thick and S355JO for sections greater or equal to 20mm thick, except for plates which shall be greater or equal to 40mm thick.

4.1.7.2.10.6 Workmanship

All steel lattice members shall be cut to jig and all holes in steelwork shall be drilled or punched to jig. All steel parts shall be carefully cut and holes located so that when the members are in position the holes will be opposite each other before being bolted up. The drilling, cutting, punching and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulty in the erection of structures on site. High tensile steel members shall be bent hot. Care shall be taken not to punch holes too close to the edge of members.

Means shall be provided to enable the Employer to carry out such checking of members, as he may consider necessary. Built-up sections, when finished, shall be true and free from all kinks, twists and open joints and the materials shall not be strained in any way.

In order to check the workmanship, not less than 1 per cent, of the members or sections corresponding to each type of tower or crossarm shall be selected at random and assembled to form complete latticed supports, cross-arms or monopole sections in the presence of the Employer representative at the manufacturer’s factory.

4.1.7.2.11 CIVIL WORKS FOR TRANSMISSION LINE

4.1.7.2.11.1 FOUNDATIONS

4.1.7.2.11.1.1 General

Lattice towers shall require mostly Concrete pad and chimney type foundations. The design of the concrete foundations of the towers shall be performed based on the requirements and assumptions set out below, and the details of the design and drawings for each type of foundations shall be submitted with the Tender.

Such design of foundations for the towers are subject to modifications to suit the site conditions as indicated in writing by the Project manager during execution of the Contract without any price adjustment to the items of the foundation.

4.1.7.2.11.1.2 Concrete Block/Pad/spread Foundation

The types of the concrete foundations and natures of earth to be considered shall be as follows:

Types of concrete foundation Assumed natures of earth yield bearing capacity		L	M	H
- Vertical	[ton/m^2]	60	40	20
- Lateral	[ton/m^2]	30	20	10
Mass	[kg/m^3]	1,600	1,500	1,400
Angle of frustum (Lattice tower)[degree]		30	20	10

All Structural Concrete shall be reinforced with steel bars to structural design details. Deformed steel bars are preferable for the reinforcement.

The abbreviations L, M and H of the concrete foundation types shall mean as follows: -

L : Light concrete foundation
M : Medium concrete foundation
H : Heavy concrete foundation

The angle of frustum of earth shall mean the angle vertical of earth frustum to resist the uplift force.
Natures of concrete to be considered shall be as follows: -

Assumed natures of concrete

Allowable strength:

-Compressive	[kg/m^2]	60
-Tensile	[kg/m^2]	6.0
-Shearing	[kg/m^2]	6.0

Mass:

-Concrete without reinforcement	[kg/m^3]	2,300
-Concrete with reinforcement	[kg/m^3]	2,400

Allowable strength on:

-Galvanized steel action	[kg/m^2]	3.6
-Round reinforcing bars	[kg/m^2]	7.2
-Deformed reinforcing bars	[kg/m^2]	12.0

Each type of foundation shall be designed based on the following formula:

[1] Against compression load

$$\frac{q}{F} \geq \frac{C+G+Ws}{A}$$

Where:
- *q* : *Yield bearing capacity of earth [ton/m^2]*
- *F* : *Factor of safety*
- *C* : *Compressive load [ton]*
- *G* : *Weight of concrete [ton]*
- *Ws* : *Weight of earth above foundation pad [ton]*
- *A* : *Area of foundation pad [m^2]*

[2] Against uplift load

$$G + \frac{Ws'}{F} \geq T$$

Where,
- *T* : *Uplift load [ton]*
- *Ws'* : *Weight of earth in frustum [ton]*
- *F* : *Factor of safety*

[3] Against lateral load

$$\frac{q' \times A'}{F} \geq Q$$

Where,
- *Q* : *Horizontal load [t]*
- *q'* : *Yield lateral bearing capacity of earth [ton/m^2]*
- *A'* : *Projected area of foundation chimney and pad [m^2]*

The factor of safety shall not less than 2.5 under the normal working conditions and 1.25 under the broken wire conditions.

The upper surfaces of the foundation pads shall be reinforced and sloped within 45 degrees to the horizontal. The minimum thickness of the edges of base pad shall be not less than 300mm.
The frustum shall be assumed to start from the top edges of the pad. Where frustums overlap each other, allowance shall be made for loss of uplift resistance.

Concrete shall cover any part of the top steelwork by at least 100 mm and shall extend above the ground for the minimum height of 350 mm. Additional 500 mm minimum chimney extension shall be provided to foots on lower side in sloping areas. The upper surface of chimney shall be sloped to ensure drainage of water.

The cleats shall be attached by bolting at the base of each stub to assist in transfer of leg load to the foundation pad. Minimum portion of stub loads in the design of cleats shall be assumed as 50 per cent.

4.1.7.2.11.1.3 Special Foundations

Besides the above mentioned concrete foundations, special foundations such as raft type foundation, rock anchor, piled foundation or others may be required. Final type of foundation

to be applied for each tower shall be determined in accordance with results of soil investigation performed by the Contractor during route survey and soil investigation.

For the purpose of tendering, basic designs shall be submitted with the tender under the following assumptions, and prices for the special foundations shall be quoted based on the design.

[a] Raft type foundation

The foundation shall be designed with the following specifications: ultimate bearing capacity of 10ton/m^2, soil weight of 1.4 ton/m^3 and no angle of frustum of soil. Weights of reinforced concrete and soil shall be taken as entirely submerged. Other design conditions specified in this subsection will be applied.

[b] Rock Foundation with Anchors

A foundation constructed on or in rock using grouted rock anchors and concrete. The anchors provide high resistance to uplift and overturning forces. This type of foundation shall be generally rare in this project.

[c] Piled foundation

Piles used for the foundation shall be either pre-casted concrete pile with circular or square cross section or in-situ concrete pile.

[i] Pile data

Pile diameter or dimension

- Circular cross section	-	Φ300 mm.
- Square cross section	-	300 x 300 mm
- Pile depth below ground level	-	12 m
- Ratio or ultimate bearing/uplift capacity of pile	-	2.5: 1

[ii] Uplift

The mass density of concrete below ground level shall be assumed as 1,600 kg/m^3 to allow for hydrostatic effects and similarly soil as 960 kg/m^3. Additional weight of concrete shall be included as necessary to provide the specified resistance to uplifting under any condition. Where bored or driven piles are proposed having no specially made bulb or enlarged concrete foot to provide positive uplift resistance but relying on skin friction alone, at least 75% of the networking uplift force, and 50% of the net broken wire uplift force shall be provided in dead weight of concrete, whichever is the greater. The cost of such concrete shall be included in the piled foundation rate.

[iii] Compression

Mass density of concrete shall be assumed as 2,300 kg/m^3 on their technical acceptability and cast.

Contractors must justify assumptions of equal performance of their piling system with that proposed. No extra payment shall be made for access tracks necessary for heavy piling rigs.

Piles shall be embedded in a reinforced concrete cap of adequate dimensions and the caps tied with nominal reinforced concrete beams of a minimum size of 460 mm deep by 300 mm wide with at least eight 19 mm diameter main reinforcing bars per beam.

Piling shall be carried out using an approved procedure throughout. The actual length and numbers of piles required at any given location shall be approved by the Engineer on the basis of the final agreed design data.

[c] Other Foundations

Where special ground conditions exist which do not allow for any of the above designs in an original or modified, special types of foundations may be employed. They will be paid for on basis of submitted schedule rates for concrete, steel and excavations applying throughout, irrespective of special conditions.

Tower prices shall cover for all costs not covered by tower foundation work where admissible including the provision of access tracks and standings for piling equipment or building of bund for the Contractor's convenience in paddy fields or other flooded areas.

4.1.7.2.11.2 Foundation Works

4.1.7.2.11.2.1 Soil Investigation

The Contractor shall make tests of subsoil conditions at every tower site by means of an approved simple hand-operated borer [sampling] and sounding tool and indicate results on the approved soil test sheets together with ground water levels and proposed foundation type to be applied at the tower position.

The Contractor shall obtain the Engineer's approval for the foundation type in advance of the foundation works at each tower site. Particular note is to be made where any poor ground is encountered likely to require special foundations. The test results shall show firm evidence to prove reasons why the proposed type of foundation is selected from the specified foundation types. The cost of the sub-soil tests is deemed included in the rate for foundation work.

The Engineer may request the Contractor additional sub-soil tests at the bottom of excavated pits, if the Engineer judges its necessity for further confirmation on the proposed foundation types. The sub-soil tests shall be done at the earliest stage of the filed works to the urgency of having tower stubs and templates on site in order that foundation works can proceed with a minimum of delay. BS5930, soil investigation code will apply as a technical guide for reference.

4.1.7.2.11.2.2 Excavation and Backfilling

Where angle towers are fitted with unequal length cross arms at each side of the tower, the tower center shall be offset to ensure that conductors are located as near as possible equidistant either side of the route centerline in adjacent spans.

The Contractor shall ensure that excavations are made to the correct depth and width. If excavations are taken deeper that the designed dimension the excess depth shall be backfilled with concrete at the Contractor's expense. If excavations are made wider than the designed dimension, such modifications to the design as the Engineer may require shall be made at the Contractor's expense.

For uplift foundations, undercutting or other approved method shall be applied as far as possible for allowing upward bearing of the foundation pad against undisturbed soil for a minimum width of 250mm all around. Alternatively, the concrete pad shall be cast to the edge of the excavation for a minimum height of 250 mm in order to gain assistance by adhesion to the original ground. In cases where the concrete block is cast in undercutting, the earth frustum assumed to resist uplift shall be considered to start from the bottom of the

vertical edges of the block. Otherwise, the frustum shall be assumed to start from the upper top of the block edges.

The backfill of all types of foundations shall be thoroughly rammed with mechanical rammers, and the ramming shall be carried out at intervals of not greater than 300 mm to ensure thorough consolidation of the backfill as the Engineer requires.

Foundation Concrete faces shall be painted with an approved bituminous paint to separate backfill from concrete before backfilling.

In no circumstances shall peat, black Cotton soil or equivalent materials be used as backfill for foundations. Where excavations are made in peat ground, backfilling to be foundations shall be made with a suitable soil or hardcore from an approved source at the Contractor's expense. Backfill shall be finished in such that the original ground contours are restored as nearly as possible, any subsidence of backfill shall be made good before the issue of the Taking-Over Certificate.

4.1.7.2.11.2.3 Stub setting

Stubs for tower foundations shall only be installed with the use of templates or by use of the lower sections of the tower with the suitable temporary bracings to ensure correct spacing. The stub setting templates shall be of approved type with sufficient rigidity to ensure correct setting of the stubs. The method selected shall be such that all four stubs are supported and interconnected by a rigid steel framework. The main members of the templates must be in the position by the template while the concrete is placed.

The templates are not to be removed until 48 hours after the foundations have been completed and backfilled. The templates shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross-section, and shall be equipped with central alignment notches or holes, corner braces, riser-braces, and stub angle bolting legs to permit the accurate setting of stubs in respect of the following requirements:

a) Longitudinal centreline
b) Tower lateral centreline
c) Anchor Bolt elevations [with reference to datum]
d) Anchor bolts levelling
e) Inclinations of stubs
f) Stub hip bevels
g) Spacing between stubs

No concrete works shall be started before the stubs are confirmed to be in the right design positions, setting details recorded in setting out form.

4.1.7.2.11.2.4 Concrete Works

[a] Concrete for concrete foundation and pile shall have the minimum required breaking strengths as specified in the technical schedules. BS 5328 will refer when specifying concrete and BS 8110 in reference to structural use of concrete

[b] Cement used shall be Portland with minimum strength of 42.5 KN/m^2 or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS-12.

[c] Aggregates shall be clean and free from dust, earthy or organic matter or salt. Coarse aggregate shall be approved grading to be retained on a mesh not less than 5mm square, and of a maximum size to pass a mesh not more than 40 mm square. Where specially approved in writing by the Engineer, coarse aggregate of uniform size which

will pass a 25mm mesh may be used throughout. Fine aggregate shall be river sand and shall be coarse, sharp, clean and fee from dust, salt, clay, vegetable matter or other impurity and shall be screened through a mesh not more than 5mm in the clear. It shall be well graded mixture of coarse and fine grains from 5mm gauge downwards. Aggregates shall conform in all ways to BS812 and KS 95:2003.

[d] Water shall be clean and free from all earth, vegetable or organic matter, salt, soil, oil, acid and alkaline substances either in solution or in suspensions. Quality shall be confirmed by lab test.

[e] At least four weeks before commencing any concreting work, the Contractor shall make trial mixes using samples of cement and fine and coarse aggregates.

The test specimens for the trial mixes shall be of cube type. Preliminary test specimens shall be taken from the proposed mixes as follows:

For each proposed mix a set of 6 specimens shall be made from each of 3 consecutive batches. Three from each set of six shall be tested at an age of seven [7] days and three [3] at an age of 28 days. The test shall be carried out in an approved laboratory.

Neither the mix proportions nor the source of supply of materials shall be altered without the prior approval of the Engineer except that the Contactor shall adjust the proportions of the mix as required, to take account of permitted variations in the materials, such approval shall be subject to the execution, to the Engineer's satisfaction, of trial mix procedures set out herein.

[f] Where directed by the Engineer, concrete cubes are to be taken and tested to verify the concrete strength during site concreting works. The Contractor shall provide the cube molds at site for the purposed, accordingly. The test specimens shall be 150 mm cubed and the mold shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mold shall be provided with the metal base having a smooth machined surface. The interior surfaces of the mold and base should be lightly oiled before concrete is placed in the mold.

[g] The cost of concrete testing shall be deemed to be included in the Contractor's general schedule rates. Testing Lab shall be approved

[h] Requirements for testing concrete samples during construction are set out in **Clause 4.1.7.2.11.6.8.**

[i] The concrete shall thoroughly wet before backfilling commences. When shutters are to be struck, backfilling of excavation is not to take place immediately, and the concrete shall be kept continuously moist to avoid rapid drying.

[j] In the event that the Contractor proposes to use ready mixed concrete for foundation work, approval must first be obtained from the Engineer, who will inspect the batching plant and cement, sand and gravel used for concrete. No ready mixed concrete shall be used in foundation work if it has been mixed in the lorry during its journey for more than 45 minutes. At the discretion of the Engineer, ready mixed concrete may be used in foundations in excess of 45 minutes journey, if the cement is added to the drum at site and is thoroughly mixed prior to placing, or alternatively if the ready mixing lorry carried its own drum during the lorry's journey and not mixed for more than 45 minutes prior to placing. The Engineer's decision to reject any of the above methods of supplying ready mixed concrete shall be final.

[k] Throughout the line route, the Contractor shall at regular intervals and at the time of survey, obtain samples of subsoil and ground water, which he shall have analysed to ascertain if any agents be present which may have an adverse effect on concrete made with normal Portland cement. The analyses shall be forwarded to the Engineer without delay together with any recommendations for the use of special cement.

The Engineer's decision as to the type of cement to be used will be final. The cost of obtaining soil and ground water samples is deemed to be included in the Contract Price. The cost of any special cement used will be paid at an appropriate rate to be agreed with the Engineer.

[l] Concrete shall be placed immediately after mixing. All concrete shall be thoroughly compacted by vibration during the operation of placing and shall be free from honeycombing and other defects. The upper surface of the concrete for all types of foundations shall be finished smooth and sloped in an approved manner to prevent accumulation of water. A concrete addictive of a type approved by the Engineer may be used.

4.1.7.2.11.2.5 Piling and Other Special Works

Pilling will be carried out using an approved procedure throughout. The actual length and numbers of piles required at any location will be approved by the Engineer on the basis of the final agreed design data and payment made for departures from the assumed tender design quantities on the basis of the difference of quantities times the Schedule variation rates. Piles shall be tested in accordance with **Clause 4.1.7.2.11.6** Tender Prices shall include for all necessary casings, pumping, and depreciation of piling machines, materials, transportation, testing and others.

Where special ground conditions exist which do not allow for any of the designs in an original or modified form, special types of foundations may be employed which will be paid for on the basis of schedule rates submitted. To this extent the submitted schedule of rates for concrete, steel and excavations shall apply throughout irrespective of special conditions.

4.1.7.2.11.3 Erection of Towers

Where tower members arrive on site with slight distortions due to handling in transit, they shall be straightened by the Contractor using approved means and offered to the Engineer for inspection and acceptance or rejection before erection commences.

In general, towers shall be assembled and erected with bolts finger tight only. Final tightening of bolts shall only take place when all members are in place. As far as practical, bolts shall be inserted with the nuts facing outwards or downwards.

Whenever wire slings or ropes are liable to abrade tower members, the members shall be suitably protected by heavy Hessian bags or strips, or by some other approved means.

The Contractor shall make use of temporary struts on panels prior to lifting, if in the opinion of the Engineer, there is likelihood of damage occurring to that panel during lifting. Where derricks are used for lifting panel they shall be securely guyed and shall be supported only at approved locations on the legs.
All monopoles shall be vertical under the stress set up by the completed overhead line to the satisfaction of the Engineer. The maximum acceptable deviation from vertical shall normally be 1%.

Proper precautions shall be taken to ensure that no parts of the monopoles or supports are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.

Suitable ladders shall be used whenever necessary during erection, but such ladders and removal step bolts shall be removed when erection work is in progress.

Before assembly of members, joints shall be free of all earth, or any other substances which might prevent the correct alignment of members. After erection, all materials shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads. Approved equipment shall be used for tightening the shear bolts which will be used from ground level up to one metre above the anti-climbing devices. After erection, the rest of the bolts up to the bottom cross arm shall have the threads smashed in an approved manner to prevent unauthorized removal.
Damage to the galvanised surfaces of bolts, tower steelwork or smashed bolts shall be repaired using zinc rich paint or similar and the cost of such repair is deemed to be included in the appropriate rates.

The Contractor must ensure that tower erection, steel handling and operation of equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as the public.

Lower parts of towers erected in the submerged area during wet seasons shall be protected from corrosion with an approved paint as ordered by the Engineer. The cost for the paint shall be quoted in the Price Schedule.

4.1.7.2.11.4 Grounding of Towers

Before placing foundation concrete, basic grounding earthing rods specified in **Clause 4.1.7.2.10.4** shall be erected to each foundation cleats. Installation shall ensure that earthing can be isolated from the tower and concrete foundation to allow earthing survey. Measurement of footing resistances of all towers shall be carried out with an approved instrument before stringing of an overhead OPGW. A target value of the resistance is less than **10 ohms**. The Contractor shall report the measured value in an approved form to the Engineer. The Engineer will instruct necessitate of installation of counterpoises to the Contractor who shall then provide the counterpoises as specified in **Clause 4.1.7.2.10.4** to the instructed towers and measure the resistances for reporting to the Engineer. In case the resistance is still high, the Engineer may order the Contractor to install additional counterpoises.

4.1.7.2.11.5 Stringing of Conductor and OPGW

a) The fullest possible use shall be made of the maximum conductor lengths in order to reduce the number of joints to the minimum. The number and location of conductor and overhead OPGW tension joints shall be approved. Tension joints shall not be less than 15m from the nearest clamp.

b) Unless the Engineer agrees to the contrary, midspan joints shall not be not used-
   (i) at locations which would allow less than 3 clear spans between mid-span joints on a given conductor and wire
   (ii) in spans crossing power lines, telecommunications lines, public roads or buildings, and
   (iii) in single span sections.

c) Conductor repair sleeves shall not be used without the permission of the Engineer, which will be granted only in exceptional circumstances.

d) Conductor and OPGW stringing shall be carried out entirely by tension stringing methods and the Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment which he intends to use. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required to install all conductors and OPGW shall be continuously controlled.

e) The conductor and OPGW tension during stringing operation shall be kept as low as possible, consistent with keeping the conductor and OPGW clear of the ground whilst in motion. At no time will the tensions be allowed to exceed 75% of the final tension.

f) All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

g) Conductor and OPGW drums shall be securely anchored during the stringing operation and drum jacks shall be of the self-braking type to prevent conductor over run.

h) Conductor an OPGW pulling shall be such as will ensure a continuously steady pull. Every precaution is to be taken to prevent damage to the conductor and OPGW. Clamps and other devices used for handling conductor and OPGW during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor and OPGW Grooves in sheaves and tensioners shall be lined with neoprene or rubber. Sheaves shall have an electrical conducting path between their suspension points and the conductor supported within them and shall run with minimum friction.

i) Conductor and OPGW shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

j) At least three months before stringing commences, the Contractor shall give due to consideration to all the factors involved and submit to the Engineer for approval a fully detailed stringing schedule stating locations of conductor and OPGW drums, winch operation for stringing and the proposed positions of mid-span joints, together with temporary staying wires of towers and all other relevant information.

k) Conductor and OPGW drums shall be closely examined before conductor pulling commences and all nails and other things which could damage the conductors and OPGW shall be removed. During stringing, the conductor and OPGW drums are to be supervised at all times and the conductor and OPGW shall be inspected for defects while it is being pulled off the drums. Any damage caused to conductors or OPGW shall be reported to the Engineer whose decision to replace or repair will be final.

l) Conductors and OPGW shall be carefully regulated to the correct prestress and initial tensions by a measurement of sags. Ambient temperature shall be measured by a thermometer suspended on the tower at the sag measurement position. Making for and application of anchor clamps shall follow regulation to initial tension without delay. Immediately after regulation and clamping has been completed in a section, the sag of conductors and OPGW shall not depart from the correct value by more that $^{+}/_{-}$1.5%. Suspension insulator sets shall be installed so that clamps are within 20mm of their correct position on the conductor.

m) The insulators strings shall be cleaned and inspected before assembly. Any defective insulator be shall be removed from site forthwith. Insulators have the security clip, cotter pins and other locking devices fully in place and shall be erected in a manner avoiding damage to the sheds, fibre-glass rod or locking devices.

n) Where required by the Engineer, the Contractor shall check prior to the issue of the Taking-Over Certificate that the sags of conductors and OPGW in selected spans are within the specified tolerance and shall make any adjustment necessary to ensure compliance.

o) Joints, clamps, etc. shall be applied using the approved tools and in such a manner that no bird-caging, over-tensioning of individual wires or layers or other deformation or damage to the conductor and OPGW occurs. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands.

p) Compression fittings shall be applied only by linemen approved by the Engineer, using approved methods. The outer surfaces of conductors and OPGW and the interiors of compression sleeves shall be scratched-brushed immediately before assembly.

q) After conductors have been made off and landed, stringing sheaves shall be removed and suspension clamps and vibration dampers shall be fitted with minimum delay. Suspension clamps shall be fitted with due regard to offsets where appropriate, and the conductor and OPGW shall be cleaned before the clamp is assembled.

r) The Conductor shall keep a record of all sagging showing details of the section, the sagging and checking spans, ambient temperature, pre-stress, initial and final sags, the date of sagging and clipping-in offset, etc. This record shall form part of the final records for the line and shall be handed over to the Engineer prior to the issue of taking-Over Certificate. The records shall be available for inspection at any time.

4.1.7.2.11.6 Tests at site

4.1.7.2.11.6.1 General

Following investigations and tests shall be carried out by the Contractor, when ordered by the Engineer.

Those investigations and tests as mentioned in the Price schedule will be paid for at the rates entered. Other investigations and tests not scheduled in the Price Schedule shall be deemed to be included in the prices of the relative items of the works.

4.1.7.2.11.6.2 Ground Prove Tests

Tests by means of an approved type of penetrometer or other approved means shall be carried out during the check survey as provided for in **Clause 4.1.7.2.5.** Results of these tests shall be submitted to the Engineer on an approved form giving a preliminary indication of the ground bearing properties and water levels, etc. Bore penetration shall be at least 9m below ground level in poor ground.

4.1.7.2.11.6.3 Laboratory Soil Tests

Where ordered by the Engineer, the Contractor shall obtain soil samples and submit these for tests to an approved laboratory to determine the necessary properties of the soils for the purpose of foundation designs. Such information shall be detailed in an approved manner and conclusions given as to the recommended bearing pressures to be adopted. Tests shall be carried out generally in the manner described in BS-1377

4.1.7.2.11.6.4 Ground Bearing Test

Where ordered by the Engineer, the Contractor shall carry out ground bearing tests to determine the ground bearing capacity, by means of loading a 300 mm square plate in an approved manner. Tests shall be carried out generally in the manner described in BS-5930.

4.1.7.2.11.6.5 Pile Bearing and Uplift Tests

Where ordered by the Engineer, the contract shall carry out pile bearing and uplift tests for all types of pile generally in accordance with the method given in the BS CP-2004. Such tests shall be carried out to determine the ultimate uplift and bearing values.

4.1.7.2.11.6.6 Foundation Loading Tests

Where ordered by the Engineer, foundation loading tests shall be carried out in full scaled individual footings.

4.1.7.2.11.6.7 Records of Site Investigation Tests

All records of site investigation tests shall be detailed in an approved manner. Sample log sheets, charts, etc. shall be submitted to the Engineer for approval before any investigation commences. All site investigation data, charts, etc. shall be handed over to the Engineer in triplicate upon satisfactory conclusion of the tests, and before the issue of Taking-Over Certificate.

Where the Contractor carried out other tests at his own expense, not ordered by the Engineer, and to the contrary, where the Employer had independent tests made along the route of the line, such information shall be made available to the Contractor.

4.1.7.2.11.6.8 Concrete Tests

The Contractor shall carry out tests on sample of concrete from the foundation works, as required by the Engineer as specified in **Clause 4.1.7.2.5.** The test specimens shall be stored at the site at a place free from vibration under damp sacks for 24 hours. They shall be then removed from the moulds, marked and stored in water at a temperature between 10^0 C and 21^0 C until the testing date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in a damp sand, or other suitable damp materials, and shall be brought in the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the time of the test.
The results shall be handed in triplicate to the Engineer, as soon as possible after testing, and not later than seven days.

4.1.7.2.11.6.9 Support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the stringing operation of overhead earthwire, as specific in **Clause 4.1.7.2.11.6.2.** The placing of tests electrodes shall normally be along the center line of the route in such direction as to ensure that the lowest resistance to earth is recorded, and a note shall be made of the direction in the time of the test.

4.1.7.2.11.6.10 Additional Footing Resistance Test

If in the opinion of the Engineer, it is necessary to reduce the tower footing resistance by means of counterpoises, the Contractor shall make further measurement after the additional counterpoises have been carried out before the stringing operation of the overhead earth wire. Any further measurement shall be carried out as necessary without extra charge.

4.1.7.2.11.6.11 Measurement of Galvanising Thickness

The Contractor shall have on site an instrument suitable for accurate checking of galvanizing thickness for the Engineer's use. The gauge shall be available from time of arrival of the first consignment of steel work until the issue of Taking-Over Certificate. The cost of the gauge and other operating expenses shall be deemed to be included in the contract price and the gauge shall remain the property of the Employer.

4.1.7.2.11.6.12 Testing of Rock Anchors

Where rock anchor foundations are used in hard rock, as provided for by the Engineer's order, the Contractor shall test individual anchors by tensile test loading to failure for obtaining design data of the foundations. **The test shall be considered satisfactory if the steel bar fails by yielding at or above its ultimate strength**.

Anchor for the testing shall be installed away from permanent foundation anchors but in the same rock. The frequency of the test shall depend upon the different types of hard rock encountered and the number of tests performed shall be such as to give confidence in the employment of rock anchor foundations and experience of the type of rock suitable for their use. The frequency of test shall, in the case of dispute, be reasonably determined by the Engineer. Tests shall be carried out generally in the manner described in BS-8081 on ground anchorages.

The cost rock test shall be included in the relevant schedule rates.

4.1.7.2.11.6.13 Test on Completion

The line shall be energized at full working voltage before handing over, and the arrangement for this and such other test as the Employer/ Engineer shall desire to make on the completed line shall be assisted by the Contractor who shall provide such labour, transport and other assistance as required without extra charge.

4.1.7.2.11.6.14 Surplus Material

Surplus material paid for by the Employer shall remain property of the Employer and shall be stored at the project terminal substation. Waste material will not be taken over or paid for by the Employer.

4.1.7.2.11.7 Costing of towers and Transmission work

4.1.7.2.11.7.1 Bill of Quantities

The quantities set out in the Volume I of bidding document -Price schedules are, unless otherwise defined, estimated quantities of the materials, design and works. They are not to be assumed as the actual and correct quantities to be executed by the Contractor in fulfilment of his obligations under the Contract. The Contactor is presumed to have satisfied himself as to the relevance of the estimated quantities in the preparation of his Tender.

4.1.7.2.11.7.2 Cost of Drawings, Reference Standards and Records

The provision of all drawings, design calculations, records and the supply of the relevant reference Standards etc. as stated or specified in the Contract shall be included in the Contract Price.

4.1.7.2.11.7.3 Cost of Survey work

The cost of full precision or check ground survey undertaken by the Contractor on the Employer's instruction shall be entered in appropriate Schedules in Volume I of the tender document, and distances shall be measured to the nearest meter along the centre-line of the route. The unit price shall include for the establishment or re-establishment of the line route from terminal points and other such fixed points the Employer may define, full ground survey, profiling, support plotting, preparation of Simms document tree marking and tree schedule and pegging of support locations.

4.1.7.2.11.7.4 Cost of Route clearance and access roads

Route clearance undertaken by the Contractor on the Employer's instruction shall be entered in the appropriate schedules in Volume I of bidding document and distances covered shall be measured to the nearest metre along the centre line of the route.

Cost of

4.1.7.2.11.7.5 Cost of tower foundations

4.1.7.2.11.7.5.1 General pricing requirements

The cost of foundations shall be entered in Schedule 4 under installation and other services. Where additional work is required over and above that provided for in the Specifications, this will be paid on a measured basis at unit prices submitted.

The unit prices for foundations shall include all necessary geotechnical investigation and geotechnical studies as defined in the Specification, or as required by relevant authorities.

The unit prices for all foundations shall include for site clearing, excavating in any material by any means, manual or mechanical, and for ensuring stability and natural drainage inside the working area, concrete, bitumastic painting for all backfilling, compacting and disposal of surplus material, routine testing, site restoration and for all necessary supports to sides of excavations.

Removal of ‘man-made’ materials such as industrial waste, etc., which the Employer agrees is hazardous and which cannot be removed by normal means shall be paid for at unit prices to be agreed.

The complete cost of foundations for a support shall be entered at the appropriate Schedule 4-unit prices. The unit price shall include for all excavations, conventional pumping (including well-point dewatering), excavation supports, concrete work, formwork, reinforcing, template steelworks, routine testing, bitumastic painting, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification.

The unit prices shall also include supply of blinding concrete or the importation of any backfill material necessary due to the excavated material being unsuitable as backfill.
The unit prices for foundations shall include the use of whichever type of cement is to be used and density of concrete necessary to meet the requirements of the specification.

The unit prices for foundations shall include all base plate steelwork installation and setting out including the use of templates if necessary, setting to any level and any excavation necessary for setting out. The protective treatment to defined concrete faces or support steelwork and provision of site protection barriers shall be included in the rates for the foundations.

The unit prices for foundations shall include the cost for all earthing requirements labour. Where site stabilizations outside the defined ‘working area’ is required this shall be undertaken at unit prices to be agreed.

The cost of design tests on foundations to prove the foundation design shall be entered in the appropriate section of Schedule 4. The unit prices shall include for the removal of concrete and steel down to 1m below ground level where this deemed necessary by the Employer.

4.1.7.2.11.7.5.2 Costing of Pile Foundations.

The cost of complete foundations for each monopole shall be entered at the appropriate Schedule 4-unit prices. The unit prices shall include for mobilization and de-mobilisation of piling rigs, setting out, cleaning, cutting to length, reinforcement and pile cap connection, jointing or piles as necessary, irrespective of number of piles, all excavations (including rock), conventional pumping (including well-point dewatering), exaction supports (including use of bentonite slurries), concrete work for piles, pile cap and tie beams, formwork,

reinforcing, Base plate steelwork, anchor bolt setting, routine testing, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification. The unit prices for piled foundations shall be based on:

- The unit price for a complete monopole foundation including pile cap and tie beams.
- A unit price for piles for the complete monopole based on the nominal length defined in Schedule 4.
- An additional unit price per foundation for the “average” length of pile greater than or less than the defined length below existing ground level. This unit price shall be applied once per complete support foundation irrespective of the number of piles in the foundation and shall be applied per metre length of increased or decreased “average” pile.

4.1.7.2.11.7.5.3 Costing of Flood Protection Walls

Where the Contractor considers that a gabion wall is necessary to protect a support, the cost shall be entered in the appropriate Schedule 4-unit prices.

4.1.7.2.11.7.6 Cost of towers

The cost of steel Lattice and braces, monopoles and sections for extensions shall be entered in Volume I, Schedule 1-unit prices. The unit prices shall include for standard cross arms, and shall include base plate steelwork.

The unit prices for steel towers shall include for access facilities, anti-climbing devices, attachment plates, Climbing Bolts, ancillary steelwork etc. used as standard on the support.

The unit prices shall include for all support mounted notice plates.

The cost of type tests on individual supports to prove the support design shall be entered at the unit prices quoted in the Schedule 4 for successful tests only. No payment for failed monopole tests. All other quality control requirements shall be included within the appropriate unit price.

The cost of tower paint including all necessary preparation, sample and routine tests shall be entered at Schedule 1-unit prices.

4.1.7.2.11.8 QUALITY ASSURANCE

4.1.7.2.11.8.1 General

The quality assurance arrangements shall conform to the appropriate sections of ISO 9001:2015 or 9002.

The Contractors/suppliers Quality Program for the Works shall define the system and procedures adopted to ensure compliance with the contract requirements. These systems shall include the following.

Hold point - “A stage in the material procurement or fabrication/workmanship process beyond which work shall not exceed without the documented approval of the employer or their appointed representatives.

Notification point - “A stage in the material procurement or fabrication/workmanship process for which advance notice of the activity is required to permit attendance.

The Contractors/suppliers are required to give the employer or their appointed representatives the requisite period of notice of any notification point for which attendance is

required. If the employer or their appointed representatives do not respond/attend after receiving the documented notification the work may proceed

4.1.7.2.11.8.2 Quality Assurance Program

The quality assurance program shall give a description system for the works and shall include the following details: -

a) The structure of the Contractors/Sub-Contractor/ Suppliers/Manufacturer organization.
b) The duties and responsibilities of staff assigned to ensure quality of the work.
c) The system for purchasing, taking delivery and verification of materials.
d) The system for ensuring quality of workmanship.
e) The system for control documentation.
f) The system for retention of records.
g) The arrangement for the Contractors/suppliers auditing.
h) A list of the administrative and work procedures required to achieve and verify the Contractor's quality requirements. These procedures shall be made readily available to the employer for inspection on request.

The Quality Assurance Program for the works shall be submitted to the employer for approval within the requisite period prior to the commencement of the works. This will be a hold Point.

4.1.7.2.11.8.3 Quality Plan

A specific Quality plan for each section of the work shall be produced by the Contractor and/or supplier. Each quality plan shall set out the activities in a logical sequence and shall take into account the following:

a) An outline of the proposed work and program sequence
b) The structure of the contractor's and/or supplier's organization for the project
c) The duties and responsibilities of staff assigned to ensure quality of the work for the project
d) Hold and Notification points
e) Submission of Engineering Documents required by this specification
f) The inspection of materials and components on receipt
g) Reference to the Contractor's and/or supplier's quality assurance procedures appropriate to each activity
h) Inspection during fabrication/construction
i) Final inspection and tests.

The Contractor's and/or suppliers Quality plan shall be submitted to the employer for approval, within the requisite period prior to the commencement of the works. This will be a hold point.

4.1.7.2.11.8.4 Related Standards

The specified BS, KS, ISO, IEC standards or other relevant internationally recognized standards approved by KPLC shall be applied in this project.

It is the Contractor's responsibility to ensure that they are in possession of the latest edition of the specified IEC standards and other relevant standards specified, including all amendments current on the defined date prior to the tender closing date.

Materials or equipment conforming to alternative international or national standards will be considered by the employer, provided that these standards ensure an equivalent or higher quality.
The Contractor/supplier shall bring to the attention of the employer any inconsistencies between the requirements of these standards and this specification.

The Contractor/supplier shall supply the requisite number of copies of the applicable reference standards specified in each appropriate section within the requisite period after the signing of the contract

Where equivalent standards are offered as an alternative, the Contractor/supplier shall, when requested by the employer, provide the requisite number of English language translation copies of the standards at no extra cost to the project.

4.1.7.2.11.8.5 Quality Control

4.1.7.2.11.8.5.1 Inspection and Testing

The prime responsibility for inspection and testing shall rest with the Contractor/supplier. The inspection and acceptance of drawings, materials and workmanship, or the waiver of inspection by the employer, shall not relieve the Contractor/supplier of any obligations or responsibilities to carry out the work in accordance with specification and good engineering requirements. The inspection and testing shall be documented such that it is possible to verify that it was undertaken. Records of inspection shall include as a minimum the project identity, the name of the inspector/tester, date of inspection/ test, operation/inspection, technique used, acceptance standard and acceptability.

4.1.7.2.11.8.5.2 Type, Sample and Routine Tests

Type, sample and routine tests shall be undertaken on all components supplied and/or installed under this project, in accordance with the requirements of this specification.
The Employer may waive the requirements for type tests on submission by the Contractor/supplier of the requisite number of test certificates, either certified by an independent quality assurance organization, or undertaken by an internationally acknowledged independent testing organization, showing that the component had successfully passed the type tests specified in this specification.

4.1.7.2.11.8.5.3 Certificate of Conformity

Prior to the issue of the Release Certificate or agreement to shipping the Contractor/supplier shall submit to the employer the requisite copies of the completed certificates of conformity (see Appendix 3.A1). The certificate shall be supported by copies of the appropriate material test certificate inspection records, type and sample test reports as detailed in the relevant section of this specification.

4.1.7.2.11.8.5.4 Non-Conforming Products

The employer shall be responsible for reviewing the non–conforming products in accordance with ISO 9001 or 9002.

4.1.7.2.11.8.5.5 Monitoring Quality Assurance Agreements

Monitoring the Quality Assurance arrangements may be undertaken by the employer during the course of the project. This will take the form of surveillance of the activities at work

locations and/or by formal audits of the Contractors/supplier system and procedures which constitutes their quality assurance arrangements. Corrective actions shall be agreed and implemented in respect of any deficiencies.
The Contractor/supplier shall provide all facilities including access (including their suppliers or sub-contractors) which may be required by the employer for monitoring activities.

4.1.7.2.11.8.5.6 Suppliers and Sub-Contractors

The Contractor shall ensure that any supplier or sub-contractor appointed by them under the project shall conform to the requirements of this specification. Prior to the appointments of any supplier/sub-contractor the Contractor shall ensure that their quality assurance arrangements comply with the requirements of ISO 9001 or 9002 and this specification.
The Contractor's auditing of their suppliers/sub-contractors quality assurance arrangements shall be documented to demonstrate to the employer their extent and effectiveness.

4.1.7.2.11.8.5.7 Method Statements

Prior to commencing any section of the work, the Contractor shall submit method statement in accordance with the requirement of the relevant section of this specification. Submission of these method statements shall be treated as Hold Points.
When requested by the Employer or their appointed representative, the Contractor shall provide additional method statements related to specific item of work.

SECTION VI

4.2 SCOPE OF WORK

OVERHEAD LINES AND SUBSTATIONS

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4.2 SCOPE OF WORKS

4.2.1 SCOPE FOR 132KV, 66KV, 33KV AND 11KV LINES

4.2.1.1 General

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

Special attention shall be paid to the Technical Specifications, where the general technical requirements are specified. The drawings enclosed herein are for bidding purposes only.

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

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

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

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

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

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

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

The scope of work for a transmission line shall cover design, manufacture, testing, supply, shipping, transportation and delivery to site, unloading, check survey and all associated profile plotting, support pegging, provision of access facilities and route clearing, installation of foundations and all associated civil works. Erection of towers, stringing, sagging, crimping, installation, testing and commissioning of the line and associated line bay.

Transmission lines shall be constructed on steel lattice or monopole towers meeting KPLC and internationally accepted standards. The specifications for transmission line

design and specifications are details under Particular Technical Specifications for transmission lines.

4.2.1.2 Cross arms:

Steel cross-arms shall be used in all cases including re-conductoring. All steel cross arms shall be grounded and shall meet international accepted standards in addition to KPLC specifications for steel structures and line fittings.

4.2.1.3 Line Conductor

The 11kV and 33kV Overhead line conductors shall be 150mm2 ACSR.
The 66kV overhead conductor shall be 300mm2 AAAC.
The 132kV overhead conductor shall be 175mm2 Lynx.
The Alternative 132kV Overhead conductor shall be 223mm2 ACCC.

4.2.1.4 Conductor Joints and Terminations

All joints and terminations shall be of **compression type** for conductors of 150mm2 and above.

4.2.1.5 Poles:

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

4.2.1.6 Line Towers:

Monopole towers shall be self-supporting, galvanized single-pole steel tubular type with body extensions. The body extensions shall be in sections of 1m and 3m in length. designed for multi-circuit use in urban areas.
For lattice steel towers a fully triangulated system of bracings shall preferably be adopted for its overall stability.
No member of the lattice tower shall be less than 6mm in thickness and 50mm in width of flange for leg members of towers and main members of the cross-arm, and 5mm and 45mm for the web and nominal members respectively.
These tower designs shall be double circuit 132 kV top and 33 kV double circuits mounted below. It shall also have provisions to carry 48 cores OPGW cable and ground Earth wire at top for lightning protection of the double circuit transmission line. Shall meet all specifications as prescribed in the Particular Technical Specification for Overhead lines and BS 8100, BS EN 50341 and BS EN 10163 plus other internationally acceptable standards.

4.2.1.7 Optical Ground Wire:

OPGW (Optical Ground Wire) shall be used in all the 33kV and above overhead lines. The standard size used by KPLC is 48 cores single mode Optic fibre. OPGW earthing shall be done after every fourth pole.

Where the 33kV and 66kV line is done in underground cable, an Underground Fibre Optic cable will be laid together in the trace of the MV cable.

4.2.1.8 Factory Acceptance Test

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

The following major equipment shall be offered for inspection

i. **Busbar and Line Conductors (75mmsq, 150mmsq & 175 mmsq ACSR and 300mmsq AAAC)**
ii. **Surge Arrestors and Insulators**
iii. **Line Concrete Poles**
iv. **Line Towers**

FAT shall be carried out as prescribed in the Particular Technical Specification.

4.2.2 SCOPE OF SUBSTATIONS WORK

4.2.2.1 General

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

Special attention shall be paid to General Specifications and Particular Technical Specifications, in which the general technical requirements are specified. The drawings enclosed herein 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 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 contractor find discrepancies in or omissions from these Specifications or from the other Documents, or should he be in doubt as to their meaning, he should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting his Bid. Such action shall, however, in no case be considered as a cause for altering the closing date of the Bid.

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

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

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

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

Equipment that is to be dismantled and removed from existing substations is to be recovered by the Contractor and deposited to KPLC stores as designated by the Employer. The recovered equipment is to be taken over by the Employer at these stores.

4.2.2.2 Standard Substation

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

4.2.2.2.1 132kV Bays

4.2.2.3.2.1 Transformer Bay (132/xxx kV)

One complete 132kV / xxxkV Transformer Bay (HV & MV) shall be equipped with:

a) 1 (One) HV and 1 (One) MV Circuit breaker - Ganged mechanism
b) 1 (One) HV and 1 (One) MV motorised isolator
c) 2 (two) sets of busbars materials and post insulators (HV & MV)
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and between the apparatus.
e) 2 (two) set of current transformers (HV & MV)
f) 1 (one) MV neutral current transformer with neutral isolating link
g) 2 (two) set of surge diverters (HV & MV) installed close to the power transformer
h) 1 (one) set of steel structures for equipment support
i) Numerical automatic voltage regulating relay (AVR) compliant to IEC61850 standards
j) 2 (two) Control panels (HV & MV) equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs*:
    i) 2 (two) Bay Control Units with control and measurement (HV & MV)
    ii) 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW (HV & MV)
    iii) Set of Mimic, Semaphores, indications, discrepancy switches and instruments (HV & MV)
    iv) Annunciation relay for Alarms and trips
    v) Set of trip circuit supervision relay (HV & MV)
    vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.
k) 2 (two) Protection panels equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs*:
    i) 1 (one) differential protection function
    ii) 1 (one) restricted earth fault function
    iii) 2 (two) overcurrent and earth fault protection function. (HV & MV)
    iv) 1 (one) MV neutral point earth fault relay function
    v) 1 (one) lot of lock-out trip relay with electrical and hand reset facilities (HV & MV)
    vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation.

4.2.2.2.1.2 132kV Line Bay

1 complete 132KV Line Bay shall be equipped with:

a) 1 (one) circuit breaker - Single pole mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) earthing switch
d) 1 (one) set of busbars materials and post insulators

e) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
f) 1 (one) set of current transformers
g) 1 (one) set of voltage transformers
h) 1 (one) set of surge diverters
i) 1 (one) set of steel structures for equipment support
j) 1 (one) Control panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs*:
    i) 1 (one) Bay Control Unit with control and measurement
    ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii) 1 (one) tariff energy meter
    iv) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    v) Annunciation relay for alarms and trips
    vi) Set of trip circuit supervision relays
    vii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation
k) 2 (two) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs*:
    i) 1 (one) multifunctional line protection IED unit (Main A) with both line distance and line differential functions.
    ii) 1 (one) multifunctional line protection IED unit (Main B) with line distance functions.
    iii) 1 (one) sensitive earth fault function
    iv) HV overcurrent and earth fault protection function.
    v) 1 (one) lot of lock-out trip relay with electrical and hand reset facilities
    vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.1.3 132kV Bus Section / Bus Coupler Bay

1 (one) complete 132kV Bus Section / Bus Coupler Bay shall be equipped with:
a) 1 (one) circuit breaker – Ganged Mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) set of busbars materials and post insulators
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
e) 1 (one) set of current transformers
f) 2 (two) set of voltage transformers
g) 1 (one) set of steel structures for equipment support
h) 1 (one) Control panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs*:
    i) 1 (one) Bay Control Unit with control and measurement
    ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    iv) Annunciation relay for alarms and trips
    v) Set of trip circuit supervision relays

vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation

l) 1 (one) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) HV overcurrent and earth fault protection function.
   ii) 1 (one) lot of lock-out trip relay with electrical and hand reset facilities
   iii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.1.4 132kV Bus Bar Protection

1 (one) 132kV Bus bar protection and control panel shall have a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*

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

4.2.2.2.2 66kV Bays

4.2.2.2.2.1 Transformer Bay (66 / xxx kV)

One complete 66kV / xxxkV Transformer Bay (HV & MV) shall be equipped with:

a) 1 (One) HV and 1 (One) MV Circuit breaker - Ganged mechanism
b) 1 (One) HV and 1 (One) MV motorised isolator
c) 2 (two) sets of busbars materials and post insulators (HV & MV)
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and between the apparatus.
e) 2 (two) set of current transformers (HV & MV)
f) 1 (one) MV neutral current transformer with neutral isolating link
g) 2 (two) set of surge diverters (HV & MV) installed close to the power transformer
h) 1 (one) set of steel structures for equipment support
i) Numerical automatic voltage regulating relay (AVR) compliant to IEC61850 standards
j) 2 (two) Control panels (HV & MV) equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 2 (two) Bay Control Unit with control and measurement (HV & MV)
   ii) 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW (HV & MV)
   iii) Set of Mimic, Semaphores, indications, discrepancy switches and instruments
   iv) Annunciation relay for Alarms and trips
   v) Set of trip circuit supervision relay (HV & MV)
   vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

k) 2 (two) Protection panels equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) differential protection function
   ii) 1 (one) restricted earth fault function
   iii) 2 (two) Overcurrent and earth fault protection IED. (HV & MV)
   iv) 1 (one) MV neutral point earth fault relay function
   v) 1 (one) lot of lock-out trip relay with electrical and hand reset facilities (HV & MV)
   vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation.

4.2.2.2.2.2 66kV Line Bay

1 complete 66KV Line Bay shall be equipped with:

a) 1 (one) circuit breaker - Ganged mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) earthing switch
d) 1 (one) set of busbars materials and post insulators
e) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
f) 1 (one) set of current transformers
g) 1 (one) set of voltage transformers
h) 1 (one) set of surge diverters
i) 1 (one) set of steel structures for equipment support
j) 1 (one) Control panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) Bay Control Unit with control and measurement
   ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii) 1 (one) tariff energy meter
   iv) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   v) Annunciation relay for alarms and trips
   vi) Set of trip circuit supervision relays
   vii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

k) 2 (two) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) multifunctional line protection IED unit with both line distance and line differential functions.
   ii) 1 (one) sensitive earth fault function
   iii) HV overcurrent and earth fault protection function.
   iv) 1 (one) lot of lock-out trip relay with electrical and hand reset facilities
   v) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.2.3 66kV Bus Section / Bus Coupler Bay

1 (one) complete 66kV Bus Section / Bus Coupler Bay shall be equipped with:

a) 1 (one) circuit breaker – Ganged Mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) set of busbars materials and post insulators
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
e) 1 (one) set of current transformers
f) 2 (two) set of voltage transformers
g) 1 (one) set of steel structures for equipment support
h) 1 (one) Control panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control Unit with control and measurement
    ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    iv) Annunciation relay for alarms and trips
    v) Set of trip circuit supervision relays
    vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

m) 1 (one) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) HV overcurrent and earth fault protection function.
    ii) 1 (one) lot of lock-out trip relays with electrical and hand reset facilities
    iii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.2.4 66kV Bus Bar Protection

1 (one) 66kV Bus bar protection and control panel shall have a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
a) 1 (one) multifunctional IED unit with busbar protection function
b) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation
c) Annunciation relay for alarms and trips
d) Lock-out trip relays with electrical and hand reset facilities

4.2.2.2.3 33kV Bays

4.2.2.2.3.1 Transformer Bay (33 / xxx kV)

One complete 33kV / xxxkV Transformer Bay (HV & LV) shall be equipped with:
a) 1 (One) MV and 1 (One) LV Circuit breaker - Ganged mechanism
b) 1 (One) MV and 1 (One) LV motorised isolator
c) 2 (two) sets of busbars materials and post insulators (MV & LV)
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the transformer bushings, to the busbars and between the apparatus.
e) 2 (two) set of current transformers (MV & LV)
f) 1 (one) LV neutral current transformer with neutral isolating link

g) 2 (two) set of surge diverters (MV & LV) installed close to the power transformer
h) 1 (one) set of steel structures for equipment support
i) Numerical automatic voltage regulating relay (AVR) compliant to IEC61850 standards
j) 1 (one) Control panels (MV & LV) equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control Unit with control and measurement (MV & LV)
    ii) 2 (two) multifunctional meters for measurement and display of kV, I, MVAR, MW (MV & LV)
    iii) Set of Mimic, Semaphores, indications, discrepancy switches and instruments
    iv) Annunciation relay for Alarms and trips
    v) Set of trip circuit supervision relay (MV & LV)
    vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

k) 1 (one) Protection panels equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) differential protection function
    ii) 1 (one) restricted earth fault function
    iii) 2 (two) Overcurrent and earth fault protection IED. (MV & LV)
    iv) 1 (one) LV neutral point earth fault relay function
    v) 1 (one) lot of lock-out trip relays with electrical and hand reset facilities (MV & LV)
l) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protective scheme which shall be prepared for SCADA operation

4.2.2.2.3.2 33kV Line Bay

1 complete 33KV Line Bay shall be equipped with:

a) 1 (one) circuit breaker - Ganged mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) earthing switch
d) 1 (one) set of busbars materials and post insulators
e) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
f) 1 (one) set of current transformers
g) 1 (one) set of voltage transformers
h) 1 (one) set of surge diverters
i) 1 (one) set of steel structures for equipment support
j) 1 (one) Control panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control Unit with control and measurement
    ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii) 1 (one) tariff energy meter
    iv) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    v) Annunciation relay for alarms and trips
    vi) Set of trip circuit supervision relays

vii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.

k) 1 (one) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) multifunctional line protection IED unit with line distance function.
   ii) 1 (one) sensitive earth fault function
   iii) MV overcurrent and earth fault protection function.
   iv) 1 (one) lot of lock-out trip relays with electrical and hand reset facilities
   v) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.3.3 33kV Bus Section / Bus Coupler Bay

1 (one) complete 33kV Bus Section / Bus Coupler Bay shall be equipped with:

a) 1 (one) circuit breaker – Ganged Mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) set of busbars materials and post insulators
d) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
e) 1 (one) set of current transformers
f) 2 (two) set of voltage transformers
g) 1 (one) set of steel structures for equipment support
h) 1 (one) Control panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) Bay Control Unit with control and measurement
   ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iii) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iv) Annunciation relay for alarms and trips
   v) Set of trip circuit supervision relays
   vi) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation.
i) 1 (one) Protection panel equipped with a minimum of following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) HV overcurrent and earth fault protection function.
   ii) 1 (one) lock-out trip relay with electrical and hand reset facilities
   iii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.3.4 33kV Auxillary Supply Transformer Bay

1 (one) complete 33kV Auxillary Supply Bay shall be equipped with:

a) 1 (one) 100kVA 33/0.415kV Dyn11 Auxillary Transformer (2x200kVA for 132kV S/S)
b) 1 (one) set of 33kV Drop out fuses
c) 1 (one) lot three-phase line materials including post insulators, clamps for the flying busbars and for connection between the busbars and the equipment.
d) 1 (one) set of 33kV Surge Arrestors

4.2.2.2.3.5 33kV Switching Station

1 (one) complete 33kV Switching Station shall be equipped with the following minimum equipment:

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

4.2.2.2.4 11kV Bays _ Outdoor Switchgear

4.2.2.2.4.1 11kV Feeder Bay

1 complete 11KV Feeder Bay shall be equipped with:

a) 1 (one) circuit breaker - Ganged mechanism
b) 2 (two) isolators with motor operation
c) 1 (one) earthing switch
d) 1 (one) set of busbars materials and post insulators
e) 1 (one) complete set of three-phase line materials including clamps for the flying busbars and for connection between the gantries, to the busbars and between the apparatus.
f) 1 (one) set of current transformers
g) 1 (one) set of surge diverters
h) 1 (one) set of steel structures for equipment support.
i) 1 (one) Control and Protection panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control and Protection Unit with control and measurement
    ii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iii) 1 (one) tariff energy meter
    iv) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    v) Annunciation relay for alarms and trips
    vi) Set of trip circuit supervision relays
    vii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation
    vi) 1 (one) sensitive earth fault function
    vii) 1 (one) LV overcurrent and earth fault protection function.
    viii) Autoreclose function
    ix) 1 (one) lock-out trip relay with electrical and hand reset facilities
    x) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.4.2 11kV Auxillary Supply Transformer Bay

1 (one) complete 11kV Auxillary Supply Bay shall be equipped with:

a) 1 (one) 100kVA 11/0.415kV Dyn11 Auxillary Transformer
b) 1 (one) set of 11kV Drop out fuses

c) 1 (one) lot three-phase line materials including post insulators, clamps for the flying busbars and for connection between the busbars and the equipment.
d) 1 (one) set of 11kV Surge Arrestors

4.2.2.2.5 11kV Bays _ Indoor Switchgear Panels

4.2.2.2.5.3 11kV Transformer Incomer Indoor Bay

1 complete 11KV Transformer Incomer Bay shall be equipped with:

a) 1 (one) Withdrawable circuit breaker
b) 1 (one) earthing switch
c) 1 (one) set of busbars materials
d) 1 (one) set of current transformers
e) 1 (one) set of Voltage transformers (with a facility for primary isolation)
f) 1 (one) Control and Protection panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control and Protection Unit with control and measurement
    ii) Arc protection
    iii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iv) 1 (one) tariff energy meter
    v) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    vi) Annunciation relay for alarms and trips
    vii) Set of trip circuit supervision relays
    viii) 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
    xi) 1 (one) LV Overcurrent and earth fault protection function.
    xii) Autoreclose function
    xiii) 1 (one) restricted earth fault function *(If NOT included in Tx HV panel)*
    xiv) 1 (one) lock-out trip relay with electrical and hand reset facilities
    xv) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.5.2 11kV Feeder Indoor Bay

1 complete 11KV Feeder Indoor Bay shall be equipped with:

a) 1 (one) Withdrawable circuit breaker
b) 1 (one) earthing switch
c) 1 (one) set of busbars materials
d) 1 (one) set of current transformers
e) 1 (one) set of surge diverters
f) 1 (one) Control and Protection panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
    i) 1 (one) Bay Control and Protection Unit with control and measurement
    ii) Arc Protection
    iii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
    iv) 1 (one) tariff energy meter
    v) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
    vi) Annunciation relay for alarms and trips
    vii) Set of trip circuit supervision relays

viii) 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
xvi) 1 (one) sensitive earth fault function
xvii) 1 (one) LV Overcurrent and earth fault protection function.
xviii) Autoreclose function
xix) 1 (one) lock-out trip relay with electrical and hand reset facilities
xx) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.5.3 11kV Bus Section Indoor Bay

1 complete 11KV Bus Section Bay shall be equipped with:

a) 1 (one) Withdrawable circuit breaker
b) 2 (two) earthing switch *(if NOT provided elsewhere on the Indoor Switchgear board)*
c) 1 (one) set of busbars materials
d) 1 (one) set of current transformers
e) 2 (two) sets of Voltage transformers - with a facility for primary isolation *(one set for each bus section. if NOT provided elsewhere on the Indoor Switchgear board)*
f) 1 (one) Control and Protection panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) Bay Control and Protection Unit with control and measurement
   ii) Arc Protection
   iii) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   iv) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   v) Annunciation relay for alarms and trips
   vi) Set of trip circuit supervision relays
   vii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative bay control. The control scheme shall be prepared for SCADA operation
   xxi) 1 (one) LV Overcurrent and earth fault protection function.
   xxii) 1 (one) lock-out trip relay with electrical and hand reset facilities
   xxiii) 1 (one) lot of necessary interposing relays, MCB's, terminal blocks and wiring to form a complete operative protection scheme which shall be prepared for SCADA operation

4.2.2.2.5.4 11kV Auxillary Transformer Indoor Bay

1 complete 11KV Auxillary Transformer Bay shall be equipped with:

a) 1 (one) Withdrawable motorised fuse switch
b) 1 (one) earthing switch
c) 1 (one) set of busbars materials
d) 1 (one) Control and Protection panel equipped with a minimum of the following IEDs and components as described in **Section VI - Clause 4.1.2.3.2** – *Protection Schemes & IEDs:*
   i) 1 (one) multifunctional meter for measurement and display of kV, I, MVAR, MW
   ii) Panel mimic diagram, semaphores, indications, discrepancy switches and instruments.
   iii) Annunciation relay for alarms and trips

iv) 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

4.2.2.2.6 Current Transformer Technical Data

The current transformers shall have cores whose Ratio, Class and Burden shall be as specified in tables below. LV and HV windings for the current transformers for this project shall be made of high grade copper. Aluminium windings shall not the accepted. Where in the attached KPLC specifications require use of Aluminium or Copper windings, it shall be ignored.

The CTs shall also meet all the other requirements contained in the attached KPLC Specifications for 33kV current transformers.

Table 4.2.2.2.6.1:
Current transformer technical parameters (23MVA, 66/11kV S/S)

66kV			**66/11kV**		**11kV**	
Line Bay			**Transformer Bay (HV/MV)**		**Feeder Bay**	
Core	Ratio	Class/Burden	Ratio	Class/Burden	Ratio	Class/Burden
1	800/400/1A	0.2/15VA	HV-400-200/1A LV-1250/1A	0.2/15VA	600-400-200/1A	0.2/15VA
2	800/400/1A	5P20/15VA	HV-400-200/1A LV-1250/1A	5P20/15VA	600-400-200/1A	5P20/15VA
3	800/400/1A	5P20/15VA	HV-400-200/1A LV-1250/1A	5P20/15VA	600-400-200/1A	5P20/15VA
4	800/400/1A	X/Vk>350V Ik<30mA	HV-400-200/1A LV-1250/1A	X/Vk>350V Ik<30mA		
5	800/400/1A	X/Vk>350V Ik<30mA	HV-400-200/1A LV-1250/1A	X/Vk>350V Ik<30mA		

Table 4.2.2.2.6.2:
Current transformer technical parameters (23MVA, 132/33kV S/S)

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

Note: *If the Current Transformer Short circuit current withstand, Ratio, Burden and Class in the **attached KPLC CT specifications** differ with the values given in the scope for the works, the **parameters** in the scope of works shall apply(prevail).*

4.2.2.2.7 Outdoor Voltage Transformer Technical Data

The technical parameters for the Voltage transformer for this project shall meet following requirements in addition to those specified in attached KPLC specifications for Voltage transformers.

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

Metering core accuracy class shall be **0.2** and not **0.5** as specified in the attached KPLC specifications for Voltage transformers.

Note: *If the Voltage Transformer Ratio, Burden and Class in the **attached KPLC CT specifications** differ with the values given in the scope for the works, the **parameters** in the scope of works shall apply(prevail).*

4.2.2.2.8 Outdoor Bus Bar and Line Conductor

The bus bar shall use appropriately rated high grade tubular Aluminium alloy, or All Aluminum Alloy Conductor. Overhead line conductors shall be 150mmsq,175mmsq ACSR, 300mmsq AAAC while 100mmsq AA conductors shall be used in 0.415kV LV. Material for tubular busbar shall be designed to withstand thermal and dynamic stresses under normal duty and maximal short-circuit current without damage. Fastening shall be such that thermal expansion is accommodated without any undue stress.

4.2.2.3 Substation Automation System - SCADA/RTU

4.2.2.3.1 General

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

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

Drawings showing the control system, protection units and the boards as they are proposed shall be supplied with the Bid.
The space needed for the boards should not exceed the available space.
Information defining the internal local control communication protocol shall be submitted with the Bid.

Complete sets of schematic diagrams for control, protection, indication, metering, signaling, alarms, etc. shall be supplied as part of the project and shall be subject to the Project Manager's approval.
The requirements as to submission of diagrams, drawings and other documents with the Bid and after award of Contract are stated in the standard form of contract.

4.2.2.3.2 Scope of Substation Automation System (SAS):

4.2.2.3.2.1 Scope of Substation Automation System (SAS) for 132/66/33/11kV S/S with 7.5 MVA transformer and above.

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

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

a) Full operational Control, Monitoring, Reporting, Alarm, Signaling and Indications facilities for NCC/RCC station control (Supervisory level).
b) Full operational control, Monitoring, reporting, alarm and indications facilities for the substation from the Human Machine interface (HMI) workstations in the substation control room (Substation Level).
c) Operational control of each new circuit/bay from the protection relay panel using the bay control unit LCD display (Bay level).
d) Control of each item of plant from the Local Control Cubicle (LCC) (Local Level)
e) The control facilities from each control point are to be interlocked (hardwired) to prevent operation of any device simultaneously from more than one control point.
f) At least one fully operational control point shall remain available in the event of a single equipment or communications failure.
g) Complete facilities must exist for the proper lockout and maintenance tagging of circuits and plant items to ensure the safety of personnel and the security of the system
h) The SA system shall use open communication protocols and be readily interfaced with third part devices operating on open protocols (IEC61850, IEC60870-101/104). The Tenderer shall describe such interfaces and provide

an experience list of devices with which the offered control system has previously been interfaced.

i) The integration works of the SAS to existing SCADA System shall not be included in the scope. However, the contractor shall provide and clearly label all the required signals and commands for Telecom and SCADA integration at the control panels' Terminal Block.

Station Level

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

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

SCADA Interface

a) 1 (one) lot complete system (equipment and software), with communication gateway, data concentrator etc. for interface to a regional (RCC) SCADA system and to the national (NCC) SCADA system. using IEC60870-101/104 protocols.
b) The integration works of the SAS to existing SCADA System shall not be included in the scope. However, contractor shall implement stage three (3) of Scada and telecommunication system i.e. testing to ensure all substation level signals and commands are received at NCC or RCC for the purpose of KPLC integration.
c) Contractor shall provide and clearly label all the required signals and commands for Telecom and SCADA integration at the Control panels' terminal block.

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

a) The system scope shall include detailed system design, manufacture, supply, installation, testing, and commissioning of SAS system comprising of:
b) 1 (One) RTU (Gateway switch) fully wired functional panel with all necessary accessories
c) 2 (two) Multiplexer Switch IP620 with Ethernet LAN switches. One for main station and another for integration with RCC.
d) Set of SFP modules necessary for integration with existing SAS system Multiplexer
e) Set of patch cords and ethernet cables necessary for Bay interconnections.
f) 110 to 48Vdc supply Converter for RTU auxiliary supply.
g) At station level the SAS system shall not have HMI Work stations for control and operation

4.2.2.3.2.3 SCADA Interface

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

4.2.2.3.3 Control and Measuring Cables

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

4.2.2.3.4 Telecommunications

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

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

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

All communications equipment installed in the country must be type approved by the Communications Authority of Kenya (CAK). The Contractor will obtain the type approval. The CAK has to be consulted and give approval for each new project and an application has to be submitted stating the location of the sites and request for the frequencies to be used. Unless otherwise stated this application for frequencies is normally done by KPLC.

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.

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.
The contractor shall offer training for five (5) technical appointees of the employer for 2 weeks at manufacturer's premises.
The contractor shall provide necessary configuration software pre-installed on a maintenance laptop with a one-time software license.

Scope of works - Telecommunication

a) The scope for 132/66/33/11 substation with a 10MVA transformer and above shall include detailed system design, manufacture, supply, installation, testing, commissioning, remedying of defects, maintaining the works during the defects liability period and any incidental work necessary for the proper completion of the work in accordance with this contract.
Scope shall include integration of STM-1/4 and IP phone system to the existing KPLC Network Management System. In some cases, there shall be need to upgrade existing telecommunication equipment to achieve data and speech routing to regional and national control centers. Survey and necessary preparation work on existing systems, equipment and substations to achieve specified functionality shall be in the scope of supply. All stations shall be equipped with two (2N0.) IP telephones extensions communicating with RCC and NCC via fibre optic.

All communication equipment supplied under this project shall be type approved by the regulator, Communication Authority of Kenya (CAK) and the Kenya Bureau of Standards (KBS) where applicable. It is the responsibility of the contractor to obtain these necessary approvals.

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

Minimum technical requirement for a 2-way base radio station are summarized below:

Specifications for VHF 2-Way Base Radio station

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

4.2.2.3.5 Auxiliary AC supply equipment

I. Main AC Distribution Board

1 (one) main distribution board designed for minimum not less than **250A** for upto 66kV rated substations and not less than **400A** for 132kV and above rated substations rating, with necessary number of panels and accessories as indicated below:

a) Auto Change Over scheme for two 3-Phase 415Vac supply sources to be incorporated in the board for 23MVA substations capacity and above
b) 2 (two) circuit breaker and busbars minimum rating of 250A, manual and auto operated for each incomer from the station supply transformers.
c) 2 (two) current transformers not less than 250/1/1A for upto 66kV rated substations and not less than 400/1/1A for 132kV and above rated substations with two cores, one core for measuring and one for protection.
d) 1 (one) constant time Overcurrent and Earth fault relay.
e) 1 (one) A-meter function with selector switch for each incomer.
f) 1 (one) V-meter function with selector switch for each incomer.
g) 1 (one) lot of feeder Miniature 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.

II. Sub-distribution Boards and Panels

1(one) lot of all necessary sub-distribution boards and panels (including the distribution panel for lighting and small power of the control building). The boards shall be completely equipped with correct rate copper bus bars, MCBs, Fuses 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.

III. Cables

1 (one) lot of all necessary armored (steel wire) flexible copper 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.

4.2.2.3.6 DC Supply System

I. Lithium Ion Phosphate Battery Units,

a) 1 (one) 110 V battery units with a capacity of **at least** 265Ah/10h for 66/33/11kV substations.
b) 2 (two) 110 V battery units with a capacity of **at least** 265 Ah/10h each for 132kV and 220kV substation.
c) 1(one) 48V battery units with a capacity of **at least** 165 Ah/10h for telecommunication equipment and SCADA for 66/33/11kV substations
d) 2(two) 48V battery units each with a capacity of **at least** 165Ah/10h for telecommunication equipment and RTU for 132kV and 220kV substations

The battery capacities shall be based upon the calculated consumption considering a full developed substation, with the above minimum ratings.

II. Battery Charger System

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

The DC supply system shall consist of the following minimum requirements:

a) Lithium ion phosphate battery units,
b) Battery cabinet
c) Inter cell connectors
d) DC battery chargers
c) Battery management system. BMS
f) Monitoring and communication systems.
g) All accessories and communication devices

Note 1: *The Lithium Ion Phosphate Battery system shall meet KPLC, IEC specifications and general requirements*

Note 2: *If the DC System ratings in the* ***attached KPLC specifications*** *differ with the values given in the scope for the works, the* ***parameters*** *in the scope of works shall apply(prevail).*

III. Distribution Board

1 (one) Distribution Board 110VDC and 48VDC system
The board shall be installed with following equipment amongst others:
a) 1 (one) appropriately rated circuit breaker with magnetic and thermal release for each feeder from the charger and battery.
b) 1 (one) appropriately rated tie breaker for each DC bus in the stations with 2 (two) battery banks.
c) 1 (one) A-meter with shunt for each battery bank.
d) 1 (one) V-meter with selector switch for the voltage between the poles and between poles and earth for each battery bank.
e) 1 (one) set of contacts on the front for banana jacks for the battery voltage and earth.
f) 1 (one) battery monitoring devices with alarm contacts.
g) 1 (one) lot of all necessary circuit breakers and miniature circuit breakers for the outgoing feeders and circuits.

20% of the breakers of any size shall be spare and readily mounted.
All necessary materials and instruments required for complete functioning of the DC supply systems.

IV. Battery Conductors

1 (one) set of appropriately sized singled core conductor from each battery units to the associated DC Distribution Boards.

V. Sub-distribution Boards and Panels

1 (one) lot of all necessary sub-distribution boards and panels for the DC systems.

The boards shall be completely equipped with bus bars, 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.

VI. Cables

1 (one) lot of all necessary DC power supply armored copper cables and associated materials, including wiring to the apparatus in the switchyard.

4.2.2.3.7 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.

4.2.2.3.8 Ancillary Equipment

The following ancillary equipment shall meet KPLC technical specifications:

I. Station Equipment

a) 2 (two) self-contained, rechargeable, portable hand-held lights.
b) 1 (one) audible alarm system with the necessary wiring.
c) Emergency lighting to be provided in the substation building.
d) 1 set of fire detection system in the control building

II. Earthing Devices

(a) 1 (one) set of three phase portable Earthing harness for outdoor 11kV upto 132kV with operating rods/link sticks suitable for Earthing of the bay conductors and bus bars.
(b) 1 (one) set of voltage indicators for 11kV and 132kV with audible and visual indication for voltage

III. Cable Accessories

1 (one) lot of all connecting material, cable boxes and material for fixing the cables. Terminals, glands and terminal labels shall be included in the material requirement

IV. Racks, Conduits, Ducts, etc.

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

4.2.2.3.9 Power transformers

To be supplied as specified for each substation, and in accordance with below data Main data for the transformers that shall be supplied:

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

Type of transformers

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

4.2.2.3.10 Civil Works

Platform Works.
Platform, equipment foundations, plot perimeter wall, earthworks, cable trenches, roads and drainages shall be constructed as specified in Particular Technical Specifications for civil works.

Switchgear Buildings
Switchgear buildings shall be constructed as specified in particular specifications for switchgear building.
Control Panels, Medium voltage indoor switchgears, AC and DC systems of different Voltage levels shall be installed in separate rooms.
In addition, a guardhouse with toilet facilities located at the main gate shall be constructed.

Power Transformer and Equipment Foundations
The power transformer and equipment foundations shall be constructed as specified in particular specifications for civil works.

Cable Trenches
Cable trenches shall be constructed as specified in Particular Technical Specifications for civil works.

4.2.2.3.11 Training in Major Equipment

The training shall be for 3 (three) KPLC Staff for each (3 staff x 4 = Total of 12) of the courses indicated here in. The training shall be held at the manufacturer's factory. All training, transport costs at manufacturer's premises shall be met by the contractor. KPLC shall meet the accommodation costs.
The training shall cover design, application, testing, commissioning and maintenance of the relevant digital control and protection systems. The training shall be biased towards principles of substation design, transmission line & towers designs, RTU, Telecommunications Control and Protection and Contract management. The training course shall have a minimum of 2 (two) weeks duration

4.2.2.3.12 Factory acceptance test

The Contractor shall arrange for 2 participants from KPLC and the Project Manager to witness tests of major equipment listed below in the manufacturer's plant. All routine tests shall be carried out in the presence of the Employer's representatives. The Contractor shall arrange for the FAT and meet full cost of the air tickets, local transport, training at manufacturer's factory and *per diem* for KPLC staff. as per SRC rates or KPLC designated rates; whichever is higher.

The Major Equipment includes:

A) LOT 1 and LOT 2: Rongai and Kathwana 2 x 23 MVA 132/33 kV

NO	Equipment/Materials
1	Power transformer (23MVA 132/33KV)
2	Lattice Towers, Gantries and substation equipment support Steel structures
3	132 kV Outdoor Switchgears Circuit breaker
4	33 kV Outdoor Switchgears Circuit breaker
5	132 kV Outdoor Switchgears Isolators
6	33 kV Outdoor Switchgears Isolators
7	132kV Instrument transformers (CTs and VTs)
8	33kV Instrument transformers (CTs and VTs)
9	132 and 33 kV Insulators

10	132 and 33kV Surge arrestors
11	Protection and Control system
12	SAS system
13	Telecommunication system
14	110V and 48V Battery and Charger
15	Phase Conductor (150mm^2, 175mm^2 and 300 mm^2 ACSR)
16	OPGW cable
17	Concrete poles

B) LOT 3: Kiserian 2 x 23 MVA 66/11 kV

NO	Equipment/Materials
1	Power transformer (23MVA 66/11KV)
2	Substation equipment support steel structures
3	66 kV Outdoor Switchgears Circuit breaker
4	11 kV Indoor Switchgears Board
5	66 kV Outdoor Switchgears Isolators
6	66 kV Instrument transformers (CTs and VTs)
7	66 kV Insulators
8	Protection and Control system
9	SAS system
10	Telecommunication system
11	110V and 48V Battery and Charger
12	Phase Conductor (150mm^2 and 300mm^2 ACSR)
13	Concrete poles
14	11 kV Power Cables

Note : FAT shall be carried out as prescribed in the particular technical specifications.

4.2.2.3.13 Commissioning Equipment or Tools

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

4.2.2.3.14 Final documentation

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

4.2.2.3.15 Facilities for the KPLC Project Implementation Team

I. Site Offices

At the location where the Contractor will establish his main site, an administration office for site supervisors from the Project Manager with basic office furniture,

drinking water, internet, telephone and a copier shall be provided by the contractor for the entire project implementation period.

II. Communication Facilities

The contractor shall supply 3Nos. Pre-paid phone and Airtime equivalent to **KES 30,000/= per month** for the KPLC Project Implementation team for the entire project implementation period. The communication facilities are subject to approval of the project manager.

III. Drawing approval and Commissioning Laptops

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

IV. Transport for Project Implementation Team

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

4.2.3 SPECIFIC SCOPE OF WORK FOR THIS PROJECT

4.2.3.1 General Scope

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

1. **Lot 1** - Establishment of 2 x 23MVA, 132/33kV substation and associated 132kV and 33kV Outdoor Switchgear at Salgaa town in Nakuru County. Construction of approximately 0.2Km in LILO of 2No. 132 kV circuits in overhead line in 175mm^2 ACSR conductor, and construction of 35km of 33kV Overhead lines in 150mm^2 ACSR conductor

2. **Lot 2** - Establishment of 2 x 23MVA, 132/33kV substation and associated 132kV and 33kV Outdoor Switchgear at Kathwana town in Tharaka Nithi County. Construction of approximately 10Km in LILO of 2No. 132kV circuits in overhead line in 175mm^2 ACSR conductor, and construction of 60km of 33kV Overhead lines in 150mm^2 ACSR conductor

3. **Lot 3** - Establishment of 2 x 23MVA 66/11kV substation and associated 66kV and 11kV Indoor Switchgear panels at Kiserian town in Kajiado County. Construction of approximately 13Km of 66kV overhead double circuit line in 300mm^2 AAAC conductor, Laying of 1.0km of 11kV 3Core 300mm^2 AL cables, and construction of 40km of 11kV Overhead lines in 150mm^2 ACSR conductor.

4.2.3.2 Lot 1 - Rongai 2 x 23MVA 132/33kV Substation and Associated Lines

The scope of 132/33 kV substation electrical and civil works shall include but not limited to main activities summarised below:

1) Establishment of 2 x 23 MVA 132/33kV substation complete with Switchgear Building, Control, Protection and SAS systems.
2) Construction of approximately 0.1km of 3 -Phase 132 kV double circuit in 175 mm^2 ACSR conductor complete with OPGW. The line shall be constructed on lattice towers.
3) Construction of 4 Nos. 132kV Line bays in LILO formation and 2Nos. 132/33kV Transformer Bays complete with associated Switchgear and Control & Protection Panels.
4) Construction of 132kV double bus bar with 1x132kV Bus Coupler Bay complete with associated switchgear, control & protection panels.
5) Construction of 2Nos. 33kV Transformer incomer Bays complete with associated Switchgear and Control & Protection Panels.
6) Construction of 33kV Busbars and 8No. of 33kV line bays complete with associated Switchgear and Control & Protection Panels.
7) Construction of a total of 0.4km of 48 cores single mode OPGW on new 132kV lines.
8) Construction of 3Kms of 3Phase 3/C, 300mm^2 XLPE 33kV cable circuit complete with transition structure and associated accessories.
9) Construction of approximately 35 km of 33 kV 3-Phase overhead circuits in 150 mm^2 ACSR conductor complete with OPGW.
10) Installation of telecommunication system at proposed Rongai substation. The system shall match existing telecommunication network systems.
11) Installation of AC and DC Auxiliary systems
12) Installation and commissioning of outdoor and indoor bay equipment
13) Construction of Chain Link fence to demarcate HV switchyard from open areas

14) Installation of substation lighting and lightning protection.
15) Construction of Control Room building as per Civil Works Particular technical specification with a minimum floor area of 350 Sqr. Meter.
16) Construction of a commercial office room as per Civil Works Particular technical specification with a minimum floor area of 50 Sqr. Meter.
17) Construction of transformer Plinths and equipment foundations
18) Construction of chain link fence for the whole substation plot that measures approximately 5 Acres. The substation shall have three main gates two for live switchyard and the other for Office /Stores.
19) Construction of guard house with washrooms
20) Construction of 5.0 m substation internal access roads.
21) Establishment of substation switchyard complete with drainage, cable trenches and other associated services.
22) Rainwater-harvesting system with ground mounted 10,000 Liters water tank and elevated 5,000 lts water tank.
23) Construction of murram all-weather 9.0 m wide external access road, approximately 250 m long from substation to the main tarmac road.

4.2.3.2.1 Bill of Quantities for Rongai 2 x 23 MVA 132/33 kV Substation and Lines

Item	Materials and Equipment Description	Unit	Qty
RNG–101	2 X 23 MVA, 132/33 kV transformers with Online Monitoring System and Condition Controlled Maintenance Free Breather	Lot	2
RNG–102	132kV Circuit Breaker - Single Pole Mechanism	Pc	4
RNG–103	132kV Circuit Breaker – 3 Pole Ganged Mechanism	Pc	3
RNG–104	132kV Motorized Isolator Without E/SW	Pc	14
RNG–105	132kV Motorized Isolator with E/SW	Pc	4
RNG–106	132kV Current Transformer	Pc	21
RNG–107	132kV Voltage Transformer	Pc	18
RNG–108	132kV Bay and Double Bus bar Materials	Lot	1
RNG–109	132kV Surge Arresters	Pc	18
RNG–110	132 kV Steel Structures for Gantries, Double Bus bar, Equipment support	Lot	1
RNG–111	Transformer Protection Relay Panels (HV and MV)	Pc	4
RNG–112	Transformer Control Panel with AVR Relay	Pc	2
RNG–113	132kV Line Protection Relay Panel (Main 1 & Main 2)	Pc	4
RNG–114	132kV Line Control Panel	Pc	2
RNG–115	132kV Bus bar Protection Relay Panel	Pc	1
RNG–116	33 kV Neutral Current transformer with an Isolating Link	Pc	2
RNG–117	33 kV Surge Arresters	Pc	30
RNG–118	Auxiliary transformer 200 kVA, 33/0.415 kV complete with power cables, surge arrestors and Drop Out fuses	Lot	2
RNG–119	33kV Circuit Breaker	Pc	10
RNG–120	33kV Motorized Isolator Without E/Switch	Pc	11
RNG–121	33kV Motorized Isolator with E/Switch	Pc	8
RNG–122	33kV Current Transformer	Pc	30
RNG–123	33kV Voltage Transformer	Pc	30
RNG–124	33 kV Bay and Bus bar Materials	Lot	1

RNG–125	33 kV Steel Structures for Gantry, Double Bus bar, Equipment support	Lot	1
RNG–126	33 kV Surge Arresters	Pc	30
RNG–127	Substation Automation and Control system (SAS)	Lot	1
RNG–128	Control and measuring cables	Lot	1
RNG–129	3-Phase AC auxiliary supply system and distribution board	Lot	1
RNG–130	110VDC Lithium-Ion Battery System with minimum capacity of 265Ahr	Lot	2
RNG–131	48VDC Lithium-Ion Battery System with minimum capacity of 165Ahr	Lot	2
RNG–132	DC supply distribution system	Lot	1
RNG–133	Substation Earthing and Lightning protection system	Lot	1
RNG–134	Switchyard Lighting System	Lot	1
RNG–135	Telecommunication system and associated accessories capable of integration with existing Telecom system and Tele-protection schemes.	Lot	1
RNG–136	Fire Detection and Suppression System	Lot	1
LINE MATERIALS			
RNG–137	Terminal Lattice towers and associated fittings	Lot	2
RNG–138	132kV 3-Phase O/Head Double circuit in 175mm^2 ACSR complete with fittings, insulators and associated line hardware in lattice towers	Lot/km	1
RNG–139	33 kV 3-Phase O/Head circuits in 150 mm^2 ACSR conductors, insulators, fittings and associated line hardware	Lot/km	35
RNG–140	33kV Cable (33 kV 3/Core, 300 mm^2 Al cables)	Lot/Km	3
RNG–141	33kV cable termination kits (33 kV 3/Core, 300 mm^2 Al cables) complete with transition structure and surge arrestors	Lot/pc	16
RNG–142	OPGW cable complete with fittings and associated Accessories for 132KV line and 33KV lines	Lot/km	36
RNG–143	Approach FO cable (Underground) complete with fittings and associated accessories	Lot/km	3
RNG–144	Fiber Optic splice Boxes and ODFs	Lot	1
RNG–145	Materials for transfer/dualling and adoption of existing 33/11/0.45kV lines and 5 No. of Distribution Substations to new lines	Lot/km	5
RNG–146	Supply 33kV ABS switches/Line Isolators with necessary hardware and fittings	Lot/pc	5
RNG–147	Concrete poles and their fittings	Lot/km	35
RNG – 148	Ancillary Equipment	Lot	1
Substation and Line Design work			
RNG-301	Substation Engineering design (Electrical, Mechanical, Civil, Control/protection, Telecommunication and SAS systems)	Lot	1

RNG-302	Coordination of relay settings and integration of protection & Control with existing system	Lot	1
RNG-303	132kV Route Survey and Line Engineering design	Lot	1
RNG-304	33kV route survey and line design	Lot	1
Substation Civil and Installation Work			
RNG–401	Transformer plinth with BOT and Oil separator	Lot	1
RNG–402	Switchgear building with a minimum floor area of 350 sqr. meter	Lot	1
RNG–403	Construction of a commercial office room with a minimum floor area of 50 Sqr. Meter.	Lot	1
RNG–404	Construction of guard house with washrooms	Lot	1
RNG–406	Platform Works – Substation equipment foundations and associated works	Lot	1
RNG–411	Substation perimeter chainlink fence for approximately Five-acre plot, with razor wire, electric fence and three main gates	Lot	1
RNG–415	LV and Control cable installation works	Lot	1
RNG–417	Substation lighting, Earthing and lightning protection	Lot	1
RNG–420	Substation equipment installation and commissioning	Lot	1
Line Work			
	Construction of 3 -Phase 132 kV double circuit (LILO) with OPGW on lattice towers.	Lot/km	2
	Construction of 33 kV 3-Phase overhead circuits complete with OPGW.		35
	Installation of 33kV Underground feeder cable	Lot/km	3
Factory acceptance test (FAT)			
	All Major Equipment	Lot	1
Training			
	Substation Design Principles, Transmission Line & Tower designs, Control and Protection, SCADA and Telecommunications	Lot	1

4.2.3.3 Lot 2 - Kathwana 2 x 23 MVA 132/33 kV Substation and Associated Lines

The scope of 132/33 kV substation electrical and civil works shall include but not limited to main activities summarised below:

1) Establishment of 2 x 23MVA 132/33kV substation complete with Switchgear Building, Control, Protection and SAS systems. The transformer shall have an online monitoring system and condition-controlled maintenance free breather.
2) Construction of approximately 10km of 3 -Phase, 132kV double circuit in 175mm^2 ACSR conductor complete with OPGW. The line shall be constructed on lattice towers.
3) Construction of 2Nos. 132kV Line bays in LILO formation and 2Nos. 132/33kV Transformer HV Bays complete with associated Switchgear and Control & Protection Panels.
4) Construction of 1x132kV Bus Section Isolator and Busbar protection panel.
5) Construction of 2Nos. 132/33kV Transformer MV Bays complete with associated Switchgear and Control & Protection Panels.
6) Construction of 33kV Busbar and 8No. of 33kV line bays complete with associated Switchgear and Control & Protection Panels.
7) Construction of a total of 12km of 48 cores single mode OPGW on new 132kV lines.
8) Construction of 1Km of 3Phase 3/C, 300mm^2 XLPE 33kV cable circuit complete with transition structures and associated accessories.
9) Construction of approximately 60 km of 33 kV 3-Phase overhead circuits in 150 mm^2 ACSR conductor complete with OPGW.
10) Installation of telecommunication system at proposed Kathwana substation. The system shall match existing telecommunication network systems.
11) Supply & installation of AC and DC Auxiliary systems
12) Installation and commissioning of outdoor and indoor bay equipment
13) Construction of Chain Link fence to demarcate HV switchyard from open areas
14) Installation of substation earthing, lighting and lightning protection.
15) Construction of Control Room building as per Civil Works Particular technical specification with a minimum floor area of 350 Sqr. Meter.
16) Construction of transformer plinths (23MVA) and equipment foundations
17) Construction of chain link fence for the whole substation plot that measures approximately 3 Acres. The substation shall have two main gates.
18) Construction of guard house with washrooms
19) Construction of 5.0 m substation internal access roads.
20) Establishment of substation switchyard complete with drainage, cable trenches and other associated services.
21) Rainwater-harvesting system with ground mounted 10,000 Liters water tank and elevated 5,000 Liters water tank.
22) Improvement of the existing 9m wide external murram access road, including construction of culverts/drifts and drainage, widening and improve of the road junction at Kamutiria town, at an approximate length of 900m from substation to the main tarmac road.
23) Recovery of the existing switching station materials and equipment to the nearest KPLC Stores

4.2.3.3.1Bill of Quantities for Kathwana 2 x 23 MVA 132/33 kV Substation and Lines

Item	Materials and Equipment Description	Unit	Qty
			Qty
KTH-101	2 X 23 MVA, 132/33 kV transformers with Online Monitoring System and Condition Controlled Maintenance Free Breather	Lot	2
KTH-102	132kV Circuit Breaker - Single Pole Mechanism	Pc	2
KTH-103	132kV Circuit Breaker – 3 Pole Ganged Mechanism	Pc	2
KTH-104	132kV Motorized Isolator Without E/SW	Pc	5
KTH-105	132kV Motorized Isolator with E/SW	Pc	2
KTH-106	132kV Current Transformer	Pc	12
KTH-107	132kV Voltage Transformer	Pc	12
KTH-108	132kV Bay and Bus bar Materials	Lot	1
KTH-109	132kV Surge Arresters	Pc	12
KTH-110	132Kv Steel Structures for Gantry, Bus bar, Equipment and Power cable support	Lot	1
KTH-111	Transformer Protection Relay Panels (HV and MV)	Pc	4
KTH-112	Transformer Control Panel with AVR Relay	Pc	2
KTH-113	132kV Line Protection Relay Panel (Main 1 & Main 2)	Pc	4
KTH-114	132kV Line Control Panel	Pc	2
KTH-115	132kV Bus bar Protection Relay Panel	Pc	1
KTH-116	33 kV Neutral Current transformer with an Isolating Link	Pc	2
KTH-117	33 kV Surge Arresters	Pc	30
KTH-118	Auxiliary transformer 200 kVA, 33/0.415 kV complete with power cables, surge arrestors and Drop Out fuses	Lot	2
KTH-119	33kV Circuit Breaker	Pc	10
KTH-120	33kV Motorized Isolator Without E/Switch	Pc	11
KTH-121	33kV Motorized Isolator with E/Switch	Pc	8
KTH-122	33kV Current Transformer	Pc	30
KTH-123	33kV Voltage Transformer	Pc	30
KTH-124	33 kV Bay and Bus bar Materials	Lot	1
KTH-125	33kV Steel Structures for Gantry, Bus bar, Equipment and Power cable support	Lot	1
KTH-126	33 kV Surge Arresters	Pc	30
KTH-127	Substation Automation and Control system (SAS)	Lot	1
KTH-128	Control and measuring cables	Lot	1
KTH-129	3-Phase AC auxiliary supply system and distribution board	Lot	1
KTH-130	110VDC Lithium-Ion Battery System with minimum capacity of 265Ahr	Lot	2
KTH-131	48VDC Lithium-Ion Battery System with minimum capacity of 165Ahr	Lot	2
KTH-132	DC supply distribution system	Lot	1
KTH-133	Substation Earthing and Lightning protection system	Lot	1

KTH-134	Switchyard Lighting System	Lot	1
KTH-135	Telecommunication system and associated accessories capable of integration with existing system and Tele-protection schemes.	Lot	1
KTH-136	Fire Detection and Suppression System	Lot	1
LINE MATERIALS			
KTH-137	Double circuit Lattice towers and associated fittings	Lot/Km	10
KTH-138	132kV 3-Phase O/Head **Double circuit** in 300mm^2 ACSR complete with fittings, insulators and associated line hardware in lattice towers	Lot/km	10
KTH-139	33 kV 3-Phase O/Head circuits in 150 mm^2 ACSR conductors, insulators, fittings and associated line hardware	Lot/km	60
KTH-140	33kV cable termination kits (33 kV 3/Core, 300 mm^2 Al cables) complete with transition structure and surge arrestors	Lot/pc	16
KTH-141	33kV Cable (33 kV 3/Core, 300 mm^2 Al cables)	Lot/Km	2
KTH-142	Aerial Earth Wire (7/14SWG) complete with fittings and associated accessories	Lot/Km	10
KTH-143	OPGW cable complete with fittings and associated Accessories for 132KV line and 33KV lines	Lot/km	70
KTH-144	Approach FO cable (Underground) complete with fittings and associated accessories	Lot/km	2
KTH-145	Fiber optic splice Boxes and ODFs	Lot	1
KTH-146	Materials for transfer/dualling and adoption of existing 33/11/0.45kV lines and Distribution Substations to new lines	Lot/km	5
KTH-147	Supply 33kV ABS switches/Line Isolators with necessary hardware and fittings	Lot/pc	8
KTH-148	Concrete poles and their fittings	Lot/km	60
KTH – 149	Ancillary equipment		
Substation and Line Design work			
	Substation Engineering design (Electrical, Mechanical, Civil, Control/protection, Telecommunication and SAS systems)	Lot	1
	Coordination of relay settings and integration of protection & Control with existing system	Lot	1
	132kV Route Survey and Line Engineering design	Lot	1
	33kV route survey and line design	Lot	1
Substation Civil and Installation Work			
	Transformer plinth with BOT and Oil separator	Lot	1
	Switchgear building with a minimum floor area of 350 sqr. meter	Lot	1
	Construction of a commercial office room with a minimum floor area of 50 Sqr. Meter.	Lot	1

	Construction of guard house with washrooms	Lot	1
	Platform Works – Substation equipment foundations and associated works	Lot	1
	Substation perimeter chainlink fence for approximately Five-acre plot, with razor wire, electric fence and three main gates	Lot	1
	LV and Control cable installation works	Lot	1
	Substation lighting, Earthing and lightning protection	Lot	1
	Substation equipment installation and commissioning	Lot	1
Line Work			
	Construction of 3 -Phase 132 kV double circuit (LILO) with OPGW on lattice towers.	Lot/km	2
	Construction of 33 kV 3-Phase overhead circuits complete with OPGW.		35
	Installation of 33kV Underground feeder cable	Lot/km	3
Factory acceptance test (FAT)			
	All Major Equipment	Lot	1
Training			
	Substation Design Principles, Transmission Line & Tower designs, Control and Protection, SCADA and Telecommunications	Lot	1

4.2.3.4 Lot 3 - Kiserian 2 x 23 MVA 66/11 kV Substation and Associated Lines

The scope of 66/11 kV substation electrical, civil and overhead line works shall include but not limited to main activities summarised below:

1) Establishment of 2 x 23 MVA 66/11kV substation complete with Switchgear Building, Control, Protection and SAS systems.
2) Construction of 3 Nos. 66kV Line bays and 2No. Transformer bays
3) Construction of approximately 13 km of 3 -Phase 66 kV double circuit in 300 mm^2 AAAC conductor complete with OPGW. The line shall be constructed on H-Poles concrete poles With installation of 3Nos Line Isolators at the tee-off points.
4) Construction of a total of 15 km of 48 core single mode OPGW on new line and 5 kms on existing Matasia 66kv line
5) Supply and Installation of 11kV Indoor metal clad Switchgear board
6) Installation of 11 kV S/core 630 mm^2 copper cable from the transformers to 11kV Indoor Switchgear board.
7) Installation of 11 kV 3/core 300 mm^2 AL cable for the feeders cable take offs, approximately 2.0 km in total length
8) Construction of approximately 40 km of 11 kV 3-Phase circuits in 150 mm^2 ACSR conductor
9) Installation of telecommunication systems at both the proposed Kiserian substation and remote source Matasia substation. The system shall match existing telecommunication network systems.
10) Installation of AC and DC Auxiliary systems
11) Installation and commissioning of bay outdoor and indoor equipment
12) Construction of Chain Link fence to demarcate HV switchyard from open areas
13) Installation of substation lighting and lightning protection.
14) Construction of Switchgear building with an extra commercial office room as per Civil Works Particular technical specification with a minimum floor area of 400 Sqr. meter
15) Construction of transformer Plinths and equipment foundations
16) Construction of masonry Perimeter wall for substation plot that measures approximately 1 Acre. The substation shall have two main gates one for live switchyard and the other for Office /Stores
17) Construction of guard house with toilets
18) Construction of 5.0 m wide substation internal access roads.
19) Establishment of substation switchyard complete with drainage, cable trenches and other associated services.
20) Establishment of materials/store yard in the remaining area of the substation plot.
21) Rainwater-harvesting system with ground mounted 10,000 Liters water tank and elevated 5,000 Liters water tank.
    Construction of a 9.0 m wide murram all-weather external access road, approximately 200 m long from substation to the main tarmac road.

4.2.3.4.1Bill of Quantities for Kiserian 2 x 23 MVA 66/11 kV Substation and Lines

NO	Materials and Equipment Description	Unit	Qty
Substation Equipment/Materials			
KSN - 101	23 MVA, 66/11 kV transformer	Pc	2
KSN - 102	66kV Circuit breakers	Pc	5
KSN - 103	66kV motorized Isolators with Earth switch	Pc	3
KSN - 104	66kV motorized Isolators without Earth switch	Pc	7
KSN - 105	66kV Current Transformer	Pc	15
KSN - 106	66kV Voltage Transformer	Pc	15
KSN - 107	66kV kV Bay and Bus bar materials	Lot	1
KSN - 108	Steel Structures for Gantry, Bus bar, equipment and Power cable support	Lot	1
KSN - 109	66kV Surge arrestors with surge counters	Pc	15
KSN - 110	Transformer Protection Panels	Pc	2
KSN - 111	Transformer Bay Control Panel with Voltage regulating IED (AVR)	Pc	2
KSN - 112	66kV Line Control and Protection panel	pc	3
KSN - 113	66kV Bus bar Control and Protection panel	pc	1
KSN - 114	11 kV Neutral CT with isolating link and associated accessories	pc	2
KSN - 115	11 kV Surge Arresters for six circuits	Pc	30
KSN - 116	Auxiliary transformer 100 kVA, 11/0.415 kV complete with supply power cable between the board and Tx. complete with termination kits	Lot	2
KSN - 117	11kV Switch Board Panel for Auxiliary transformers	Pc	2
KSN - 118	11kV Switch Board Panel for feeders	Pc	8
KSN - 119	11kV Switch Board Panel for Bus section and Bus riser for switchgear Board	Lot	2
KSN - 120	11kV Switch Board Panel for transformer Incomers	Pc	2
KSN - 121	11kV S/Core, 630mm2 Copper Cables between transformer and switchgear board, Complete with indoor and outdoor terminations kits	Lot	1
KSN - 122	11kV cable termination kits (11 kV 3/Core, 300 mm^2 Al cables) on both end of 8 Nos. of Cable circuits (Indoor and Outdoor)	Set	16
KSN - 123	11kV 3/Core, 300 mm^2 AL cable for feeder outs	Lot/km	2
KSN - 124	Substation Automation and Control system (SAS)	Lot	1
KSN - 125	Telecommunication system and associated accessories capable of integration with existing system at Kiserian and remote end	Lot	2
KSN - 126	AC and DC Distribution boards and auxiliary system	Lot	1
KSN - 127	110VDC (Lithium Ion) System with minimum capacity of 265 Ahr and Charger	Lot	1
KSN - 128	48VDC (Lithium-Ion) System with minimum capacity of 165 Ahr and Charger	Lot	1

KSN - 129	Control and measuring cables	Lot	1
KSN - 130	Substation Earthing and Lightning protection system	Lot	1
KSN - 131	Switchyard lighting system	Lot	1
KSN - 132	Substation fire protection system	Lot	1
Line Materials			
KSN - 133	66 kV 3-Phase O/H Double circuit in 300mm^2 AAA Conductor complete with Line fittings, Insulators and associated line hardware	Lot/km	13
KSN - 134	11 kV 3-Phase O/H circuits in 150 mm^2 ACSR conductors, insulators, Line fittings and associated line hardware	Lot/km	40
KSN - 135	OPGW cable complete with fittings and associated accessories	Lot/km	20
KSN - 136	ADSS FO Cable complete with fittings and associated Accessories	Lot/km	5
KSN - 137	Fibre optic splice Boxes and ODFs at Kiserian and remote source	Lot	1
KSN - 138	Underground fibre approach cable with fittings at Kiserian and remote source	Lot	1
KSN - 139	Materials for transfer/dualling and adoption of existing 33/11/0.45kV lines and 5No. Distribution substations to new lines	Lot/km	5
KSN - 140	Supply of 6Nos.11kV Line Isolators complete with hardware accessories	Lot	1
KSN – 141	Supply of 3Nos. 66 kV Line Isolators complete with hardware accessories	Lot	1
KSN - 141	Concrete Pole fittings, stay wire and Accessories	Lot/km	66
KSN – 142	Ancillary equipment	Lot	1
Substation and Line Design work			
KSN-301	Substation Engineering design (Electrical, Mechanical, Civil, Control/protection, Telecommunication and SAS systems)	Lot	1
KSN-302	Coordination of relay settings including Source substation	Lot	1
KSN-303	66 kV route survey and line design	Lot	1
KSN-304	11kV route survey and line design	Lot	1
Substation Civil and Installation Work			
	Transformer plinth with BOT and Oil separator	Lot	1
	Control room building with an internal commercial office, and a minimum floor area of 400 sqr. meter	Lot	1
	Platform Works – Substation equipment foundations and associated works	Lot	1
	Substation perimeter masonry wall for entire plot, with razor wire, electric fence and two main gates	Lot	1
	Substation equipment installation and commissioning	Lot	1
Line Work			

	Construction of 66 kV double circuit overhead line Civil work, pole erection and dressing with OPGW	Lot/km	13
	Installation and Commissiong of 11kV feeder out	Lot/km	40
Factory acceptance test (FAT)			
	All Major Equipment	Lot	1
Overseas training			
	Substation Design Principles, Transmission Line & Tower designs, Control and Protection, SCADA and Telecommunications	Lot/Pax	10

4.2.3.5 ESHS Activities for the Substation and Associated Lines

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

Cost of ESHS activities shall be deemed to have been included in the pricing of substation and lines works. No separate price schedule is required for ESHS scope.

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

4.3 GUARANTEED TECHNICAL PARTICULARS FOR EQUIPMENTS AND MATERIALS

4.3.1 Preamble

4.3.1.1 The Guaranteed Technical Particulars Schedules MUST be filled in, signed and stamped by manufacturer for each LOT and submitted with the bidding document. Type test reports and Certificate of Accreditation from testing body/Laboratory MUST be provided for evaluation. Also, all relevant manufacturer's equipment technical documents MUST be provided for reference to support the guaranteed values.

4.3.1.2 Bidder shall offer only one type of equipment/material for each of the equipment/material required and from ***one manufacturer only.*** No more than one equipment/material of each type required shall be offered from more than one manufacturer. Where the bidder offers more than one equipment/material of one type from different manufacturers contrary to this clause, the employer shall choose ***only one of the equipment for evaluation***. All other equipment shall not be considered.

4.3.1.3 Only guaranteed technical particulars provided herein shall be filled **(*Do not fill technical guarantees in the attachments of KPLC material specifications).***

4.3.1.4 All data entered in the Guaranteed Technical Particulars are guaranteed values by the manufacturer and shall not be departed from whatsoever.

SCHEDULE 1: GUARANTEED TECHNICAL PARTICULAR - PHASE CONDUCTOR

GURANTEES FOR PHASE LINE CONDUCTOR			Guaranteed Value		Ref. Doc
Item	**Particulars**	**Unit**	**150mm^2 ACSR**	**175mm^2 ACSR**	
1	**Phase Stranded conductor**				
	Manufacturer and Country of manufacture				
	Year of service outside the country of manufacture (5 years Minimum)	Years			
	Manufacturing experience (7 years minimum)	Years			
	Type of Conductor/Code Name	State			
	Reference IEC/BS Standards	State			
	Type test reports and Accreditation certificate	State			
	Aluminium wire	Nos/mm			
	Steel wire	Nos/mm			
	Overall conductor diameter	mm			
	Nominal cross-sectional area of conductor	mm^2			
	Minimum current rating	A			
	Cross-section of Aluminium area	mm^2			
	Cross-section of Steel area	mm^2			
	Weight per km	kg			
	Rated tensile strength	KN			
	Maximum DC resistance at 20 ^oC	Ω/m			
	Maximum AC resistance at 75 ^oC	Ω/m			
	Resistivity at 20 ^oC	mm^2/m			
	Continuous max. operating temperature	^oC			
	Modulus of Elasticity	kg/mm^2			
	Conductor lay	state			
	Minimum weight of grease	Kg/km			
	Length of conductor per drum	m			
	Approximate net weight per drum	kg			
2	**Individual wires before stranding**				
	Tolerance of diameter of Aluminium wire	%			
	Tolerance of diameter of Steel wire	%			
	Minimum tensile strength of Al. wire	kg/mm^2			
	Minimum tensile strength of Steel wire	kg/mm^2			
	Conductivity of AL	%			
	Minimum twisting number of steel wire: -100 x diameter (length)	Nos.			
	Galvanization: - Min. coating weight of Zinc	grams/m^2			

SCHEDULE 2: GUARANTEED TECHNICAL PARTICULARS - OUTDOOR CIRCUIT BREAKERS (Single Pole for 132kV Line CB and Ganged for 132KV Transformer CB)

GURANTEES FOR OUTDOOR CIRCUIT BREAKERS			Guaranteed Values		Refer. Doc
Item	**Particular Specifications**	**Unit**	**132 KV**	**33kV**	
1	Circuit Breakers type (Model)	State			
2	Manufacturer and Country	State			
3	Reference IEC/BS Standards	State			
4	Year of service outside the country of manufacturer (5ears minim)	Years			
	Manufacturing experience (10 years minimum)	Years			
5	Operating service conditions (Altitude and temperature)	State			
6	Type test reports and Accreditation certificate	State			
7	Arc quenching Medium	State			
8	Pole design operation (ganged)	State			
9	Tank design type	State			
10	Highest rated voltage	kV			
11	Nominal rated Voltage	kV			
12	Rated frequency	Hz			
13	Rated continuous current at 40 ^{o}C	A			
14	Lightning Impulse withstand voltage 1.2/50µs	kVpeak			
15	One minute power frequency withstand voltage, dry and wet	kVrms			
	Rated short-time (short circuit) current/3sec.	kArms			
	Rated short circuit making current for 3 Sec	kApeak			
16	Maximum contact resistance of Main Contact	Ohms			
17	Rated operation Sequence	State			
18	Rated Current Breaking capacity	kApeak			
19	Bushing type	State			
20	First pole to clear factor	State			
21	Minimum creepage distance of Insulator	mm			
22	Minimum clearance between phases	mm			
23	Minimum clearance to Earth	mm			
24	Opening time	State			
25	Closing time	State			
26	Operating mechanism type	State			
27	Rated control voltage Tripping/Closing coil	Vdc			
28	Spring charging motor/Control voltage	Vdc			

29	Main contact material	State			
30	Charging spring status indication	State			
31	Terminal connector material (Tinned Bi-metallic)	State			
32	Number of Auxiliary contacts (NO and NC)	No			
33	Minimum Operations permissible before maintenance	No			
34	Manual ON and OFF operation Switch	State			
35	Anti-Pumping device	State			
36	Auxiliary supply (Single phase)	State			
37	Circuit Breaker Position Indication	State			
38	Heaters and Hygrometer	State			
39	Mechanical Trip/Close device	State			
40	Control cubicle IP Class	State			
41	Control cubicle powder coating colour shade	State			

SCHEDULE 3A: GUARANTEED TECHNICAL PARTICULAR FOR ISOLATORS WITH EARTH SWITCH

Item	Particular Specifications	Unit	Guaranteed Value		Refer. Doc
			132 KV	33KV	
1	Disconnector type/Model	State			
2	Manufacturer and country	State			
3	Disconnector design type (Double side break and horizontally opening)	State			
4	Operating service conditions (Altitude and temperature)	State			
5	Reference Standards	State			
6	Type test reports and Accreditation certificate	State			
7	Manufacturing experience (10 years minimum)	Years			
8	Years of service outside country of manufacture (5 years min)	Years			
9	Rated Voltage	kV			
10	Nominal voltage	kV			
11	Lightening Impulse withstands voltage 1.2/50ms				
	Contacts Closed	kV peak			
	Contacts Open	kV peak			
12	Rated Power frequency Voltage withstand (Wet and dry)				
	Contacts Closed	kVrms			
	Contacts Open	kVrms			
13	Rated frequency	50 Hz			
14	Rated Continuous operating current	Amps			
15	Rated short circuit withstand current for 3 seconds	KA/3Sec			
16	Minimum creepage distance of Insulators	mm			
17	Mechanical endurance (Min. Open–Close)	Cycle			
18	Maximum open and Closing time	Seconds			
19	Drive mechanism Motor protection	State			
20	Contact resistance of Main contacts	micro-Ω			
21	Main contact material (Tinned Copper)	State			
22	Thickness of Silver/Tin coating	microns			
23	Isolator Mechanical handle	State			
24	Electrical and mechanical operations before maintenance	State			
25	Motor Control Voltage	Vdc			
26	Auxiliary supply (Single phase)	Vac			
27	Integral earths Switch where required	State			

Item	Particular Specifications	Unit	Guaranteed Values		Refer. doc.
28	Earth switch Mechanical and electrical operation before maintenance	State			
29	Earth Switch mechanical handle	Provide			
30	Isolator and Earth switch mechanical interlock (Available /Not available)	State			
	Isolator and Earth switch Electrical interlocks (Available/not Provided)	State			
31	Minimum no. of spare Auxiliary NO and NC contacts	Nos			
32	Control Box IP degree of protection	State			
33	Padlocking facility required	State			
34	Thickness of zinc galvanization of ferrous parts	State			
35	Earthing points	State			
36	Insulator material (Brown glazed porcelain)	State			

SCHEDULE 3B: GUARANTEED TECHNICAL PARTICULAR FOR ISOLATORS WITHOUT EARTH SWITCH

Item	Particular Specifications	Unit	Guaranteed Value		Refer. Doc
			132 KV	33KV	
1	Disconnector type/Model	State			
2	Manufacturer and country	State			
3	Disconnector design type (Double side break and horizontally opening)	State			
4	Operating service conditions (Altitude and temperature)	State			
5	Reference Standards	State			
6	Type test reports and Accreditation certificate	State			
7	Manufacturing experience (10 years minimum)	Years			
8	Years of service outside country of manufacture (5 years min)	Years			
9	Rated Voltage	kV			
10	Nominal voltage	kV			
11	Lightening Impulse withstands voltage 1.2/50ms				
	Contacts Closed	kV peak			
	Contacts Open	kV peak			
12	Rated Power frequency Voltage withstand (Wet and dry)				
	Contacts Closed	kVrms			
	Contacts Open	kVrms			
13	Rated frequency	50 Hz			
14	Rated Continuous operating current	Amps			
15	Rated short circuit withstand current for 3 seconds	KA/3Sec			
16	Minimum creepage distance of Insulators	mm			
17	Mechanical endurance (Min. Open–Close)	Cycle			
18	Maximum open and Closing time	Seconds			
19	Drive mechanism Motor protection	State			
20	Contact resistance of Main contacts	micro-Ω			
21	Main contact material (Tinned Copper)	State			
22	Thickness of Silver/Tin coating	microns			
23	Isolator Mechanical handle	State			
24	Electrical and mechanical operations before maintenance	State			
25	Motor Control Voltage	Vdc			
26	Auxiliary supply (Single phase)	Vac			
27	Integral earths Switch where required	State			

Item	Particular Specifications	Unit	Guaranteed Values		Refer. doc.
28	Earth switch Mechanical and electrical operation before maintenance	State			
29	Earth Switch mechanical handle	Provide			
30	Isolator and Earth switch mechanical interlock (Available /Not available)	State			
	Isolator and Earth switch Electrical interlocks (Available/not Provided)	State			
31	Minimum no. of spare Auxiliary NO and NC contacts	Nos			
32	Control Box IP degree of protection	State			
33	Padlocking facility required	State			
34	Thickness of zinc galvanization of ferrous parts	State			
35	Earthing points	State			
36	Insulator material (Brown glazed porcelain)	State			

SCHEDULE 4A: GUARANTEED TECHNICAL PARTICULAR - OUTDOOR CURRENT TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Values		Refer doc.
			132 KV Line	132kV TX	
1	Current transformer type (Oil-hermetically sealed)	State			
2	Manufacturer and Country	State			
	Manufacturing experience (10 years minimum)	Years			
3	Service operating conditions (Altitude/Temperature)	State			
4	Years of service outside country of manufacture (5 years min.)	Years			
5	Type test reports and Accreditation certificate	State			
6	Reference IEC/BS standards	State			
7	Rated Highest voltage	kV			
8	Nominal Voltage	kV			
9	Current transformer tank design type (Dead tank)	State			
10	Rated frequency	Hz			
11	One-minute Power frequency Voltage withstand				
a	Primary winding	kVrms			
b	Secondary winding Insulation level	kVrms			
12	Lightning impulse withstand voltage 1.2/50µms	kVpeak			
13	Primary Rated currents ratios	A			
14	Rated secondary current	A			
15	CTs Core, Class and Burden	Core 1 Core 2 Core 3 Core 4			
16	Short circuit withstand current for 3seconds	kA peak			
17	Safety factor	State			
	Instrument Security factor	State			
18	Maximum Temperature rise (Winding/Oil)	State			
19	Number of cores	No			
20	Primary and Secondary winding material	State			
21	Primary terminal material	State			
22	Bushing type	State			
23	Minimum creepage distance of insulator	mm			
24	Secondary and Primary Earthing points	State			
25	IP Class of terminal box	State			
26	Marking/Labelling	State			

SCHEDULE 4B: GUARANTEED TECHNICAL PARTICULAR - OUTDOOR CURRENT TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Values		Refer doc.
			33kV Line	33KV TX	
1	Current transformer type (Oil-hermetically sealed)	State			
2	Manufacturer and Country	State			
	Manufacturing experience (10 years minimum)	Years			
3	Service operating conditions (Altitude/Temperature)	State			
4	Years of service outside country of manufacture (5 years min.)	Years			
5	Type test reports and Accreditation certificate	State			
6	Reference IEC/BS standards	State			
7	Rated Highest voltage	kV			
8	Nominal Voltage	kV			
9	Current transformer tank design type (Dead tank)	State			
10	Rated frequency	Hz			
11	One-minute Power frequency Voltage withstand				
a	Primary winding	kVrms			
b	Secondary winding Insulation level	kVrms			
12	Lightning impulse withstand voltage 1.2/50µms	kVpeak			
13	Primary Rated currents ratios	A			
14	Rated secondary current	A			
15	CTs Core, Class and Burden	Core 1 Core 2 Core 3 Core 4			
16	Short circuit withstand current for 3seconds	kA peak			
17	Safety factor	State			
	Instrument Security factor	State			
18	Maximum Temperature rise (Winding/Oil)	State			
19	Number of cores	No			
20	Primary and Secondary winding material	State			
21	Primary terminal material	State			
22	Bushing type	State			
23	Minimum creepage distance of insulator	mm			
24	Secondary and Primary Earthing points	State			
25	IP Class of terminal box	State			
26	Marking/Labelling	State			

SCHEDULE 5A: GUARANTEED TECHNICAL PARTICULARS - 132kV OUTDOOR VOLTAGE TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Value	Refer. doc.
			132 KV	
1	Voltage transformer type	State		
2	Manufacturer and Country	State		
	Manufacturing experience (10 years minimum)	Years		
3	Years of service outside country of manufacture (5 years Min.)	Years		
	Service operating conditions (Altitude and temperature)	State		
4	Type test reports and Accreditation certificate	State		
5	Reference IEC/BS standards	State		
6	Rated Highest voltage	kV		
7	Nominal Voltage	kV		
8	Voltage transformer tank design type	State		
9	Rated frequency	Hz		
10	One-minute Power frequency Voltage withstand	State		
a	Primary winding	kVrms		
b	Secondary winding Insulation level (minimum 2.5kV)	kVrms		
11	Lightning impulse Voltage withstand at 1.2/50µs	kVpeak		
12	Short circuit withstand current for 3 Seconds	kApeak		
13	Burden and Accuracy class	State		
14	Number of cores	State		
15	Protection winding Class, Burden at 0.8Pf lagging	State		
16	Measuring winding Class and Burden at 0.8Pf lagging	State		
17	Voltage Ratio (Primary/Secondary)	State		
18	Maximum Temperature rise (Winding/Oil)	State		
19	Rated Voltage safety factor	State		
20	Instrument Security factor	State		
21	Permissible partial discharge (PD): PD test Voltage (r.m.s) = Um/√3 PD test Voltage (r.m.s) = 1.2Um√3	State		
22	Primary and secondary winding material	State		
23	Primary terminal	State		
24	Bushing type (Brown glazed porcelain)	State		
25	Minimum creepage distance	mm		
26	Secondary and Primary Earthing Point	State		
27	IP Class of terminal box	State		
28	Markings/Labelling	State		

SCHEDULE 5A: GUARANTEED TECHNICAL PARTICULARS - 33kV OUTDOOR VOLTAGE TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Value	Refer. doc.
			33 KV	
1	Voltage transformer type	State		
2	Manufacturer and Country	State		
	Manufacturing experience (10 years minimum)	Years		
3	Years of service outside country of manufacture (5 years Min.)	Years		
	Service operating conditions (Altitude and temperature)	State		
4	Type test reports and Accreditation certificate	State		
5	Reference IEC/BS standards	State		
6	Rated Highest voltage	kV		
7	Nominal Voltage	kV		
8	Voltage transformer tank design type	State		
9	Rated frequency	Hz		
10	One-minute Power frequency Voltage withstand	State		
a	Primary winding	kVrms		
b	Secondary winding Insulation level (minimum 2.5kV)	kVrms		
11	Lightning impulse Voltage withstand at 1.2/50µs	kVpeak		
12	Short circuit withstand current for 3 Seconds	kApeak		
13	Burden and Accuracy class	State		
14	Number of cores	State		
15	Protection winding Class, Burden at 0.8Pf lagging	State		
16	Measuring winding Class and Burden at 0.8Pf lagging	State		
17	Voltage Ratio (Primary/Secondary)	State		
18	Maximum Temperature rise (Winding/Oil)	State		
19	Rated Voltage safety factor	State		
20	Instrument Security factor	State		
21	Permissible partial discharge (PD): PD test Voltage (r.m.s) = Um/√3 PD test Voltage (r.m.s) = 1.2Um√3	State		
22	Primary and secondary winding material	State		
23	Primary terminal	State		
24	Bushing type (Brown glazed porcelain)	State		
25	Minimum creepage distance	mm		
26	Secondary and Primary Earthing Point	State		
27	IP Class of terminal box	State		
28	Markings/Labelling	State		

SCHEDULE 6A: GUARANTEED TECHNICAL PARTICULARS FOR COMPOSITE LINE POST INSULATORS (VERTICAL AND HORIZONTAL)

COMPOSITE INSULATORS					
Item	**Particulars Specifications**	**Unit**	**Guaranteed Value**		**Refer Doc.**
			132kV	**33kV**	
1.	Insulator type (Polymeric)	State			
2.	Design type and Service condition (Altitude and temperature)	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Manufacturing experience (10 years minimum)	Years			
6.	Year of service outside the country of manufacture (5 years minimum)	Year			
7.	Type test reports and accreditation certificate of testing laboratory	Provide			
8.	Rated Highest Voltage (kV)	kV			
9.	Nominal Voltage	kV			
10.	Minimum failing Load	KN			
11.	Pollution Category	state			
12.	Dielectric material (Silicon rubber)	state			
13.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}			
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
15.	Minimum creepage distance	mm			
16.	Nominal total height	mm			
17.	Short circuit withstand current/3sec	KA			
18.	Housing shield resistance	KΩ			
19.	Shed spacing –projection ratio	state			
	Minimum distance between sheds	mm			
20.	Creepage clearance ratio				
21.	Specified mechanical load, tension (Minimum)	kN			
22.	Material of fittings				
23.	Minimum sheath thickness	mm			
24.	Material of housing and sheds (HTV silicon)	state			
25.	Minimum distance between sheds	state			
26.	Zinc coating thickness on ferrous parts	state			
27.	Colour of final insulator housing	state			
28.	Minimum sheath thickness of Silicon	state			
29.	Number of units	No			
30.	Mounting brackets	state			

SCHEDULE 6B: GUARANTEED TECHNICAL PARTICULARS FOR COMPOSITE INSULATORS (TENSION AND SUSPENSION TYPE)

Item	Particular Specifications	Unit	Guaranteed Value				Refer Doc.
			Suspension type		Tension type		
			132KV	33 KV	132KV	33 KV	
1.	Insulator type (Polymeric)	State					
2.	Design type/Model	State					
3.	Manufacturer and Country	State					
4.	Reference IEC/BS Standards	State					
5.	Service operating condition	State					
6.	Manufacturing experience (10 yrs min.)	Years					
7.	Year of service outside country of manufacture (5yrs min.)	Year					
8.	Type test reports and Accreditation certificate	Provide					
8.	Rated highest Voltage (kV)	kV					
9.	Nominal Voltage	kV					
10.	Failing tensile load/strength	KN					
	Cantilever failing load	KN					
11.	Pollution Category	State					
12.	Dielectric material	State					
13.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}					
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}					
15.	Minimum creepage distance	mm					
16.	Insulator Housing characteristics						
	One-minute power frequency withstand voltage, 50Hz, wet and dry	kV_{rms}					
	Lighting impulse withstand voltage, 1.2/50µs wet	kV_{peak}					
17.	Short circuit withstand current for 3sec	kA					
18.	Housing shield resistance	kΩ					
19.	Permissible head load (Static)	N					
	Permissible head load (dynamic)	N					
21.	Insulator of fittings	Provide					
22.	Material of housing and sheds (HTV silicon)	State					
23.	Minimum distance between sheds	State					
24.	Zinc coating thickness of ferrous parts	State					
25.	Colour of final insulator housing	State					
26.	Minimum sheath thickness of Silicon	State					

SCHEDULE 6C: GUARANTEED TECHNICAL PARTICULARS FOR SUBSTATION POST INSULATORS

Item	Particular Specifications	Unit	Guaranteed Value		Refer Doc.
			132KV	33 KV	
	Insulator type (Porcelain for Substation)	State			
2.	Design type	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Service operating conditions (Altitude and temperature)	State			
6.	Manufacturing experience (10 years min)	Years			
7.	Year of service outside the country of manufacture (5 years min.)	Year			
8.	Type test reports and Accreditation certificate	Provide			
9.	Rated highest Voltage (kV)	kV			
10.	Nominal Voltage	kV			
11.	Maximum Mechanical failing Load	KN			
12.	Pollution Category	State			
13.	Dielectric material (Silicon rubber)	State			
14.	One-minute power frequency withstand voltage at 50 Hz, (wet and dry)	kV_{rms}			
15.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
16.	Minimum creepage distance	mm			
17.	Nominal total height	mm			
18.	Short circuit withstand current/3sec	kA			
19.	Housing shield resistance	kΩ			
20.	Shed spacing–projection ratio	state			
	Minimum distance between sheds	mm			
21.	Creepage clearance ratio	State			
22.	Cantilever failing load	kN			
23.	Maximum Puncture rated voltage	kV			
24.	Insulator of fittings	Provide			
25.	Minimum sheath thickness	mm			
26.	Material of housing and sheds	State			
27.	Minimum distance between sheds	State			
28.	Zinc coating thickness on ferrous parts	State			
29.	Colour of final insulator housing	State			

SCHEDULE 7: GUARANTEED TECHNICAL PARTICULARS FOR SURGE ARRESTORS

SURGE ARRESTORS					
Item	**Particular Specifications**	**Unit**	**Guaranteed Values**		**Refer. doc**
			132KV	**33KV**	
1	Surge arrestor type (Metal Oxide (MOV) Gapless	State			
2	Manufacturer and country of origin	State			
3	Service operating conditions (Altitude and temperature)	State			
4	Reference IEC/BS Standards	State			
5	Type test reports and Accreditation certificate	Provide			
	Manufacturers experience (10 years minimum)	Years			
6	Minimum years of service outside country of manufacture (5 years minimum)	Years			
7	Surge arrestor housing (Polymeric)	State			
8	Highest system Voltage (Um, KV)	kV			
9	Rated frequency	Hz			
10	Rated Voltage (Ur, KV)	kV			
11	Max, continuous Operating Voltage	kVrms			
12	Nominal discharge current	kA			
13	Nominal discharge current	kA			
14	Short circuit withstands current Asymmetrical peak	kA			
15	Maximum duration of Earth fault as per IEC 60099-4	Sec			
16	Long duration discharge class	A/µS			
17	Partial discharge	pC			
18	Energy discharge capability at Ur	KJ/KV			
19	Temporary Over voltage with stand for 1Sec.	kV rms			
20	Temporary Overvoltage withstand for 10 Sec.	kV rms			
22	Distribution and Discharge class	kA/Class			
23	Earth fault factor as IEC 60099-4	State			
24	Maximum response time/operation time	Micro-sec			
25	System Lightning Impulse withstand voltage 1.2/50µs	kV peak			
26	One minute System power frequency withstands Voltage, dry and wet	kV rms			
27	Short circuit current withstands	kA/3Sec.			
28	Housing shield resistance	kΩ			
29	Creepage distance	mm			
30	Maximum residual Voltage at steep lightning and switching impulse currents at;				
a	10kA (1/2µS)	State			
	40kA (80/20µS)	State			
b	500kA (30/70µS)	State			
	2kA (30/70µS)	State			
	Max. Lightning Impulse Protection Level	kVpeak			

31	Steep current impulse protection level	kVpeak			
32	Operation counter	State			
33	Leakage current meter/Indicator	State			
34	Mounting base type	State			
35	Number of units per complete insulator (1)	No			

SCHEDULE 8: GUARANTEED TECHNICAL PARTICULARS FOR DC SYSTEM

48V AND 110 VDC LITHIUM ION PHOSPHATE BATTERIES				
			110V/265Ah	**48V/165Ah**
A. GENERAL				
1	Battery type (lithium ion phosphate, prismatic, rechargeable)	*State*		
2	Manufacturer and Country	*State*		
3	Reference IEC/IEEE/UL Standards (IEC 62619, IEC 62620, IEC 62485-5, IEEE 946, UL 1973)	*State*		
	Manufacturing experience (10 years min)	*State (years)*		
4	Years of service outside the country of manufacture (5 years min)	*State (years)*		
5	Type test reports and ISO/IEC 17025 accreditation certificate of testing laboratory	*State*		
B. LITHIUM ION PHOSPHATE BATTERY UNIT				
8	Ambient operating temperature	*State (°C)*		
9	Maximum operating temperature	*State*		
10	Cell designation (nominal voltage per cell and capacity)	*State*		
11	Discharge rate type of cells as per IEC 62620 (medium rate, M)	*State (Ah)*		
12	Rated Capacity at C5 (5-hour rate) at 25°C	*State (V)*		
13	Discharge end voltage at 25±5°C	*State (no.)*		
14	Number of cells per bank	*State*		
15	Cell rated voltage	*State (V)*		
	Nominal voltage per cell	*State (V)*		
	Float / charge voltage per cell (controlled via BMS)	*State (V)*		
	Boost voltage per cell	*State (years)*		
16	Design life span (15 years minimum)	*State (cycles)*		
17	Cycle life (5000 or more full discharges with less than 10% capacity loss)	*State (A)*		
18	Nominal capacity normal charging current (maximum 0.2C5)	*State (°C)*		
19	Recommended charging voltage (per cell)	*State (°C)*		
20	Internal resistance at 25°C	*State*		

48V AND 110 VDC LITHIUM ION PHOSPHATE BATTERIES				
			110V/265Ah	**48V/165Ah**
21	Ageing coefficient	*State*		
22	Charge efficiency (97% minimum)	*State (Ah)*		
23	Operating temperature range	*State (V)*		
	a) Discharge (−20 to 60°C)	*State (no.)*		
	b) Charge (−10 to 60°C)	*State*		
	c) Storage (−30 to 75°C)	*State (V)*		
24	Cells hermetically sealed, maintenance free	*State (V)*		
25	Cell container material (stainless steel or aluminium alloy) and shape (prismatic)	*State (V)*		
26	Sealing lid attachment (laser welded)	*State (years)*		
27	Dimensional tolerance (±1% as per IEC 62620)	*State (cycles)*		
28	Overall dimensions per cell	*State (A)*		
	Height, h (max)	*State (°C)*		
	Width, d	*State*		
	Length, b (max)	*State*		
	Cell connection bolt size	*State (Ah)*		
	Approximate cell weight	*State (V)*		
29	Positive electrode material (lithium ion phosphate)	*State (no.)*		
30	Negative electrode material (graphite)	*State*		
31	Separator material (layers of polypropylene fibrous membrane)	*State (V)*		
32	Electrolyte composition (as per IEC 62619 / IEC 62620)	*State (V)*		
33	Positive terminal (aluminium) and negative terminal (nickel-plated copper)	*State (V)*		
34	Nickel-plated copper and bimetal lugs for load wiring supplied	*State (years)*		
35	Pressure relief vent / venting device	*State (cycles)*		
36	Insulating film around each cell	*State*		
37	Cell marking and labelling (manufacturer, serial no., type, date, country, voltage, Ah, polarity, 'PROPERTY OF KPLC')	*State*		

48V AND 110 VDC LITHIUM ION PHOSPHATE BATTERIES				
			110V/265Ah	**48V/165Ah**
C. BATTERY MANAGEMENT SYSTEM (BMS)				
38	BMS provided: monitors voltage, current, temperature and state of charge	*State*		
39	Under-voltage, over-voltage, over-current, short-circuit and over-temperature protection	*State*		
40	Active and passive cell balancing	*State*		
41	Battery internal resistance monitoring	*State*		
42	LCD display of cell voltage, state of charge, temperature and alarms	*State*		
43	GPS positioning and tracking function	*State*		
44	Data memory (at least 10,000 run logs, SD card, first-in first-out export)	*State*		
45	Communication protocols (RS 485, CANBUS/Modbus)	*State*		
46	Remote monitoring (SNMP and LAN) and interface to substation automation	*State*		
47	Alarm and data logging facility	*State*		
48	Parallel battery bank operation	*State*		
D. BATTERY CHARGER				
49	Charger rating: output voltage and battery bank rating served	*State*		
	DC output voltage, nominal	*State (V)*		
	Float range	*State (V)*		
	Boost range	*State (V)*		
50	Rated DC output current	*State (A)*		
51	Trickle (maintenance) current range	*State (A)*		
52	Boost current range	*State (A)*		
53	Mains type (number of phases)	*State*		
54	Mains AC voltage and permitted variation	*State*		
55	Frequency and permitted variation	*State (V)*		
56	DC output voltage regulation (±1% at float voltage, 0 to 100% load)	*State (V)*		
57	Cubicle material, vermin-proof and well ventilated (steel sheet)	*State (V)*		

48V AND 110 VDC LITHIUM ION PHOSPHATE BATTERIES				
			110V/265Ah	**48V/165Ah**
58	Cubicle mounting (floor mounted, holding down bolts)	*State (A)*		
59	Cubicle colour (dark admiralty grey, shade 632 of BS 381C) and coating thickness (80 µm min)	*State (A)*		
60	Automatic trickle and boost charging, constant current method	*State (A)*		
61	Boost charge temperature cut-off, settable timer and voltage drop detection	*State*		
62	Protection against reverse polarity and overloads	*State*		
63	Power transformer (double wound, air cooled, earth shield)	*State (V)*		
64	Alarm repeat relay (two contacts: local and SCADA)	*State (V)*		
65	Local alarm annunciator (LED/LCD, manual reset)	*State (V)*		
66	Alarms provided (charger failure, earth fault, battery low/high voltage, mains failure, boost charge failure, battery temperature cut-off)	*State (A)*		
67	Indicating instruments (ammeters, voltmeters, centre-zero ammeter)	*State (A)*		
68	Isolation switches and MCBs	*State (A)*		
E. BATTERY CABINET, ACCESSORIES AND INTER CELL CONNECTORS				
69	Cabinet material (phosphatized steel with powder epoxy acid-resistant coating)	*State*		
70	Cabinet seismic design (category D, Occupancy Category IV, 0.50g SDS, Ip 1.5 as per IBC2006)	*State*		
71	Cabinet supplied fully wired and assembled	*State*		
72	Accessories supplied (digital voltmeter, cell lifter, cell numbers, anticorrosion compound, goggles, apron, gloves to IEC 60903)	*State*		
73	Inter cell connector material (nickel-plated copper) and insulation / shrouds	*State*		
74	Connector rating (30-minute discharge current; short circuit 4 kA for 1 s)	*State*		
75	Bolts, nuts and washers material (nickel-plated or stainless steel)	*State*		

SCHEDULE 9: GUARANTEED TECHNICAL PARTICULARS FOR CONCRETE POLES

LINE CONCRETE POLES					
Item	**Particular Specifications**		**Employer's requirement**	**Guaranteed Value**	**Refer doc.**
1	Name and Address of the Manufacturer		State		
	Minimum years of manufacturing (7 years min)		State		
	Minimum years of poles service in Kenya (5 years min)		State		
	Model of the offered poles		State		
	Manufacturer's warranty and guarantee		Provide		
2	Sizes of the Poles Offered		State		
3	Reference Design Standard of manufacture		State		
4	Reference testing Standard		State		
5	Type of pole offered	Reinforced	State		
		Pre-stressed	State		
6	**Minimum poles requirement**				
a	Design Strength		State		
b	Quality of finish		State		
c	Admixture		State		
d	Mode of compaction		State		
e	Finished pole free from honeycombing		State		
7	Earthing (Conductor material size)		State		
8	Provision of Earthing Ferrules		State		
9	**Size and strength Class of poles**				
a	Pole taper		State		
b	Safety Factor		State		
c	Color of finished poles		State		
d	Manufacturing Capacity (units per month)		state		
e	Type Test Reports and Accreditation certificate		provide		
f	Type test Certificate from KBES as per ISO/IEC 17025		provide		
g	Acceptance tests to be witnessed by KPLC Engineers		List		

SCHEDULE 10: GUARANTEED TECHNICAL PARTICULARS FOR POWER TRANSFORMER

GUARANTEES FOR 23MVA 132/33KV POWER TRANSFORMERS				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
1.	Power transformer Make/Model	State		
2.	Manufacturer and Country	State		
3.	Minimum Manufacturing experience (13 years)	Years		
4	Minimum years of service outside country of origin (7 years)	Years		
5.	Design Service operation conditions (Altitude and Temperature)	State		
6.	Type test reports and accreditation certificate	Provide		
7.	Reference IEC/BS standards	State		
8.	Transformer nominal capacity	MVA		
9.	Rated voltage and Frequency	kV/Hz		
10.	Vector Group as per given region	State		
11.	Nominal Voltage	kV		
12.	One-minute Power frequency Voltage withstand, 50Hz, 60 sec, wet			
	Primary winding Insulation level	kVrms		
	Secondary winding Insulation level	kVrms		
13.	Lightning impulse withstands voltage 1.2/50µs, wet +Ve	kVpeak		
	Primary winding	State		
	Secondary winding	State		
14.	Continuous maximum rating current on Nominal and extreme tapping at ambient temperature	A		
15.	Capacity during ONAN Cooling (Maximum)	MVA		
16.	Rated No-load voltage at rated frequency on:			
17.	HV, principal tapping	kV		
	HV, Highest tapping	kV		
	HV, Lowest tapping	kV		
	LV winding	kV		
18.	Tapping ranges from principal tapping			
	HV no of plus tappings	No		
	HV no of minus tappings	No		
	Neutral positions			
	HV steps in % of rated voltage	State		
19.	No-load losses at:			
	90 % rated voltage and frequency	kW		
	100% rated voltage and frequency	kW		
	110% rated voltage and frequency	kW		
20.	No-load current at rated voltage and frequency	A		
21.	Total No load loss (Core +Stray loss) at rated current at 75^{o} C (%)	kw		
22.	Total losses at 75^{o}C on principal tapping at unity power factor and rated currents (ONAN)	Kw		
23.	Impedance at rated current and frequency at 75^{o} C			
	Positive sequence at nominal tap	%		
	Positive sequence at Max. Voltage tap	%		
	Positive sequence at Min. Voltage tap	%		
	Maximum temperature rise on continuous operation at rated			

24.	MVA for:			
	Top oil (by thermometer)	^oC		
	Windings (by resistance)	^oC		
25.	Efficiency at 75^oC on principal tapping, at unity power factor and at 0.8 pf lagging			
	120% full load	%		
	100% full load	%		
	75% full load	%		
	50% full load			
26.	Regulation at full load at 75^oC on principal tapping			
	At unity power factor:	%		
	At 0.8 power factor Lagging	%		
27.	HV, LV and Neutral windings insulation type	State		
28.	Maximum working flux density at rated voltage on principal tapping and rated frequency:	T		
29.	Core design type	State		
30.	Grade of laminated and maximum thickness	mm		
31.	Magnetizing current at nominal voltage at principal tapping	A		
32.	Maximum hot spot temperature of winding	^oC		
33.	Equivalent resistance referred to HV side	ohms		
34.	Equivalent reactance referred to HV side	ohms		
35.	Maximum current carrying capacity of bushings			
	HV bushings	A		
	LV bushings	A		
36.	Maximum noise level	State		
	Transformer and tap changing equipment energized and at no-load with ONAN cooling	dB		
37.	Number of core legs	State		
38.	Type of windings:	State		
	HV	State		
	LV	State		
39.	Winding conductor material (HV/LV/Neutral)			
40.	Bushing's material (HV/LV/Neutral)	State		
41.	Principal bushing insulator materials (HV/LV/Neutral)			
42.	Creepage distance of Bushing (HV/LV)			
43.	Thickness of transformer tank (Sides/Bottom/Top)	mm		
44.	Thickness of tank paint coating	mm		
45.	Type of Gasket material and Manufacturer	state		
46.	Transformer color coating (Admiral grey)	State		
47.	Thickness of radiator plates	mm		
48.	Thickness of radiator hot dip zinc galvanizing coat	micron		
49.	Number of radiators	No		
50.	Total weight of the transformer with and without oil	kg		
51.	Inspection manholes and sizes	N0/mm		
52.	**On-load tap changer**			
53.	Model and manufacturer	state		
54	Type Vacuum (In-tank)	state		
55	Total number of tappings including principal	17		

56	Rated currents of			
57	Selector switch	A		
58	Diverter switch	A		
59	Resistors	A		
60	Driving motor power consumption	kW		
61	Driving motor (3-phase, 415Vac/50hz)	State		
62	Control cabinets with heaters	State		
63	Voltage regulating relay supply	Vdc /Vac		
64	Motor drive unit Control Voltage (230Vac/50Hz)	1-phase		
65	Paralleling circuit wired, Master–Follower Mode of operation	State		
66	RTCC Panel with AVR relay	State		
67	Overall dimensions of transformer (LXWXH)	mm		
68	Winding and Top oil temperature indicators	State		
69	Pressure relief device	State		
70	Silica gel breathers	State		
71	Buchholz relays	State		
72	Alarms and trip to be provided including;	State		
	Oil/gas flow transformer, alarm	State		
	Oil/gas flow transformer, trip	State		
	Oil gauge low level, alarm	State		
	Oil gauge low level, trip	State		
	Top oil temp. high, alarm	State		
	Top oil temp. critical, trip	State		
	Winding temp. high, alarm	State		
	Winding temp. critical, trip	State		
73	Temperature indicators required:	State		
	HV and LV winding	State		
78	Oil level gauges required	State		
	Main conservator tank	State		
79	Bushing CTS to be provided as per VOL. II Biding document works requirements	Required		

SCHEDULE 11A: ONLINE MONITORING SYSTEM FOR POWER TRANSFORMERS

Clause number	Requirement	KPLC Requirement	Guar. Value	Refer. doc
Manufacturer's Name and address		State		
Country of Manufacture		State		
Name and model Number		State		
1.	Scope	State		
2.	Normative References	State		
3.	Definitions and Abbreviations	State		
3.1.	Abbreviations	State		
4.1.	SERVICE CONDITIONS			
4.1.1	The Online Monitoring system for Power Transformer shall be suitable for use outdoors in tropical areas and harsh climatic conditions including areas exposed to:			
a)	Altitudes above sea level;	State		
b)	Humidity ;	State		
c)	Average ambient temperature	state		
d)	Pollution:	state		
4.2.	DESIGN AND CONSTRUCTION			
4.2.1.	Screening and armoring of All control , instrumentation and power cables	State		
4.2.2.	All components of the transformer (active part, bushings, cooling system) monitored by one single fan-less Intelligent Electronic Device (IED),	State		
4.2.3.	Monitoring modules for data acquisition installed at the transformer	State		
4.2.4.	support the operation and maintenance of a transformer with regard to			

Clause number	Requirement	KPLC Requirement	Guar. Value	Refer. doc
4.2.4.1	Use sensors, modeling and diagnostic functions to detect incipient faults at an early stage	State		
4.2.4.2	provide tools which enable the user to operate a transformer close to its thermal limits, with taking into account thermal aging and avoiding critical hot spot temperature.	State		
4.2.4.3.	Enable the user to perform condition-based maintenance of the transformer.	State		
4.2.4.4.	Enable the user to have an overview at a glance about the transformer by clear visualization of transformer condition by traffic lights within software user interface and with LEDs on control cubical in the field.	State		
4.2.5.	The Online Monitoring system for Power Transformer include Online Monitoring of the following parameters for Power Transformer:			
(a)	3 Gas DGA measuring Hydrogen (H2), Carbon Monoxide (CO) and Acetylene (C2H2) plus moisture	State		
(b)	Partial Discharge of the Transformer	State		
(c)	Tan Delta & capacitance of the Bushings	State		
(d)	Ambient temperature	State		
(e)	Top oil temperature	State		
(f)	Bottom oil temperature	State		
(g)	Transformer winding moisture tracking	State		
(h)	Radiator Bank Temperature monitoring	State		
4.2.6.	All equipment provided by the manufacturer shall be new, free from defects	State		
4.2.7	The Online Monitoring system for Power Transformer Combine in a single system and measure the following:			
4.2.7.1.	Partial Discharge (PD) in the transformer main tank and bushings	State		
4.2.7.2.	Relative variations of capacitance and power factor of each bushing	State		
4.2.7.3.	Three Gas contents(Hydrogen (H2), Carbon Monoxide (CO) and Acetylene(C2H2) in the insulating oils in the transformer main tank using photo- acoustic spectroscopy or NIR technology. The equipment shall measure each gas individually and give results in ppm. Moisture should also be measured in ppm.	State		

Clause number	Requirement	KPLC Requirement	Guar. Value	Refer. doc
4.2.8	The monitoring system is housed in a single IP56 acquisition box, wall or stand mounted, to be placed near the transformer.	State		
4.2.9	The Online Monitoring system for Power Transformer shall:			
(a)	Include data storage (>1 year)	State		
(b)	web-server and integrated modem	State		
(c)	be GPS free and no active electronics placed on the top of transformer	State		
(d)	be connected to SCADA or DCS using known protocols such as Modbus, DNP3 or IEC61850	State		
(e)	support RS232, RS485, Fiber optic, 3G, Ethernet carriers	State		
(f)	include 3 x LED Indicators (Power, Service, Alarm) and Alarm relay contacts	State		
4.3.	It shall have the following technical particulars			
4.3.1.	Dissolved Gas Analysis			
4.3.1.1.	Be capable of correlating 3 fault gases, moisture-in-oil, oil temperature, and ambient temperature to the transformer load	State		
4.3.1.2.	Gas Analyzing shall be on the Photo Acoustic Spectroscopy (PAS) or NIR (Near Infra-Red) Spectro-photometry or any other competing technology without the need of any consumables.	State		
4.3.1.3.	Be required to have a separate oil inlet pipe and separate oil return pipe to ensure quality of oil sampling.	State		
4.3.1.4.	Have an embedded web-server to allow remote access using any smart device (such as smart phone or tablet) based on the user providing access via Ethernet or SIM.	State		
4.3.1.5.	Not require download and install of any third party software for communication with the online DGA monitor.	State		
4.3.1.6.	Have an on board 7 inch color touchscreen HMI to allow review of data, graphs and the password protected control of settings.	State		
4.3.1.7.	Supply access to Instructions on how to take a manual oil sample accessible via the touch screen HMI	State		
4.3.1.8.	The user interface to provide the following Dissolved Gas Analysis via its 7" on board HMI			
(a)	DGA Graph Trending	State		

Clause number	Requirement	KPLC Requirement	Guar. Value	Refer. doc
(b)	DGA Instantaneous Values	State		
(c)	DGA Scheduling	State		
(d)	DGA Online Monitor Alarm Management	State		
(e)	Cross Data Trending	State		
(f)	Data Export to User device	State		
4.3.2.	Bushing Monitoring			
4.3.2.1.	Bushing monitoring by direct measurement of bushing capacitance and Tan Delta by Schering bridge principle.	State		
4.3.2.2.	Connected at the bushings Test Tap, through properly designed adaptors, including protections in order to disallow the Test Tap pin to remain floating, even with the signal cable disconnected from the adaptors.	State		
4.3.2.3.	Provide hourly summary, indicating:			
(a)	Transformer Status (ON/OFF)	State		
(b)	Current Polar Plot (through web app)	State		
(c)	Relative (%) and Referenced (pf) Capacitance, Relative (%) and Referenced (%) Power Factor	State		
(d)	Top oil, Bottom oil, Tap Changer and Environmental Temperatures, plus Humidity. Data shall be provided through additional sensors added to the system	State		
4.3.3.	Partial Discharge Monitoring			
4.3.3.1.	Each partial discharge monitoring system is based on UHF technique and immune from noise from electrical connections at bushings, line corona etc.	State		
4.3.3.2.	PD monitoring done by providing 2 nos. of UHF sensors of drain valve type suitable for PD frequency range of 100MHz to 1500MHz with fully shielded sensor and extra port for functionality check and calibration signal.	State		
4.3.3.3.	PD monitoring module is based on wide band signal processing technique and should be immune from noise by using transformer tank as faraday cage.	State		
4.3.3.4.	The PD monitoring system is provided with PD monitoring software for trending PD activity and generating advance warning.	State		
4.3.4.	Central Server			

Clause number	Requirement		KPLC Requirement	Guar. Value	Refer. doc
4.3.4.1.	Shall display the list of all monitored devices		State		
4.3.4.2.	Shall display the status of all monitored devices (connected, not connected, alarm active)		State		
4.3.4.3.	Allow direct connection to the monitored device		State		
4.3.4.4.	Periodically retrieve the data from each monitoring device		State		
4.3.4.5.	Display the Condition Group of each monitoring device (good, normal, defective, faulty, failure)		State		
4.3.4.6.	Upgrade each device when a new software release is available		State		
4.3.4.7.	Notify alarms through email		State		
4.3.4.8.	Provide secure connection with proper user credentials and user roles		State		
4.3.5.	Software				
4.3.5.1.	The operating software used in the monitoring server shall be the multitasking and real- time operating system		State		
4.3.5.2.	The software of the monitoring IED must include and not limiting to the following:				
(a)	The expert system provides the user with recommendations and information to optimize the operation and maintenance of the transformer/reactor by means of algorithms for analyzing the on-line acquired variables which are implemented in the software.		State		
(b)	Dissolved gas analysis and diagnostic tool according to MSS, Doernenburg, Rogers, extended Rogers, IEC 60599, Duval and Key Gas.		State		
(c)	Report generator, which automatically creates protocols with status information about the transformer and its main component		State		
(d)	Laptop properties and communication cable		State		
4.4	It shall have the technical particulars as shown in table 1 below:				
	Parameter	**Requirement**			
	Input Power	Mains power supply	90 - 250 VAC, 47 - 63 Hz, 300W max	Specify	
		H_2	5 - 5,000 PPM	Specify	
		C_2H_2	0.1 – 50,000 PPM	Specify	

Clause number	Requirement			KPLC Requirement	Guar. Value	Refer. doc
	Dissolved Gas Analysis	CO	1 – 50,000 PPM	Specify		
		H_20 (RS)	1 - 100% RS	Specify		
		Accuracy	± 5% or ± LDL (whichever is greater)	Specify		
	Bushing Monitoring	Input channels	2 sets of 3 phases, simultaneous acquisition on all channels	Specify		
		Simultaneous channels	3 (up to 6)	Specify		
		Sensors	Bushing Tap Adaptors	Specify		
		Input measuring range	0 - 200mA	Specify		
		Accuracy	Amplitude: 0.1%, Relative Phase Angle: 0.05°	Specify		
		Resolution	12 bit	Specify		
		Sampling rate	>10 kS/s	Specify		
		Power system frequency	50 - 60Hz, ± 0.01 Hz	Specify		
	Communication Options	Protocols	Modbus, DNP3 & IEC61850	Specify		
		Carriers	RS232, RS485, Ethernet, Fiber, 3G	Specify		
		HMI	7" High Resolution Colour LCD	Specify		
	DATA- Partial Discharge and Bushing	Acquisition mode	Continuous	Specify		
		Trending	Hourly, daily, weekly, monthly	Specify		
		Storage	> 1 year	Specify		
	Alarms	High-vis LED's	Red, Amber, Green	Specify		

Clause number	Requirement			KPLC Requirement	Guar. Value	Refer. doc
		Alarm relay contact	4 x NO or NC, user configurable	Specify		
	I/O	Analog inputs	3 x PT100, 3 x 4 - 20 mA, 1 x Load CT	Specify		
		Digital inputs	5 x 24V isolated	Specify		
4.4.1.	**Warranty and training**					
4.4.1.1.	The Online Monitoring system for Power Transformer shall be backed by a minimum of 12-months factory warranty.			submit		
4.4.1.2.	Technical support and software upgrade, where applicable shall be provided free of charge to KENYA POWER for a period of not less than 36 months.			State		

SCHEDULE 11B: Condition Controlled Maintenance Free Type Breather for Power Transformer

Clause number	Requirement		Bidder's offer
Manufacturer's Name and address		State	
Country of Manufacture		State	
Name and model Number		State	
1.	Scope	State	
2.	Normative References	State	
3.	Definitions and Abbreviations	State	
3.1.	Abbreviations	State	
4.1.	**SERVICE CONDITIONS**		
4.1.1	The Condition Controlled Maintenance Free Type Breather for Power Transformer shall be suitable for use outdoors in tropical areas and harsh climatic conditions including areas exposed to:		
a)	Altitudes above sea level;	State	
b)	Humidity ;	State	
c)	Average ambient temperature	state	
d)	Pollution:	state	
4.2.	**DESIGN AND CONSTRUCTION**		
4.2.1.	The main Transformer tank and Onload Tap Changer conservators shall be fitted with a Maintenance-Free type silica gel Breathers which shall be equipped with a humidity sensor, a condition based microprocessor control unit and LED status indication.	State	
4.2.2.	The desiccant is dehydrated by the built-in heating unit which is controlled by sensors, thus obviating the need for periodic desiccant replacement. The dehydrating breather is mounted on the pipe to the oil conservator at a height of 1200 mm approximately from transformer rail top level.	State	

Clause number	Requirement		Bidder's offer
4.2.3.	Material & External Construction of the Breather shall be such that all external parts are suitable for outdoor use & resistive to transformer oil, ultraviolet rays, pollution & salt water and shall work without any trouble for ambient temperature between 0° C to +80°C.	State	
4.2.4.	Following LEDs for local display on control unit, and suitable contacts & analog signal shall be provided for wiring to remote location:		
a)	LED for Power of control unit - ON	State	
b)	LED for Filter heater- ON	State	
c)	LED for Anti-condensation heater (of control unit) - ON	State	
d)	LED & relay contact for "Device Error"	State	
e)	LED & relay contact for Regeneration active (De-humidification in process)	State	
f)	Analogue output signal (4-20mA) for the Temperature of air (in filter unit / pipe).	State	
4.2.5.	The Breather shall be equipped with test button which should allow carry out a self-test and to check the functions like relay circuits, heating or the signal transmission in the control room, etc. at any time.	State	
4.2.6.	Control unit shall be equipped with a USB / RS 485 port for downloading the operational data logged by the unit.	State	
4.2.7.	All necessary software required for downloading and analyzing the logger data shall also be provided by the supplier.	State	
4.2.8.	The moisture and temperature measurement system (sensor) installed should be modular making it easy to replace the same if at all the same is necessary during the service of breather.	State	
4.2.9.	The equipment shall operate at input supply of 230V AC, 50 Hz. Any converter if required shall be supplied ,with the equipment.	State	
4.2.10.	Degree of Protection shall be at least IP55 for which type Test report shall be submitted.	State	
4.2.11.	Necessary protective devices shall be provided in order to protect the equipment against over voltages & high-frequency interference.	State	

Clause number	Requirement		Bidder's offer
4.2.12.	The control unit shall be equipped with suitable heater to prevent moisture condensation.	State	
4.2.13.	The size of Condition controlled maintenance free dehydrating breather shall be decided based on the volume of transformer oil during detailed engineering.		

SCHEDULE 12: GUARANTEED TECHNICAL PARTICULTARS FOR AUXILIARY TRANSFORMER

AUXILIARY TRANSFORMERS 200 KVA, 33/0.42 KV				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
1	Transformer Make/Model	State	100 KVA	
2	Manufacturer and Country	State		
3	Minimum years of service outside country of origin (7 years min)	Years		
	Minimum manufacturing experience (13 years min)	Years		
4	Design Service operating condition (Altitude and temperature)	State		
5	Type test reports and accreditation certificate	Provide		
6	Reference IEC/BS standards	State		
7	Transformer capacity	MVA		
	Highest rated voltage (HV/LV)	kV		
8	Rated Frequency	Hz		
9	Vector Group (Dyn11)	State		
10	Nominal Voltage (HV/LV)	kV		
11	One-minute Power frequency Voltage withstand			
	Primary winding	kVrms		
	Secondary winding (0.42)	kVrms		
12	Lightning impulse withstands voltage 1.2/50μs - Primary winding	kVpeak		
13	Continuous maximum rating on any tapping when operation under the ambient conditions	KVA		
14	**Off- load tap changer**			
	Rated Off-load Voltage at rated frequency on:			
	HV, principal tapping	kV		
	HV, extreme plus tapping	kV		
	HV, extreme minus tapping	kV		
15	Tapping ranges from principal tapping:			
16	HV no of plus tappings	No		
	HV no of minus tappings	No		
	Total tap positions (5)	No		
17	HV steps in % of rated voltage (± 2 x 2.5%)	%		
18	No-load losses at 75° C	kw		
19	Load losses at 75° C			
	50 % loading, rated voltage and frequency	kW		
	75% loading, rated voltage and frequency	kW		
	100% loading, rated voltage and frequency	kW		
	125% Loading, rated voltage and frequency	kW		
21	No-load current at rated voltage and frequency	A		
22	Total No load loss (Core +Stray loss) at rated current at 75° C (%)	kw		

AUXILIARY TRANSFORMERS 200 KVA, 33/0.42 KV TRANSFORMER				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
23	Total load losses at 75°C at rated currents	KW		
24	Impedance voltages at rated current, Unity power factor and frequency at 75° C at nominal tap	%		
25	Max temperature rise at			
	i) Top oil	°C		
	ii) Winding	°C		
26	Efficiency at 75°C on principal tap, at unity power factor and at 0.8 power factor lagging;			
	120% full load	%		
	100% full load	%		
27	HV and LV windings insulation type			
28	Maximum working flux density at rated voltage on principal tapping and rated frequency:	Tesla		
29	Core design type	State		
30	Grade of laminated CRGO and manufacturer	State		
31	Winding conductor material (HV, LV and Neutral)	Copper		
32	Bushing material (HV and LV)	State		
33	Total creepage distance for porcelain Bushing (HV/LV)	State		
34	Thickness of transformer tank (minimum)			
a	Corrugated sides	3.0mm		
b	Bottom	5.0 mm		
c	Top	5.0 mm		
35	Thickness of tank paint coating (minimum)	micron		
36	Finished transformer color (Admiral grey)	State		
37	Following devices shall be installed:			
	Pressure relief	State		
	Oil level indicator visible from ground	State		
	Non-standard Nuts/Bolts on top cover	State		
	Lifting lugs and Arcing horns	State		
38	Sound level at 100% Load	State		

SCHEDULE 13: GUARANTEED TECHNICAL PARTICULARS - PROTECTION IEDS (RELAYS)

SCHEDULE 13A: GUARANTEES FOR DISTANCE PROTECTION RELAY				
Item	**Particular Specifications**	**Units**	**Guarat Value**	**Refer. Doc**
1.	Manufacturer's Name and Country	State		
	Type or designation name of Relay	State		
	Minimum of 10 years Manufacturing experience	state		
	Minimum of 5 years in service outside country of manufacture	state		
	Type test report and Accreditation certificate	Provide		
	Manufacturing reference standards	State		
	Ratings: Ac Inputs: 1-5Amp	State		
	Power Supply Voltage: 110VDC or (Universal 24-240Vdc).	State		
	Evidence of sales in 3 other continents outside the continent of manufacture (state Countries)	State		
	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
	Model design type (numerical)	state		
	Supported communication protocols 60870- 5-103, 61850-9-2	State		
	Mounting design (Flush)	State		
	suitable for use on a feeder in a 1&1/2 Breaker substation arrangement. (suitable/not suitable)	state		
2.	High speed output relays for circuit breaker opening (state no. of output relay).	State		
	Full Scheme Distance relay (scheme type)	state		
	Number of similar Relay sold to date to the export market: requirement; minimum number 1000	State		
	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
	Operating time for fast operating output relays	State		
	Operating time for other output trip relays	State		
3.	Tripping logic			
4.	Number of Zones of protection (state 1 or 2 or 3 or 4)	State		
5.	Zone Impedance Comparator Characteristics (state: mho, Quadrilatel.)	State		
6.	Impedance setting range for each Zone (state for Z1,Z2,Z3 and Z4)	State		
7.	Communication Aided Schemes for Distance Protection	state		
8.	Communication Aided schemes for Directional Earth Fault (DEF) Protection	state		
	Pick up setting range for the DEF element (state in amps)	state		
	Load Encroachment Discrimination feature(available/not available)	state		
9.	Fuse Failure Supervision (available/ not available)	state		
10.	Weak end in feed & Echo feature (available/not available)	state		
11.	Current reversal guard Feature(available/not available)	state		
12.	Power Swing Tripping & Blocking function(available/not available)	state		
13.	Voltage Memory Function (available/not available)	state		
14.	SOTF Function (available)	state		
	Settings range for the SOTF Function (time delay)	State		
15.	Back-up Overcurrent and Earth fault protection function	State		
	(available/not available)			

16.	Under-Frequency and rate of frequency change Protection function	State		
17.	Settings range for the Backup Overcurrent and Earth Fault Protection	state		
18.	Circuit Breaker contact wear feature(available/unavailable)	state		
19.	Broken Conductor detection(available/unavailable)	state		
20.	Auto-reclose Function that is able to operate as per the specifications	State		
21.	Accuracy for Distance to Fault Location (in %)	State		
	Automatic display of fault details on the Relay- List the fault data displayed	State		
22.	Storage capacity for disturbance records, trip/fault records and events records (No. of events and No of records)	indicate		
23.	Fault Locator with automatic Distance to Fault indication on the LCD screen in km. (available/unavailable)	state		
24.	Relay configuration & parameter settings, Event & Fault records and LED status are retained upon loss of relay DC Power supply	State		
25.	Metering provided	State		
26.	Number of Binary Inputs	State		
27.	Number of Binary outputs	state		
28.	Ratings for output relay contacts (current and voltage)	State		
29.	Number of LEDs	indicate		
30.	Communication protocols	state		
31.	Communication ports provided	State		
32.	Type and size of connection terminals for cable termination at the back of relay (type and diameter size)	state		
33.	Relay to Laptop connection cables offered (number and type).	state		
34.	Software for relay configuration and parameter setting and fault data Analysis offered with the relay in CD form.	indicate		

Item	13 B: GUARANTEED TECHNICAL PARTICULARS FOR LINE DIFFERENTIAL RELAY			
	Particular Specifications	**Employers' requirement**	**Guar. Value**	**Refer. Doc**
1.	Country of manufacture/origin			
2.	Manufacturer's Name	State		
3.	Type or Designation name of Relay	State		
4.	Test reports and accreditation certificate of testing laboratory	provide		
5.	mounting design (Flush)	state		
6.	Design (Numerical, modular, others)	State		
7.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
8.	Experience in manufacture of Line Current Differential relay (minimum 13years)	state		
9.	Minimum of 7 years of relay service outside country of manufacture	state		
10.	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
11.	Minimum operating current /relay sensitivity	State		
12.	Minimum operating time	State		
13.	Simultaneous Tripping at both ends of the line even with no in feed at one end.			
14.	Phase segregated measurement of current magnitude and phase angle (phase segregation available/unavailable)	State		
15.	High Speed relay operation suitable for protection of Transmission Line (high speed relay available, time of tripping)	state		
16.	Transformer Inrush restraint and ratio and phase angle compensation (available/unavailable)	State		
17.	Direct Transfer of Trip Function between the relays via fibre optical cable (available/unavailable)	State		
18.	Operates with directly connected fibre cables (direct connection/via multiplexer)	state		
19.	Differential Protection blocks upon loss of communication to prevent mal-operation (blocks/does not block)	State		
20.	Auto-reclose Function: Available modes of Auto-reclose (SPAR+DAR)	State		
21.	Integrated Distance Protection (available/unavailable)	State		
22.	Number of Zones for integrated distance Protection	State		
23.	Zone Impedance Comparator Characteristics (mho, quadrilateral, both)	state		
24.	Impedance Settings range for each Zone	State		
25.	Automatic Display on the LCD screen of Distance to Fault in km (available/unavailable)	State		
26.	Back up Overcurrent and Earth Fault Protection (available/unavailable)	State		
27.	Settings range for Back up Overcurrent and Earth fault Protection Elements (current range)	state		
28.	Storage capacity for **disturbance records**, **trip records** and **events record**	capacity for each		
29.	Metering capability (U,I,P,Q,S,F,F&CosØ)	State		
30.	Number of Binary Inputs	State		
31.	Number of Binary outputs	state		

32.	Ratings for relay output contacts (current, voltage)	state		
33.	Ratings for relay input contacts	State		
34.	Number of LEDs	State		
35.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/unavailable)	State		
36.	Communication protocols	State		
37.	Communication ports provided	state		
38.	Type and size of connection terminals for cable termination	state		
39.	Relay to Laptop connection cables offered	State		
40.	Software for relay configuration and parameter setting and fault data Analysis offered for use with the relay. Software to be offered in CD form	Indicate		

13 C: GUARANTEES FOR RESTRICTED EARTH FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. doc**
1.	Manufacturer and country of origin name	State		
2.	Model and designation name of relay	indicate		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal24-240VDC).	State		
5.	Design type: Numerical conforming to protocol IEC 61850-8-1and Goose messaging	State		
6.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
7.	Relay must have been sold to other two continents outside continent of manufacture (give names of the continents)	state		
8.	Experience in manufacture of Restricted Earth Fault Relay (number of years of manufacture)	Years		
9.	Minimum of 10 years Manufacturing experience	state		
10.	Minimum of 5 years in service outside country of manufacture	state		
11.	Complete order number for offered Relay	State		
12.	Applicable for High Impedance operating principle	indicate		
13.	Minimum pick up & setting range	State range		
14.	Relay Operating time at 5 x setting current (time in seconds)	indicate time		
15.	Number of LEDs	State		
16.	Number of Binary inputs	State		
17.	Number of Binary outputs	State		
18.	Ratings of output relay contacts (current and voltage)	State		
19.	Keypad for relay parameter settings and data access (available/unavailable)	State		
20.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/unavailable)	State		
21.	Software for relay configuration and parameter setting. Software to be offered in CD form(yes/no)	Indicate		
22.	Connection cable from Laptop to Relay to be offered(yes/no)	Indicate		
23.	**Stabilizing Resistor**			
24.	Type and reference number of Stabilizing Resistor offered.	State		
25.	Setting Range of Offered resistor in Ohms (range in ohms).	State		
26.	Maximum through fault for the REF scheme calculation (in kA).	State		
27.	**Voltage Dependent Resistor (Metrosil)**			
28.	Type and reference number of Voltage Dependent Resistor (VDR) Metrosil offered. Rated voltage of VDR based on maximum fault current of 25kA.	State		
29.	Both Stabilising Resistor and Voltage dependent resistor are housed in a single box with external connection terminals suitable panel mounting.	State		
30.	Software for relay configuration and parameter setting	State		
31.	Communication cable from Laptop to relay offered	State		

SCHEDULE 13 D: GUARANTEES FOR 3PHASE UNIDIRECTIONAL OVERCURRENT & E/ FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or Model of the relay	type		
3.	Complete order number for offered Relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
7.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
8.	Experience in manufacture of Three Phase Overcurrent and Earth Fault relay (10 years minimum)	state		
9.	Years of Service outside country of Origin (Minimum 5 years)	state		
10.	Design (Numerical type)	State		
11.	Mounting design (Flush)	State		
12.	Protection Functions offered and parameters setting range for all protection elements	indicate		
13.	Time-current characteristics available for various Overcurrent, Earth fault elements and other protection elements	State		
14.	Broken Conductor Function (available/unavailable)	State		
15.	Under frequency Protection(available/unavailable)	state		
16.	Circuit Breaker contact wear feature(available/unavailable)	State		
17.	Number of LEDs provided	state		
18.	Number of Binary Inputs	state		
19.	Number of Binary outputs	state		
20.	Ratings of output relays contacts (current, voltage)	state		
21.	Communication ports (type and number)	state		
22.	Communication protocols	state		
23.	Circuit Breaker maintenance(available/unavailable)	state		
24.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/not available)	indicate		
25.	Configuration of Start and trip contacts (possible/not possible)	State		
26.	Storage capacity for disturbance, event and trip/fault records	State		
27.	Metering/Measurement capability (P,Q,I,V,CosØ)	Indicate		
28.	Size of LCD screen	State		
29.	Relay Keypad for relay parameter setting and data access	state		
30.	Software for relay configuration and parameter setting.	State		
31.	Connection cable from Laptop to Relay offered	state		
32.	Type and size of relay terminals for cable connection			

SCHEDULE 13 E: GUARANTEES FOR SENSITIVE EARTH FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of relay	Type		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 30-300VDC).	State		
5.	Experience in manufacture of SEF Relay (10 years minimum)	state		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1	State		
7.	Years of Service outside country of origin (5 years Minimum)	state		
8.	Complete order number for offered Relay	State		
9.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
10.	Current setting range for earth fault relay - 0.005In-0.8In	State		
11.	Definite time delay characteristic; Setting range, 0- 30 Seconds.	State		
12.	Circuit Breaker Maintenance function	State		
13.	Fault records, Event Records and disturbance records.	State		
14.	Drop off /pickup ratio >90%	State		
15.	Low transient overreach < 10%	State		
	Auto reclose function			
i.	Autoreclose function shall be enabled in the distance relay or in the overcurrent and earth fault rely	State		
ii.	Selectable 1 - 3 Autoreclose shots	State		
iii.	Independent set dead time for each shot	State		
iv.	Independent set dead time for each shot	State		
v.	Autoreclose inhibit after manual close	State		
vi.	Autoreclose inhibit for Overcurrent high set-element	State		
16	Connection cable from Laptop to Relay offered	state		
17	Software for relay configuration and parameter setting.	State		

13 F: GUARANTEES FOR BIASED DIFFERENTIAL RELAY FOR TWO WINDING TRANSFORMER PROTECTION				
Item	**Particular Specifications**	**Units**	**Quart. Value**	**Ref. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of the relay offered	State		
3.	Complete order number of offered relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Mounting design (Flush)	State		
7.	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
8.	Design type numerical	State		
9.	Number of similar Relay sold to date to the export market: (requirement minimum number 1000)	State		
10.	Evidence of sales in 3 other continents outside the continent of manufacture (state countries)	State		
11.	Experience in manufacture of Biased Differential Protection relay (minimum 10 years)	state		
12.	Minimum of 5 years in service outside country of manufacture	state		
13.	Minimum operating current for biased differential /relay sensitivity and setting range	Indicate		
14.	Minimum operating time at 2 x setting	Indicate		
15.	Provision of unrestrained High-set differential element and setting range	Indicate		
16.	Magnetizing Inrush detection method(s) and settings range	Indicate		
17.	Provision of Integral CT correction ratio feature and setting range(available/unavailable)	State		
18.	Integral Vector Group compensation feature(available/unavailable)	State		
19.	Display of HV & LV differential and bias currents on the LCD screen(available/unavailable)	State		
20.	Storage capacity for Disturbance, Event and Trip/Fault records (disturbance, events and trips)	Indicate		
21.	Display of Fault currents on the LCD (available/unavailable)	State		
22.	Provision of over-fluxing Alarm and Trip functions	State		
23.	5^{th} Harmonic restraint feature and settings range	Indicate		
24.	Dual- Bias characteristics (available/unavailable)	State		
25.	Relay trip Indication by Red LED (available/unavailable)	State		
26.	No of Binary Inputs and Binary Outputs	State		
27.	Ratings of relay output contacts (current and voltage)	State		
28.	Number of LEDs	State		
29.	Ability to latch output contacts (available/unavailable)	State		
30.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/Unavailable)	Indicate		
31.	LCD screen and Keypad for programming relay parameter settings and data access(available/unavailable)	Indicate		
32.	Communication protocols	State		
33.	Communication ports provided	State		

34.	Type and size of terminals for cable connection	State		
35.	Software offered for relay configuration and programming	Indicate		
36.	Communication cable to Laptop (offered /not offered)	Indicate		
37.	Metering capability (U,I,P,Q,S,F,F&CosØ)	Indicate		

13 G: GUARANTEES FOR FEEDER PROTECTION AND BAY CONTROL IED				
Item	**Particular Specifications**	**Units**	**Guara Value**	**Refer. Doc**
1.	Manufacture and country	State		
2.	Applicable protocol IEC 61850-8-1and Goose messaging	State		
3.	Model of the IED	State		
4.	Manufacturing reference standards	State		
5.	Ratings: Ac Inputs: 1-5Amp	State		
6.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
7.	Number of similar Relay sold to date to the export market: Required minimum1000 pcs	State		
8.	Experience of 10 years in manufacture of BCU/BCPU	state		
	Years of Service outside country of Origin (5 years minimum)	state		
9.	Numerical design (numeric)	State		
10.	Protection functions and features in the IED i. Three phase overcurrent ii. Earth fault iii. Sensitive Earth Fault iv. Broken Conductor detection v. 3phase Autoreclose function vi. Under and Over Frequency Protection	State		
11.	Earth Fault and Sensitive Earth Fault Protection in separate element	State		
12.	Earth Fault and Sensitive earth fault elements shall have separate CT Inputs.	State		
13.	Two stages of High Set Element for both overcurrent and earth fault protection function-setting range of 1-20In (minimum) and a definite time delay setting of 0-60 seconds (minimum).	State		
	Current setting range for overcurrent 0.5In-2.0In (minimum)	State		
14.	Current setting range for earth fault 0.05In-0.8In (minimum)	State		
15.	Auto reclose function: i. Three phases auto reclose ii. Selectable 1-3 autoreclose shots iii. Independently set dead time for each shot iv. Autoreclose inhibit after manual close v. Autoreclose inhibition for over current high set element	State		
16.	Minimum of eight (8) each LEDs for alarms and trip annunciation.	State		
17.	Binary inputs and Outputs- minimum twelve (12 each)			
18.	Mounting design (Flush)	State		
19.	Number of CT inputs	State		
20.	Number of VT inputs	State		
21.	Protection and control Functions: Parameter setting range for each function including time-current characteristics O/C, E/F, SEF, etc.	State		

SCHEDULE 13 H: GUARANTEES FOR BUS BAR PROTECTION IED (IF OFFERED)				
Item	**Particular Specifications**	**Employer's requirement**	**Guara. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Model of offered relay	State		
	Manufacturing reference standards	State		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
5.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
6.	Protection principle (low impedance on numeric principle)	State		
7.	Minimum of 10 years' experience in manufacture of Bus bar protection Relay	state		
8.	Minimum of 5 years in service outside country of Origin	state		
9.	Bus bar protection- centralized and phase segregated	State		
10.	Dynamic bus replica feature for each zone of protection	State		
11.	Mounting design (Flush)	State		
12.	Reference standards	state		
13.	Number of similar Relay sold to date to the export market: - (Required minimum number is1000)	State		
14.	Evidence of sales in two other continents outside the continent of manufacture (state countries)	State		
15.	Minimum operating time	Indicate		
16.	Check criteria for trip (check relay, zone relay)	Indicate		
17.	Detection of CT saturation within a few milliseconds into an external fault	State		
18.	Integral CT correction ratio feature and setting range	required		
19.	CTs trouble monitoring for each protected zone	required		
20.	Display of differential and Line current on LCD screen	required		
21.	Storage capacity for disturbance, Event and Fault records and Oscillographs (Input analogue to cover 20nos. bays)	indicate for each		
	Relay trip Indication by Red LED	required		
22.	No of Binary Inputs	State		
23.	No. of Binary Outputs	State		
	Ratings of relay output contacts (current and voltage)	State		
24.	Number of LEDs	State		
25.	Ability to latch output contacts	required		
26.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/Unavailable)	required		
27.	LCD screen and Keypad for programming relay parameter settings and data access (available/unavailable)	required		
28.	Communication protocols (IEC 61850-8-1)	State		

29.	Communication ports provided	State		
30.	Overcurrent back up and end-fault protection (available/Not available)	State		
31.	Type and size of terminals for cable connection	State		
32.	Software offered for relay configuration and programming	Indicate		
33.	Laptop to relay connection cable (offered /not offered)	Indicate		
34.	Metering capability (U,I,P,Q,S,F,F& Cos Ø)	Indicate		
35.	Connection cable from Laptop to Relay offered	State		
36.	Software for relay configuration and parameter setting.	State		

SCHEDULE 14: GUARANTEED TECHNICAL PARTICULARS FOR OPGW CABLE

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guart. Value**	**Refer. Doc**
1	Manufacturer and Country		State		
2	Minimum experience in manufacture of OPGW	Years	10		
3	Minimum years of service outside country of Origin	Years	7		
4	Number of fibers	OPGW	≥48		
	Single mode fiber type		G655		
5	Core diameter	µm	8.3/9 with 3% tolerance		
6	Fiber Cores per loose tube		12		
7	Fiber Color Coding –12 number		TIA-598 - C		
8	Clad diameter	µm	125.0 + 2		
9	Core-clad concentricity		< 2%		
10	Coating diameter	µm	250.0 + 15		
11	Coating concentricity	>	0.70		
12	Attenuation: 1310 nm 1550 nm	dB/km	< 0.40 < 0.25		
13	Bending attenuation: 1310nm 1550nm	dB/km	≤ 0.40 < 0.25		
14	Temperature dependence	dB/km	≤0.05 (-20°C to +85°C)		
15	Cut-off wavelength	nm	< 1250		
16	Chromatic dispersion:				
17	Zero dispersion at	nm	1310 ± 12 1550 + 15		
18	Zero dispersion slope (max.)	ps/nm^2 (km)	0.092 0.085		
19	Mode field diameter				
	1300 nm 1550 nm	m m	9.30 ± 0.50 10.50 ± 1.00		
20	IL-proof test level	g/m^2	35 x 106		
21	Splice attenuation	dB/ splice	0.02		
22	Connector loss	dB/connector	< 0.5		
	Approach Underground Cable				
23	Manufacturer's Name and country	-	State		
24	Type	-	Armoured		
25	Number of fibers	-	>48		
26	Fibers per tube	NO	12		
27	Long-term Loading tensile	IEC 60794-1-2-E1A	1200 N		
28	Short-term Loading tensile	IEC 60794-1-2-E1B	2700 N		
29	Crush Performance, Long term	IEC 60794-1-2-E3	800N/10 cm		

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guarat Value**	**Refer. Doc/.**
30	Crush Performance, Short term	IEC 60794-1-2-E3	3000N/10 cm		
31	Minimal installation Bending radius	IEC 60794-1-2-E11	15 x OD		
	ODF				
32	Manufacturer's Name and country	-	State		
33	Type/model	-	State		
34	Number of fiber interconnections	-	≥48		
35	Connector loss	DB/connector	< 0.5		
36	Screw on type connectors	-	yes		
37	Wall mounted cabinet	-	yes		
38	Fiber Optic Cable routine tests as per IEC 60794-1-2E/F	No	State all tests		

SCHEDULE 15: GUARANTEED PARTICULARS FOR MEASURING INSTRUMENTS

GUARANTEES FOR MEASURING INSTRUMENTS				
Item	**Particulars**	**Unit**	**Guaranteed. Value**	**Refer. doc**
1	**Indicating Instruments**			
	AC and DC Ampere meter, and Voltmeter, Wattmeter, VAr - meter, Frequency-meter and other indicating instruments:	State		
i	Physical dimension Instrument for: (A, V (AC), V (DC), W, etc.)	(mm)		
ii	-Reference standard	list		
iii	- Error	%		
iv	- Max. admissible current	$\%.I_N$		
v	- Max. admissible voltage	$\%.I_N$		
2	**Energy meters (to be filled for each meter)**			
i	Meter for (MWh, MVArh) Physical dimension	mm		
ii	-Error with 5% load	%		
iii	-Error with 10% load	%		
iv	-Error with 20% load	%		
v	-Error with 100% load	%		
vi	-Max. admissible current	$\%.I_N$		
3	**Metering Converters (Transducers)**			
i	- Converter for (MW, MVAr, A, etc):			
ii	- Error	%		
iii	- Linearity	%		
iv	- Max. admissible current for 0.5 seconds	$\%.I_N$		
v	- Max. admissible current continuously	$\%.I_N$		
vi	- Max. admissible voltage for 0.5 seconds	$\%.I_N$		
vii	- Max. admissible voltage continuously	$\%.I_N$		
4	**Alarm/Trip Annunciators**			
i	- Reference standard	State		
ii	- Digital type	State		
	(i) Digital and Analogue inputs/output	State		
iii	- Number of windows per annunciators (minimum 8)	No		
iv	- Physical size of each annunciator (area of the cap)	mm		
	i) Reset and mute button	State		

Note: *To be filled in for each Instrument*

SCHEDULE 16: GUARANTEED TECHNICAL PARTICULRAS FOR LV CABLES

GUARANTEES FOR CONTROL AND SIGNAL CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guant. value**	**Refer. Doc**
1	**Low Voltage Cables (Auxiliary Supply)**				
i	- Conductor material		Copper		
	Design type		Concentric and stranded		
ii	- Current carrying capacity at $75^{O}C$	A	State		
	(iv) Rated Voltage	kV	state		
	(v) 1min. power withstfrequency voltage	KVrms	state		
iii	(vi) Short circuit current withstands for 3secs	KA	State		
iv	- Insulation material		PVC		
v	- Steel wire Armoure and screen		Required		
vi	- Protective coating		Required		
vii	- minimum nominal diameter		$25mm^2$		
viii	- Weight of heaviest reel, including cable - Number of cores	Kg No	Kg four		
2	**Control, Protection and Measuring Cables**				
i	- Conductor material		Copper		
	ii) Design type		Concentric and stranded		
ii	- Insulation material		PVC		
	- Current carrying capacity at $75^{O}C$	A	State		
	(viii) Rated Voltage	kV	1		
	(ix) 1min. power frequency voltage withstand	KVrms	3		
iii	- Steel wire Armouring and screen		required		
iv	Protective coating		required		
v	- Nominal diameter per core		$2.5mm^2$		
vi	- Overall diameter of cable and number of core	mm/No	state		
vii	- Weight of heaviest reel, including cable	kg	state		
viii	- Size of biggest reel, diameter/width	mm/mm	state		
3	**Telecommunication and Relay/Control Panel internal wiring cables**				
i	- Conductor material		Copper		

ii	Design type		Concentric and stranded		
iii	- Rated voltage	V	600		
iv	- Insulation material		PVC		
v	-1min. power frequency voltage withstand	KVrms	state		
vi	- Flexible stranded single core		state		
vii	- Nominal diameter per core (minimum)		$1.5mm^2$		
viii	- Overall diameter of cable and number of cores	Mm/No	State		
ix	- Weight of heaviest reel, including cable	Kg	State		
x	- Size of biggest reel, diameter/width	mm	State		
4	**Special Cables (where applicable)**				
i	-Special signal and data applicable		state		
ii	-Conductor material		state		
iii	-Insulation material		state		
iv	-Mode of protection		state		
v	-Diameter per core		state		
vi	-Overall diameter of cable reel		state		

SCHEDULE 17: GUARANTEED TECHNICAL PARTICULRAS FOR EARTHING CONDUCTOR

GUARANTEES FOR EARTHING CONDUCTOR					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guar. Value**	**Ref. Doc**
1	Maximum Earth ground resistance desired values				
2	Under the Control building	Ohms	State		
	Under the Switchyard (HV Earthing system)	Ohms	State		
	LV Earthing system	Ohms	State		
3	Material for Main Grid and Risers earthing conductor		Copper		
4	Resistance of Main earth grid conductor at $20^{O}C$	Ω/km	State		
5	Minimum nominal cross section area of main grid and risers	mm^2	95		
6	Max. temperature of earth conductor during 3 Sec. rated phase - ground fault	$O^{0}C$	State		
7	Rated Phase to ground fault current of main grid conductor at rated maximum temperature	kA	State		
8	Material for Earth rods		Copper		
9	Maximum resistance of each Earth rod	Ohms	State		
10	Length and diameter of earth rods	m/mm	State		
11	Method of interconnecting earth grid conductors		State		

SCHEDULE 18: GUARANTEED TECHNICAL PARTICULRAS FOR RTU (SAS) EQUIPMENT

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particular Specifications**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
1.	Manufacturers Name and address	State		
2.	Country of Manufacture	State		
3.	Model or type of RTU	State		
4.	Equipment applicable standards	State		
5.	Minimum RTU Manufacturing experience (10 years)	State		
6.	Minimum years of service outside country of Manufacture (5years)	State		
7.	Service working conditions	Specify		
8.	Safety and environmental compliance	State		
9.	Free standing Panel dimension	Specify		
10.	Relays shall be encapsulated type	Specify		
11.	Accommodate signal from both Analogue and Digital transducers	Specify		
12.	Tele information plan requirement interfacing	required		
13.	single command outputs, double command outputs	Specify		
14.	regulation command outputs e.g. raise/lower command outputs for transformer tap changer control	Specify		
15.	analogue set point transmission and output	Specify		
16.	single, double and multiple state digital inputs	Specify		
17.	analogue measured inputs	Specify		
18.	metering pulse inputs for acquisition of energy meter values	Specify		
19.	Sequential Event recording (SER) with time stamping of events at the RTU	Specify		
20.	RTU time synchronization	Specify		
21.	Self-testing and diagnostic functions for detection and reporting of any error	Specify		
22.	Automatic re-starting function corresponding control centre with downloading function.	Specify		
23.	Support encryption and LAN/WAN Access	Specify		
24.	Shall support IEC 61850 protocol for process communication	Specify		
25.	RTU to be fully equipped for 8 substation bays plus spare capacity of 25% for each type of data	Specify		
	RTU shall be expandable in the field by at least 50% of the size of the initial point capacity by addition of Input and Output cards only	Specify		
	Addition of enclosures, internal cabling/wiring, chassis, or power supplies shall not be necessary when adding these I/O cards.	Specify		
26.	RTU shall be accessible through the communication network for the Supervisory Control & Data Acquisition (SCADA) System at the National Control Centre (NCC) and Regional Control Centres (RCC) to scan.	Specify		
27.	Plug-in type relays shall be used with sockets directly mounted on a DIN rail.	Specify		
	RTU firmware requirements			
28.	RTU firmware characteristics	Specify		
29.	Use of standard firmware	Specify		
30.	It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU	Specify		
31.	all firmware delivered must be up to date and in final form, including all standard firmware changes	Specify		

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particular Specifications**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
32.	Firmware shall be loadable by service notebook locally at minimum, download of firmware and parameter sets trough SCADA system, using the data communication links.	Specify		
33.	Changing of EPROMs or similar devices shall not be necessary when updating RTUs firmware	Specify		
34.	230V AC power outlets	Provide		
35.	DC Power supply			
36.	Any hardware required to convert the 48 V battery voltage to the required internal voltages for the RTU hardware shall be provided and adequate	Specify		
37.	The RTUs shall be capable of operating with ungrounded or grounded (either polarity) input power.	Specify		
38.	Dielectric strength/Impulse voltage test (≥2.5kV, 1 minute)	Specify		
	Interposing Relays	Specify		
39.	Tele commands	Specify		
40.	Coil voltage shall be 48 VDC; Coil voltage variation shall be ±20%.	Specify		
41.	Signal voltage on the contact circuit shall normally be 110 VDC	Specify		
42.	The rated contact current shall be minimum 5ADC making/breaking.	Specify		
43.	Telecommunication indications	specify		
44.	Coil voltage shall be 110 VDC; Coil voltage variation shall be ±20%.	Specify		
45.	Signal voltage on the contact circuit shall normally be 48VDC	Specify		
46.	The rated contact current shall be minimum 3ADC making/breaking.	Specify		
47.	2NO and 2NC contacts for interposing relay	Specify		
48.	Relays shall be fitted with a visual operation indicator (either mechanical or LED)	Specify		
	Transducers			
49.	Electrical parameters – Current, voltage, active power, reactive power, apparent power, frequency and power factor transducers	requires		
50.	Four programmable analogue outputs, two digital outputs and RS-485 Modbus functionality for transducers.	Specify		
51.	programmed via easy-to-use software compliant with IEC 60688	Specify		
52.	Relays Characteristics of the digital programmable transducers	Specify		
53.	Measurement Accuracy Class (0.2 and 0.5)	specify		
54.	Current circuit (In)	1-5 A		
55.	Transducer supply- 40-120 VDC /110Vac	Specify		
56.	Communication Ports	Required		
	Serial USB port-USB Mini-B connector Modbus RTU 38400 baud (auto)	Specify		
	Serial RS485 port- Three screw terminals for ≤ 6 mm2 Modbus RTU 1200 – 38400 baud	Specify		
57.	Digital outputs (No)	2		
58.	Analogue outputs (No)	4		
59.	MFM devices	Required		

SCHEDULE 19: GAURANTEED TECHNICAL PARTICULARS - TELECOMMUNICATION SYSTEM

GUARANTEEES FOR SUBSTATION TELECOM SYSTEM					
No	**Particular Specifications**	**Unit**	**Employer's requirement**	**Guar Value**	**Refer . Doc**
1	Manufacturer's Name and Country		State		
2	Multiplexer type/Model		STM-1/4		
3	Nx2MBit Multiplexer		State		
4	Terminal equipment (State id provided)		State		
5	Minimum experience in manufacture of SDH Multiplexer	Years	10		
6	Minimum years of Service outside country Origin of the Multiplexer	Years	7		
7	Multiplexer technology		SDH, GBE & MPLS-TP		
8	SDH Capacity [STM-1]	Mbps	155.52MBps		
9	GBE Capacity	Gbps	1.25Gbps		
10	Maximum extension of transmission capacity of terminal equipment by adding plug in cards		State		
11	Maximum extension for multiplexer and terminal equipment racks.		State		
12	Maximum extension of transmission capacity for the multiplexer based on 2MBit-hierarchy		State		
13	Integration to existing KPLC NMS		Required		
14	Configurability from existing NMS		Required		
15	Telephony Voice Service capability		Required		
16	SCADA Data Service capability		Required		
17	CCTV data service capability		Required		
18	Teleprotection capability for HV substations as per IEC 60834-1		Required		
19	Craft Interface Connectivity to equipment		ITU-T G.773		
20	Optical interface for use between Teleprotection and digital Multiplexer		IEEE C37.94		
21	Data Communication channel to NMS and between nodes		ECC/ITU-T G.773		
22	Connection of PDH electrical tributary interfaces to the SDH equipment		ITU-T G.703		
23	Synchronous optical interface protection		1+1 Protection		
24	Timing and synchronization		ITU-T G. 783		
25	Supply of associated accessories and materials		Required		
26	Perpetual telecom equipment license		Required		
27	Supply of equipment wall mounted cabinet		Required		

SCHEDULE 20: GUARANTEED TECHNICAL PARTICULARS FOR 33KV CABLE

33KV THREE CORE 300 mm^2 ALUMINIUM XLPE CABLE					
Item	**Particular Specifications**		**Unit**	**Guarant Value**	**Refer. doc**
1.	Manufacturer and country of origin				
2.	Minimum manufacturing experience (10 years minimum)		Years		
3.	Years of service outside country of manufacture (5 years minimum)		Years		
4.	Type test report and accreditation certificate of testing laboratory		Provide		
5.	Service condition (altitude and temperature)		State		
6.	Applicable IEC/BS standard(s)		State		
7.	Rated Continuous operating temperature		^{O}C		
8.	Short with withstand temperature for 5Secs.		^{O}C		
9.	Conductor material				
10.	Minimum insulation thickness and resistivity at 90^{O}C		mm/Ω		
11.	Insulation	Material (XLPE)	State		
		Minimum Thickness	mm		
		Screen tape around the conductor	State		
12.	Water barriers				
13.	Metallic Screen	Type and material	State		
		Min. Tape/Wires screen area	State		
		Thickness of separation layer	mm		
		Short time current of tape/Wire screen for 3sec at 90 - 200 ^{O}C	kA/3Sec		
14.	Extruded PVC Over sheath	Withstand power frequency at 90 ^{O}C for 1sec	kVrms		
		Over sheath min. thickness	mm		
		Anti-termite protection	State		
		Fire resistance	State		
		Marking	State		
15.	Wire Armour	Material of armour wire and tape	State		
		Nominal armour wire diameter	mm		
16.	**Ratings and Characteristics**				
	Conductor nominal cross-sectional area		Sqr mm		
	Voltage rating Uo/U(Um)		kV		
	Conductor shape		State		
	Maximum conductor DC resistance at 20^{o}C		Ω/km		
	Maximum conductor AC resistance at 90^{o}C		Ω/km		
	Minimum conductor diameter		mm		
17.	Current capacity	Buried underground	A		
		In air (trench)	A		
18.	Power frequency withstand test voltage for 5min		kVrms		
19.	Short Circuit rating of conductor for 3sec at (90-250 ^{O}C)		kA/3Sec		
20.	Maximum Capacitance/km		µF/km		
21.	Impedance @50Hz@90 ^{O}C		Ω/km		
22.	Inductance/km		mH/km		
23.	Maximum charging current/km		A/km		
24.	Impulse withstand voltage as per IEC60230		kVpk		
25.	Minimum bending radius (Static)		mm		
26.	Weight per Km (kg/km)		Kg/km		

SCHEDULE 21: GUARANTEED TECHNICAL PARTICULARS FOR SUBSTATION STEEL STRUCTURES.

GUARANTEES FOR SUBSTATION STEEL STRUCTURES					
NO.	**Particulars**	**KPLC Requirements**	**Unit of measure**	**Guarat. Value**	**Refr. Doc**
1.	Manufacturer Name and address		State		
2.	Country of manufacture		State		
3.	Type/design of steel structures (hot-rolled and complies with the requirements of Kenya Standard ES 02-572 angle channels/tubular)		State		
4.	Applicable standards		State		
5.	Minimum Manufacturing experience (7 years)		State		
6.	Years of service outside country of manufacture (Mini.5 years)		State		
7.	Delivery time				
8.	Production capacity				
9.	Operating environmental service conditions		State		
10.	Type test report and accreditation certificate		Provide		
11.	Surface integrity of hot-rolled sections for use in the manufacture of steel structures		State		
12.	Mechanical Properties (steel Gauge and Class)		State		
13.	Tensile strength of the steel		N/mm2		
14.	Yield stress of the steel		N/mm2		
15.	Tolerances for Mass/Thickness (max. ± 3)		mm		
16.	Elongation		%		
17.	Galvanizing Thickness (Min. ≥ 110 µm)		µm		
18.	Modulus of Elasticity		State		
19.	Density		State		
20.	Nominal length (mm)		mm		
21.	Finished materials surface (smooth and free from spots, dross and flaking, uneven and coating grey and Ash deposits)		state		
22.	Materials before and after fabrication are straight and free from twists				
23.	Sheared or cropped edge are dressed to clean finish and free from distortion		State		
24.	Type of Welding and Mode of cleaning of welds		State		
25.	A.ANGLES, CHANNELS, HOLLOW SECTIONS				
	Tensile strength	>430<460 N/mm2			
	Yield strength	255 N/mm2			
	Tolerances				
	Length	± 1mm to 3mm			

	Thickness	± 0.5mm			
	Out of square	Max deviation 2mm			
	Straightness	0.3 % of length			
	Elongation	24-26%			
	Galvanising thickness	>110 Microns			
	Modulus of Elasticity	20 x 10*9			
	Density	7860kg/m3			
	Nominal length	±0.4%			
	B. BOLTS/NUTS/WASHERS				
a	Safe working shear stress	120 N/mm2			
b	Grade of (Bolts/Nuts)	8.8			
c	Thread tolerances - threads	0.01mm			
d	Galvanizing Thickness	>85			
26	**Holes**				
	All holes are drilled in one operation and burrs are removed				
	Holes are not formed by a gas cutting process				
	All matching holes for bolts register with each other so that a gauge 2mm less in diameter than the diameter of the bolt passes freely through the assembled members in a direction at right angle to such members				
	Erection clearances for cleated ends of members connecting steel to steel				
	Bending of flat straps are carried out cold				
27	**Welding**				
	Type of welding				
	Mode of cleaning of welds				
28	**Galvanizing**				
	All punching, cutting, drilling, screw tapping and the removal of burrs are completed before the galvanising process commences				
	Type of galvanization				
	Galvanisation thickness				
	Bolts are completely galvanised including the threads, and the threads are left uncoated in the case of nuts				
	Uniformity of the zinc coating				
	Post-treatment after galvanization (chromating)				
28.	**Testing**	State			
	Tests to be performed during FAT	Required			
	Standards for Inspection and FAT testing	State			
	Copies of previous test certificates	State			

	All manufactured steel structures shall be offered for FATs and inspection in the presence of KPLC engineers at the manufacturers premises				
	Supplier shall replace without charge to KPLC items that do not meet specifications				
29.	**Markings**				
	"Property of KPLC" and grade of steel				

SCHEDULE 22: GUARANTEED TECHNICAL PARTICULARS- HIGH CONDUCTIVITY ALUMINIUM ALLOY TUBES FOR ELECTRICAL PURPOSES

Clause	Description		Bidder's offer
-	Name of the Manufacturer, address and Country of manufacturing		
	Name & address of Bidder		
	Type/Model Reference Number of items offered		
1	Scope: It shall be the responsibility of the supplier to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the aluminium alloy tubes for Kenya Power		
2	Applicable Standards		
3	Terms and Definitions		
4.1	General Requirements: 4.1.1 & 4.1.2		
4.2	Materials and Construction		
	4.2.1		
	4.2.2		
	4.2.3		
	4.2.4		
	4.2.5		
	4.2.6		
	4.2.7		
4.3	Dimensions	Outside diameter (mm)	
		Wall thickness (mm)	
		Length (m)	
4.4.1	Chemical Composition to BS EN 573-3	Silicon, Si (%)	
		Iron, Fe (%)	
		Copper, Cu (%)	
		Manganese, Mn (%)	
		Chromium, Cr (%)	
		Zinc, Zn (%)	
		Titanium, Ti (%)	
		Others – each (%)	
		Others – total (%)	
		Aluminium, Al (%)	
4.4.2	Mechanical Properties (to BS EN 755-2)	Temper	
		Yield stress (MPa)	
		Tensile strength (MPa)	
		Hardness (HB)	
		Elongation A (%)	
		Elongation A50mm (%)	
4.4.3	Physical Properties, 20 °C	Density (kg/m³)	
		Melting range (°C)	
		Electrical conductivity (MS/m)	
		Thermal conductivity (W/m.K)	
		Co-efficient of thermal expansion (10^{-6}/K)	
		Modulus of elasticity (GPa)	
	Mass per unit length, kg/m (at 20 °C)	40mm o.d., 4mm thickness	
		50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	
		40mm o.d., 4mm thickness	

	Second moment, cm⁴ (at 20 °C)	50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	
	Current carrying capacity, A (busbar temperature of 80 °C, ambient of 35 °C)	40mm o.d., 4mm thickness	
		50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	

SCHEDULE 23: GUARANTEED TECHNICAL PARTICULARS- LINE TOWERS

		Unit	Guaranteed Values					
Item	Particulars		Types of Towers					
			S	L	M	H	HS	T
1	Manufacturer Name and address	State						
	Country of manufacture	State						
3	Manufacturing experience (Mini.10 years)	State						
4	Service outside country of manufacturer (Mini.7 years)	State						
5	Delivery time	State						
6	Production capacity	State						
7	Type of towers (Mult circuit self-supporting, tubular monopole)	State						
Reference design standards		State						
9	2 Nos. Lattice self-supporting steel tower (Optional)	State						
10	Design Service conditions (Temperature and Altitude)	State						
11	Type test report and Accreditation certificates	Provide						
12	Tower steel material shall be high tensile steel (Grade S355J2G3 and S420)	State						
13	Basic design span (200-300 m)	m						
14	Factor of Safety for Normal and Broken conductor	State						
15	Design spans for towers (Basic/Wind/Weight and Upright)	Provide						
16	Minimum design loads for towers (Wind, Max. conductor tension and horizontal)							
	Wind pressure on conductor. OPGW & Pole structure (N/m2)							
b	Max conductor tension (N)							
17	Minimum Pole sections (bottom, Middle and taper) diameter and wall thickness	State						
18	Quality assurance Plan	Provide						
19	Towers Overall height (standard tower height)	m						
20	Tower body extensions (+0m)	m						
21	Step Bolts and Ladder	State						
22	Tower corrosion protection							
a	Hot-dip galvanization zinc coating thickness	µm						
b	Epoxy paint coating thickness for base plate and bottom member	State						
23	Tower identification and marking	State						
24	Base plate minimum thickness and diameter	mm/m						
25	Tower earthing and lightning protection	State						
26	Cross-Arm material and type of design	State						
27	Design of conductor cross-Arm spacing as per Live line maintenance	m						
28	Type and minimum length of cross-Arm	m						
28	Vertical clearance between OPGW top Phase conductor	m						
	Width of Tower body at:							
	Top Cross-Arm	m						
	Middle level	m						
	Bottom level (+0m)	m						
30	Weight of Towers:							

	+0m body extension		kg						
	+3m body extension		kg						
	+6m body extension		kg						
31	Earthing/grounding of Towers	Max. Earth resistance	Ω						
32	Tower member steel minimum thickness		6 mm						
33	Members Slenderness Ratio	Compression - 250	ratio						
		Tension - 350							
34	Tower Accessories (Step-bolts, Ladder, Number and danger plates, anti-climb device								
35	Type of foundation reinforcement steel bars		State						
36	Minimum tower foundation diameter		State						
37	Minimum foundation Design Depth:								
	+0m body extension	2400							
	+3m body extension		mm						
	+6m body extension		mm						
33	Width of Base Pad	Design							
	+0m body extension		mm						
	+3m body extension		mm						
	+6m body extension	2800	mm						
34	Minimum thickness of Base Pad								
	+0m body extension	500	mm						
	+3m body extension		mm						
	+6m body extension		mm						
35	Minimum width of Column (where applicable)								
	+0m body extension	1200	mm						
	+3m body extension		mm						
	+6m body extension		mm						
36	Bitumastic Paint	Pad & Column	State						
	Soil geotechnical investigation levels	S/L 1-3 and M/HS/T:1-4							
	Resistivity	Every tower spot							
	Ground water	S-5%, H/T-All							
	Minimum Backfilling	300 mm layers							
38	Concrete Trial mix	Before works	State						
	Cement strength	42.5	N/mm^2						
	Structural strength	25	N/mm^2						
	Precast strength	30	N/mm^2						
39	Stub provisions	Earthing point/Cleats	State						
40	Stub Length:	3000	mm						
	+0m body extension +3m body extension		mm						
	+6m body extension		mm						
	Stub Size & Thickness								
39	Anchor bolts/Stub setting out	Setting template	State						

40	Tower Test as per IEC 60652 and 60826	S+6 - 1 H+6 – 1	State						
41	Foundation Test as per IEC 61936-1, BS EN 50341, 1997, BS 1377 and 224tt	S+6 - 1 H+6 – 1	State						
	DIMENSIONS AND WEIGHT OF TOWER								
42	Overall height of standard tower (+0m)	m							
43	Length of top conductor crossarm	m							
44	Length of bottom conductor crossarm	m							
45	Vertical spacing of conductor:								
	Ground wire and top conductor	m							
	Top conductor and bottom conductors	m							
46	Width of tower body at:								
	Top of tower	m							
	Lowest crossarm	m							
	Ground level of standard tower (+0m)	m							
47	Weight of towers								
	-3m body extension	kg							
	+0m body extension	kg							
	+3m body extension	kg							
	+6m body extension	kg							
	LOAD ON FOUNDATION FROM TOWERS								
48	Compression Load								
	-3m body extension	kg							
	+0m body extension	kg							
	+3m body extension	kg							
	+6m body extension	kg							
49	Uplifting Load								
	-3m body extension	kg							
	+0m body extension	kg							
	+3m body extension	kg							
	+6m body extension	kg							
	CONCRETE PAD FOUNDATION AND STUB LENGTH								
50	Depth of Foundations								
	-3m body extension	mm							
	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
51	Width of Base Pad								
	-3m body extension	mm							
	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
52	Thickness of Base Pad								
	-3m body extension	mm							

	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
53	Top Width of Chimney								
	-3m body extension	mm							
	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
54	Bottom Width of Chimney								
	-3m body extension	mm							
	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
55	Volume of Excavation								
	-3m body extension	cu. m							
	+0m body extension	cu. m							
	+3m body extension	cu. m							
	+6m body extension	cu. m							
56	Volume of Concrete								
	-3m body extension	cu. m							
	+0m body extension	cu. m							
	+3m body extension	cu. m							
	+6m body extension	cu. m							
57	Length of Stubs: (stub length x cleat)								
	-3m body extension	mm							
	+0m body extension	mm							
	+3m body extension	mm							
	+6m body extension	mm							
	Markings								
58	“Property of KPLC” and grade of steel								
59	Information to be marked indelibly:								
60	Manufacturer Name/Trademark								
61	Designation of section								
62	Number of pieces in the bundle								
63	Length of the sections								
64	Weight of the bundle								
	Galvanizing								
65	All punching, cutting, drilling, screw tapping and the removal of burrs are completed before the galvanising process commences								
66	Type of galvanization								
67	Galvanisation thickness								
68	Bolts are completely galvanised including the threads, and the threads are left uncoated in the case of nuts								
69	Uniformity of the zinc coating								
70	Post-treatment after galvanization (chromating)								

71	All steel shall be free from blisters, scale, laminations, segregations and other defects, and no rolling laps								

SCHEDULE 24: GUARANTEED TECHNICAL PARTICULARS- LINE TOWERS AERIAL EARTHWIRE

Clause	**REQUIREMENT**	**BIDDER'S OFFER** *(indicate full details of offered item)*	
1	Name & address of manufacturer	state	
	Country of manufacture	state	
	Manufacturer's letter of authorization (for each item)		
2.0	Reference standards	state	
3.0	Terms & definitions	state	
4.1	Service Conditions	state	
4.2	**Stay Wires**		
4.2.1	Materials and standard of manufacture	specify	
4.2.1.1	Base metal and level of galvanization	specify	
4.2.1.2	Galvanized wire and standard of complied to	specify	
4.2.2	**Construction**		
4.2.2.1	Standard of manufacture of wires	state	
4.2.2.2	Direction of lay and lay ration	state	
4.2.2.3	Diameter tolerance of single wires	State value	
4.2.2.4	Pitch for concentrically twisted wires	State value	
4.2.2.5	Provision for joints	specify	
4.2.3	**Standard sizes of stay wires**		
	Standard Size (to BS 183)	State value	
	Grade (to BS 183)	State grade	
	Minimum elongation in 600mm, %	State value	
	Minimum breaking load, kN	State value	
4.3	**Guy Grips**		

Clause	**REQUIREMENT**	**BIDDER'S OFFER** *(indicate full details of offered item)*	
4.3.1	Size of stay wire and failing load	specify	
4.3.2	Standard of manufacture	state	
4.3.3	Standard of manufacture of steel wires	state	
4.3.4	Formation of guy grips and performance	specify	
4.3.5	Re-usability of guy grips	specify	

4.3 GUARANTEED TECHNICAL PARTICULARS FOR EQUIPMENTS AND MATERIALS

4.3.1 Preamble

4.3.1.1 The Guaranteed Technical Particulars Schedules MUST be filled in, signed and stamped by manufacturer for each LOT and submitted with the bidding document. Type test reports and Certificate of Accreditation from testing body/Laboratory MUST be provided for evaluation. Also, all relevant manufacturer's equipment technical documents MUST be provided for reference to support the guaranteed values.

4.3.1.2 Bidder shall offer only one type of equipment/material for each of the equipment/material required and from ***one manufacturer only.*** No more than one equipment/material of each type required shall be offered from more than one manufacturer. Where the bidder offers more than one equipment/material of one type from different manufacturers contrary to this clause, the employer shall choose ***only one of the equipment for evaluation***. All other equipment shall not be considered.

4.3.1.3 Only guaranteed technical particulars provided herein shall be filled **(*Do not fill technical guarantees in the attachments of KPLC material specifications).***

4.3.1.4 All data entered in the Guaranteed Technical Particulars are guaranteed values by the manufacturer and shall not be departed from whatsoever.

SCHEDULE 1: GUARANTEED TECHNICAL PARTICULAR - PHASE CONDUCTOR

GURANTEES FOR PHASE LINE CONDUCTOR			Guaranteed Value		Ref. Doc
Item	**Particulars**	**Unit**	**150mm^2 ACSR**	**300mm^2 AAAC**	
1	**Phase Stranded conductor**				
	Manufacturer and Country of manufacture				
	Year of service outside the country of manufacture (5 years Minimum)	Years			
	Manufacturing experience (7 years minimum)	Years			
	Type of Conductor/Code Name	State			
	Reference IEC/BS Standards	State			
	Type test reports and Accreditation certificate	State			
	Aluminium wire	Nos/mm			
	Steel wire	Nos/mm			
	Overall conductor diameter	mm			
	Nominal cross-sectional area of conductor	mm^2			
	Minimum current rating	A			
	Cross-section of Aluminium area	mm^2			
	Cross-section of Steel area	mm^2			
	Weight per km	kg			
	Rated tensile strength	KN			
	Maximum DC resistance at 20 ^oC	Ω/m			
	Maximum AC resistance at 75 ^oC	Ω/m			
	Resistivity at 20 ^oC	mm^2/m			
	Continuous max. operating temperature	^oC			
	Modulus of Elasticity	kg/mm^2			
	Conductor lay	state			
	Minimum weight of grease	Kg/km			
	Length of conductor per drum	m			
	Approximate net weight per drum	kg			
2	**Individual wires before stranding**				
	Tolerance of diameter of Aluminium wire	%			
	Tolerance of diameter of Steel wire	%			
	Minimum tensile strength of Al. wire	kg/mm^2			
	Minimum tensile strength of Steel wire	kg/mm^2			
	Conductivity of AL	%			
	Minimum twisting number of steel wire: -100 x diameter (length)	Nos.			
	Galvanization: - Min. coating weight of Zinc	grams/m^2			

SCHEDULE 2: GUARANTEED TECHNICAL PARTICULARS - OUTDOOR CIRCUIT BREAKERS

GURANTEES FOR OUTDOOR CIRCUIT BREAKERS			Guaranteed Values	Refer. Doc
Item	**Particular Specifications**	**Unit**	**66 KV**	
1	Circuit Breakers type (Model)	State		
2	Manufacturer and Country	State		
3	Reference IEC/BS Standards	State		
4	Year of service outside the country of manufacturer (5ears minim)	Years		
	Manufacturing experience (10 years minimum)	Years		
5	Operating service conditions (Altitude and temperature)	State		
6	Type test reports and Accreditation certificate	State		
7	Arc quenching Medium	State		
8	Pole design operation (ganged)	State		
9	Tank design type	State		
10	Highest rated voltage	kV		
11	Nominal rated Voltage	kV		
12	Rated frequency	Hz		
13	Rated continuous current at 40 ^{o}C	A		
14	Lightning Impulse withstand voltage 1.2/50µs	kVpeak		
15	One minute power frequency withstand voltage, dry and wet	kVrms		
	Rated short-time (short circuit) current/3sec.	kArms		
	Rated short circuit making current for 3 Sec	kApeak		
16	Maximum contact resistance of Main Contact	Ohms		
17	Rated operation Sequence	State		
18	Rated Current Breaking capacity	kApeak		
19	Bushing type	State		
20	First pole to clear factor	State		
21	Minimum creepage distance of Insulator	mm		
22	Minimum clearance between phases	mm		
23	Minimum clearance to Earth	mm		
24	Opening time	State		
25	Closing time	State		
26	Operating mechanism type	State		
27	Rated control voltage Tripping/Closing coil	Vdc		
28	Spring charging motor/Control voltage	Vdc		

29	Main contact material	State			
30	Charging spring status indication	State			
31	Terminal connector material (Tinned Bi-metallic)	State			
32	Number of Auxiliary contacts (NO and NC)	No			
33	Minimum Operations permissible before maintenance	No			
34	Manual ON and OFF operation Switch	State			
35	Anti-Pumping device	State			
36	Auxiliary supply (Single phase)	State			
37	Circuit Breaker Position Indication	State			
38	Heaters and Hygrometer	State			
39	Mechanical Trip/Close device	State			
40	Control cubicle IP Class	State			
41	Control cubicle powder coating colour shade	State			

SCHEDULE 3: GUARANTEED TECHNICAL PARTICULAR FOR ISOLATORS WITH/WITHOUT EARTH SWITCH

Item	Particular Specifications	Unit	Guaranteed Value	Refer. Doc
			66 KV	
1	Disconnector type/Model	State		
2	Manufacturer and country	State		
3	Disconnector design type (Double side break and horizontally opening)	State		
4	Operating service conditions (Altitude and temperature)	State		
5	Reference Standards	State		
6	Type test reports and Accreditation certificate	State		
7	Manufacturing experience (10 years minimum)	Years		
8	Years of service outside country of manufacture (5 years min)	Years		
9	Rated Voltage	kV		
10	Nominal voltage	kV		
11	Lightening Impulse withstands voltage 1.2/50ms			
	Contacts Closed	kV peak		
	Contacts Open	kV peak		
12	Rated Power frequency Voltage withstand (Wet and dry)			
	Contacts Closed	kVrms		
	Contacts Open	kVrms		
13	Rated frequency	50 Hz		
14	Rated Continuous operating current	Amps		
15	Rated short circuit withstand current for 3 seconds	KA/3Sec		
16	Minimum creepage distance of Insulators	mm		
17	Mechanical endurance (Min. Open–Close)	Cycle		
18	Maximum open and Closing time	Seconds		
19	Drive mechanism Motor protection	State		
20	Contact resistance of Main contacts	micro-Ω		
21	Main contact material (Tinned Copper)	State		
22	Thickness of Silver/Tin coating	microns		
23	Isolator Mechanical handle	State		
24	Electrical and mechanical operations before maintenance	State		
25	Motor Control Voltage	Vdc		
26	Auxiliary supply (Single phase)	Vac		
27	Integral earths Switch where required	State		

Item	Particular Specifications	Unit	Guaranteed Values		Refer. doc.
28	Earth switch Mechanical and electrical operation before maintenance	State			
29	Earth Switch mechanical handle	Provide			
30	Isolator and Earth switch mechanical interlock (Available /Not available)	State			
	Isolator and Earth switch Electrical interlocks (Available/not Provided)	State			
31	Minimum no. of spare Auxiliary NO and NC contacts	Nos			
32	Control Box IP degree of protection	State			
33	Padlocking facility required	State			
34	Thickness of zinc galvanization of ferrous parts	State			
35	Earthing points	State			
36	Insulator material (Brown glazed porcelain)	State			

SCHEDULE 4: GUARANTEED TECHNICAL PARTICULAR - OUTDOOR CURRENT TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Values	Refer doc.
			66 KV	
1	Current transformer type (Oil-hermetically sealed)	State		
2	Manufacturer and Country	State		
	Manufacturing experience (10 years minimum)	Years		
3	Service operating conditions (Altitude/Temperature)	State		
4	Years of service outside country of manufacture (5 years min.)	Years		
5	Type test reports and Accreditation certificate	State		
6	Reference IEC/BS standards	State		
7	Rated Highest voltage	kV		
8	Nominal Voltage	kV		
9	Current transformer tank design type (Dead tank)	State		
10	Rated frequency	Hz		
11	One-minute Power frequency Voltage withstand			
a	Primary winding	kVrms		
b	Secondary winding Insulation level	kVrms		
12	Lightning impulse withstand voltage 1.2/50µms	kVpeak		
13	Primary Rated currents ratios	A		
14	Rated secondary current	A		
15	CTs Core, Class and Burden	Core 1 Core 2 Core 3 Core 4		
16	Short circuit withstand current for 3seconds	kA peak		
17	Safety factor	State		
	Instrument Security factor	State		
18	Maximum Temperature rise (Winding/Oil)	State		
19	Number of cores	No		
20	Primary and Secondary winding material	State		
21	Primary terminal material	State		
22	Bushing type	State		
23	Minimum creepage distance of insulator	mm		
24	Secondary and Primary Earthing points	State		
25	IP Class of terminal box	State		
26	Marking/Labelling	State		

SCHEDULE 5: GUARANTEED TECHNICAL PARTICULARS - OUTDOOR VOLTAGE TRANSFORMERS

Item	Particular Specifications	Unit	Guaranteed Value	Refer. doc.
			66 KV	
1	Voltage transformer type	State		
2	Manufacturer and Country	State		
	Manufacturing experience (10 years minimum)	Years		
3	Years of service outside country of manufacture (5 years Min.)	Years		
	Service operating conditions (Altitude and temperature)	State		
4	Type test reports and Accreditation certificate	State		
5	Reference IEC/BS standards	State		
6	Rated Highest voltage	kV		
7	Nominal Voltage	kV		
8	Voltage transformer tank design type	State		
9	Rated frequency	Hz		
10	One-minute Power frequency Voltage withstand	State		
a	Primary winding	kVrms		
b	Secondary winding Insulation level (minimum 2.5kV)	kVrms		
11	Lightning impulse Voltage withstand at 1.2/50µs	kVpeak		
12	Short circuit withstand current for 3 Seconds	kApeak		
13	Burden and Accuracy class	State		
14	Number of cores	State		
15	Protection winding Class, Burden at 0.8Pf lagging	State		
16	Measuring winding Class and Burden at 0.8Pf lagging	State		
17	Voltage Ratio (Primary/Secondary)	State		
18	Maximum Temperature rise (Winding/Oil)	State		
19	Rated Voltage safety factor	State		
20	Instrument Security factor	State		
21	Permissible partial discharge (PD): PD test Voltage (r.m.s) = Um/√3 PD test Voltage (r.m.s) = 1.2Um√3	State		
22	Primary and secondary winding material	State		
23	Primary terminal	State		
24	Bushing type (Brown glazed porcelain)	State		
25	Minimum creepage distance	mm		
26	Secondary and Primary Earthing Point	State		
27	IP Class of terminal box	State		
28	Markings/Labelling	State		

SCHEDULE 6A: GUARANTEED TECHNICAL PARTICULARS FOR COMPOSITE 66KV LINE POST INSULATORS (VERTIVAL AND HORIZONTAL)

66 KV COMPOSITE INSULATORS					
Item	**Particulars Specifications**	**Unit**	**Guaranteed Value**		**Refer Doc.**
			Vertical	**Horizontal**	
1.	Insulator type (Polymeric)	State			
2.	Design type and Service condition (Altitude and temperature)	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Manufacturing experience (10 years minimum)	Years			
6.	Year of service outside the country of manufacture (5 years minimum)	Year			
7.	Type test reports and accreditation certificate of testing laboratory	Provide			
8.	Rated Highest Voltage (kV)	kV			
9.	Nominal Voltage	kV			
10.	Minimum failing Load	KN			
11.	Pollution Category	state			
12.	Dielectric material (Silicon rubber)	state			
13.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}			
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
15.	Minimum creepage distance	mm			
16.	Nominal total height	mm			
17.	Short circuit withstand current/3sec	KA			
18.	Housing shield resistance	KΩ			
19.	Shed spacing –projection ratio	state			
	Minimum distance between sheds	mm			
20.	Creepage clearance ratio				
21.	Specified mechanical load, tension (Minimum)	kN			
22.	Material of fittings				
23.	Minimum sheath thickness	mm			
24.	Material of housing and sheds (HTV silicon)	state			
25.	Minimum distance between sheds	state			
26.	Zinc coating thickness on ferrous parts	state			
27.	Colour of final insulator housing	state			
28.	Minimum sheath thickness of Silicon	state			
29.	Number of units	No			
30.	Mounting brackets	state			

SCHEDULE 6B: GUARANTEED TECHNICAL PARTICULARS FOR COMPOSITE INSULATORS (TENSION AND SUSPENSION TYPE)

Item	Particular Specifications	Unit	Guaranteed Value				Refer Doc.
			Suspension type		Tension type		
			11KV	66 KV	11KV	66 KV	
1.	Insulator type (Polymeric)	State					
2.	Design type/Model	State					
3.	Manufacturer and Country	State					
4.	Reference IEC/BS Standards	State					
5.	Service operating condition	State					
6.	Manufacturing experience (10 yrs min.)	Years					
7.	Year of service outside country of manufacture (5yrs min.)	Year					
8.	Type test reports and Accreditation certificate	Provide					
8.	Rated highest Voltage (kV)	kV					
9.	Nominal Voltage	kV					
10.	Failing tensile load/strength	KN					
	Cantilever failing load	KN					
11.	Pollution Category	State					
12.	Dielectric material	State					
13.	One-minute power frequency withstand voltage, 50 Hz, wet and dry	kV_{rms}					
14.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}					
15.	Minimum creepage distance	mm					
16.	Insulator Housing characteristics						
	One-minute power frequency withstand voltage, 50Hz, wet and dry	kV_{rms}					
	Lighting impulse withstand voltage, 1.2/50µs wet	kV_{peak}					
17.	Short circuit withstand current for 3sec	kA					
18.	Housing shield resistance	kΩ					
19.	Permissible head load (Static)	N					
	Permissible head load (dynamic)	N					
21.	Insulator of fittings	Provide					
22.	Material of housing and sheds (HTV silicon)	State					
23.	Minimum distance between sheds	State					
24.	Zinc coating thickness of ferrous parts	State					
25.	Colour of final insulator housing	State					
26.	Minimum sheath thickness of Silicon	State					

SCHEDULE 6C: GUARANTEED TECHNICAL PARTICULARS FOR SUBSTATION POST INSULATORS

Item	Particular Specifications	Unit	Guaranteed Value		Refer Doc.
			66KV	11 KV	
	Insulator type (Porcelain for Substation)	State			
2.	Design type	State			
3.	Manufacturer and Country	State			
4.	Reference IEC/BS Standards	State			
5.	Service operating conditions (Altitude and temperature)	State			
6.	Manufacturing experience (10 years min)	Years			
7.	Year of service outside the country of manufacture (5 years min.)	Year			
8.	Type test reports and Accreditation certificate	Provide			
9.	Rated highest Voltage (kV)	kV			
10.	Nominal Voltage	kV			
11.	Maximum Mechanical failing Load	KN			
12.	Pollution Category	State			
13.	Dielectric material (Silicon rubber)	State			
14.	One-minute power frequency withstand voltage at 50 Hz, (wet and dry)	kV_{rms}			
15.	Lighting impulse withstand voltage, 1.2/50µs	kV_{peak}			
16.	Minimum creepage distance	mm			
17.	Nominal total height	mm			
18.	Short circuit withstand current/3sec	kA			
19.	Housing shield resistance	kΩ			
20.	Shed spacing–projection ratio	state			
	Minimum distance between sheds	mm			
21.	Creepage clearance ratio	State			
22.	Cantilever failing load	kN			
23.	Maximum Puncture rated voltage	kV			
24.	Insulator of fittings	Provide			
25.	Minimum sheath thickness	mm			
26.	Material of housing and sheds	State			
27.	Minimum distance between sheds	State			
28.	Zinc coating thickness on ferrous parts	State			
29.	Colour of final insulator housing	State			

SCHEDULE 7: GUARANTEED TECHNICAL PARTICULARS FOR SURGE ARRESTORS

11KV AND 66KV SURGE ARRESTORS					
Item	**Particular Specifications**	**Unit**	**Guaranteed Values**		**Refer. doc**
			66KV	**11KV**	
1	Surge arrestor type (Metal Oxide (MOV) Gapless	State			
2	Manufacturer and country of origin	State			
3	Service operating conditions (Altitude and temperature)	State			
4	Reference IEC/BS Standards	State			
5	Type test reports and Accreditation certificate	Provide			
	Manufacturers experience (10 years minimum)	Years			
6	Minimum years of service outside country of manufacture (5 years minimum)	Years			
7	Surge arrestor housing (Polymeric)	State			
8	Highest system Voltage (Um, KV)	kV			
9	Rated frequency	Hz			
10	Rated Voltage (Ur, KV)	kV			
11	Max, continuous Operating Voltage	kVrms			
12	Nominal discharge current	kA			
13	Nominal discharge current	kA			
14	Short circuit withstands current Asymmetrical peak	kA			
15	Maximum duration of Earth fault as per IEC 60099-4	Sec			
16	Long duration discharge class	A/µS			
17	Partial discharge	pC			
18	Energy discharge capability at Ur	KJ/KV			
19	Temporary Over voltage with stand for 1Sec.	kV rms			
20	Temporary Overvoltage withstand for 10 Sec.	kV rms			
22	Distribution and Discharge class	kA/Class			
23	Earth fault factor as IEC 60099-4	State			
24	Maximum response time/operation time	Micro-sec			
25	System Lightning Impulse withstand voltage 1.2/50µs	kV peak			
26	One minute System power frequency withstands Voltage, dry and wet	kV rms			
27	Short circuit current withstands	kA/3Sec.			
28	Housing shield resistance	kΩ			
29	Creepage distance	mm			
30	Maximum residual Voltage at steep lightning and switching impulse currents at;				
a	10kA (1/2µS)	State			
	40kA (80/20µS)	State			
b	500kA (30/70µS)	State			
	2kA (30/70µS)	State			
	Max. Lightning Impulse Protection Level	kVpeak			

31	Steep current impulse protection level	kVpeak			
32	Operation counter	State			
33	Leakage current meter/Indicator	State			
34	Mounting base type	State			
35	Number of units per complete insulator (1)	No			

SCHEDULE 8: GUARANTEED TECHNICAL PARTICULARS FOR DC SYSTEM

48V AND 110 VDC LITHIUM-ION PHOSPHATE BATTERY SYSTEM				
			110V/265Ah	**48V/165Ah**
A. GENERAL				
1	Battery type (lithium ion phosphate, prismatic, rechargeable)	*State*		
2	Manufacturer and Country	*State*		
3	Reference IEC/IEEE/UL Standards (IEC 62619, IEC 62620, IEC 62485-5, IEEE 946, UL 1973)	*State*		
	Manufacturing experience (10 years min)	*State (years)*		
4	Years of service outside the country of manufacture (5 years min)	*State (years)*		
5	Type test reports and ISO/IEC 17025 accreditation certificate of testing laboratory	*State*		
B. LITHIUM ION PHOSPHATE BATTERY UNIT				
8	Ambient operating temperature	*State (°C)*		
9	Maximum operating temperature	*State*		
10	Cell designation (nominal voltage per cell and capacity)	*State*		
11	Discharge rate type of cells as per IEC 62620 (medium rate, M)	*State (Ah)*		
12	Rated Capacity at C5 (5-hour rate) at 25°C	*State (V)*		
13	Discharge end voltage at 25±5°C	*State (no.)*		
14	Number of cells per bank	*State*		
15	Cell rated voltage	*State (V)*		
	Nominal voltage per cell	*State (V)*		
	Float / charge voltage per cell (controlled via BMS)	*State (V)*		
	Boost voltage per cell	*State (years)*		
16	Design life span (15 years minimum)	*State (cycles)*		
17	Cycle life (5000 or more full discharges with less than 10% capacity loss)	*State (A)*		
18	Nominal capacity normal charging current (maximum 0.2C5)	*State (°C)*		
19	Recommended charging voltage (per cell)	*State (°C)*		

48V AND 110 VDC LITHIUM-ION PHOSPHATE BATTERY SYSTEM				
			110V/265Ah	**48V/165Ah**
20	Internal resistance at 25°C	*State*		
21	Ageing coefficient	*State*		
22	Charge efficiency (97% minimum)	*State (Ah)*		
23	Operating temperature range	*State (V)*		
	a) Discharge (−20 to 60°C)	*State (no.)*		
	b) Charge (−10 to 60°C)	*State*		
	c) Storage (−30 to 75°C)	*State (V)*		
24	Cells hermetically sealed, maintenance free	*State (V)*		
25	Cell container material (stainless steel or aluminium alloy) and shape (prismatic)	*State (V)*		
26	Sealing lid attachment (laser welded)	*State (years)*		
27	Dimensional tolerance (±1% as per IEC 62620)	*State (cycles)*		
28	Overall dimensions per cell	*State (A)*		
	Height, h (max)	*State (°C)*		
	Width, d	*State*		
	Length, b (max)	*State*		
	Cell connection bolt size	*State (Ah)*		
	Approximate cell weight	*State (V)*		
29	Positive electrode material (lithium ion phosphate)	*State (no.)*		
30	Negative electrode material (graphite)	*State*		
31	Separator material (layers of polypropylene fibrous membrane)	*State (V)*		
32	Electrolyte composition (as per IEC 62619 / IEC 62620)	*State (V)*		
33	Positive terminal (aluminium) and negative terminal (nickel-plated copper)	*State (V)*		
34	Nickel-plated copper and bimetal lugs for load wiring supplied	*State (years)*		
35	Pressure relief vent / venting device	*State (cycles)*		

48V AND 110 VDC LITHIUM-ION PHOSPHATE BATTERY SYSTEM				
			110V/265Ah	**48V/165Ah**
36	Insulating film around each cell	*State*		
37	Cell marking and labelling (manufacturer, serial no., type, date, country, voltage, Ah, polarity, 'PROPERTY OF KPLC')	*State*		
C. BATTERY MANAGEMENT SYSTEM (BMS)				
38	BMS provided: monitors voltage, current, temperature and state of charge	*State*		
39	Under-voltage, over-voltage, over-current, short-circuit and over-temperature protection	*State*		
40	Active and passive cell balancing	*State*		
41	Battery internal resistance monitoring	*State*		
42	LCD display of cell voltage, state of charge, temperature and alarms	*State*		
43	GPS positioning and tracking function	*State*		
44	Data memory (at least 10,000 run logs, SD card, first-in first-out export)	*State*		
45	Communication protocols (RS 485, CANBUS/Modbus)	*State*		
46	Remote monitoring (SNMP and LAN) and interface to substation automation	*State*		
47	Alarm and data logging facility	*State*		
48	Parallel battery bank operation	*State*		
D. BATTERY CHARGER				
49	Charger rating: output voltage and battery bank rating served	*State*		
	DC output voltage, nominal	*State (V)*		
	Float range	*State (V)*		
	Boost range	*State (V)*		
50	Rated DC output current	*State (A)*		
51	Trickle (maintenance) current range	*State (A)*		
52	Boost current range	*State (A)*		
53	Mains type (number of phases)	*State*		
54	Mains AC voltage and permitted variation	*State*		

48V AND 110 VDC LITHIUM-ION PHOSPHATE BATTERY SYSTEM				
			110V/265Ah	**48V/165Ah**
55	Frequency and permitted variation	*State (V)*		
56	DC output voltage regulation (±1% at float voltage, 0 to 100% load)	*State (V)*		
57	Cubicle material, vermin-proof and well ventilated (steel sheet)	*State (V)*		
58	Cubicle mounting (floor mounted, holding down bolts)	*State (A)*		
59	Cubicle colour (dark admiralty grey, shade 632 of BS 381C) and coating thickness (80 µm min)	*State (A)*		
60	Automatic trickle and boost charging, constant current method	*State (A)*		
61	Boost charge temperature cut-off, settable timer and voltage drop detection	*State*		
62	Protection against reverse polarity and overloads	*State*		
63	Power transformer (double wound, air cooled, earth shield)	*State (V)*		
64	Alarm repeat relay (two contacts: local and SCADA)	*State (V)*		
65	Local alarm annunciator (LED/LCD, manual reset)	*State (V)*		
66	Alarms provided (charger failure, earth fault, battery low/high voltage, mains failure, boost charge failure, battery temperature cut-off)	*State (A)*		
67	Indicating instruments (ammeters, voltmeters, centre-zero ammeter)	*State (A)*		
68	Isolation switches and MCBs	*State (A)*		
E. BATTERY CABINET, ACCESSORIES AND INTER CELL CONNECTORS				
69	Cabinet material (phosphatized steel with powder epoxy acid-resistant coating)	*State*		
70	Cabinet seismic design (category D, Occupancy Category IV, 0.50g SDS, Ip 1.5 as per IBC2006)	*State*		
71	Cabinet supplied fully wired and assembled	*State*		
72	Accessories supplied (digital voltmeter, cell lifter, cell numbers, anticorrosion compound, goggles, apron, gloves to IEC 60903)	*State*		

48V AND 110 VDC LITHIUM-ION PHOSPHATE BATTERY SYSTEM				
			110V/265Ah	**48V/165Ah**
73	Inter cell connector material (nickel-plated copper) and insulation / shrouds	*State*		
74	Connector rating (30-minute discharge current; short circuit 4 kA for 1 s)	*State*		
75	Bolts, nuts and washers material (nickel-plated or stainless steel)	*State*		

SCHEDULE 9: GUARANTEED TECHNICAL PARTICULARS FOR CONCRETE POLES

LINE CONCRETE POLES					
Item	**Particular Specifications**		**Employer's requirement**	**Guaranteed Value**	**Refer doc.**
1	Name and Address of the Manufacturer		State		
	Minimum years of manufacturing (7 years min)		State		
	Minimum years of poles service in Kenya (5 years min)		State		
	Model of the offered poles		State		
	Manufacturer's warranty and guarantee		Provide		
2	Sizes of the Poles Offered		State		
3	Reference Design Standard of manufacture		State		
4	Reference testing Standard		State		
5	Type of pole offered	Reinforced	State		
		Pre-stressed	State		
6	**Minimum poles requirement**				
a	Design Strength		State		
b	Quality of finish		State		
c	Admixture		State		
d	Mode of compaction		State		
e	Finished pole free from honeycombing		State		
7	Earthing (Conductor material size)		State		
8	Provision of Earthing Ferrules		State		
9	**Size and strength Class of poles**				
a	Pole taper		State		
b	Safety Factor		State		
c	Color of finished poles		State		
d	Manufacturing Capacity (units per month)		state		
e	Type Test Reports and Accreditation certificate		provide		
f	Type test Certificate from KBES as per ISO/IEC 17025		provide		
g	Acceptance tests to be witnessed by KPLC Engineers		List		

SCHEDULE 10: GUARANTEED TECHNICAL PARTICULARS FOR POWER TRANSFORMER

GUARANTEES FOR 23MVA 66/11KV POWER TRANSFORMERS				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
1.	Power transformer Make/Model	State		
2.	Manufacturer and Country	State		
3.	Minimum Manufacturing experience (13 years)	Years		
4	Minimum years of service outside country of origin (7 years)	Years		
5.	Design Service operation conditions (Altitude and Temperature)	State		
6.	Type test reports and accreditation certificate	Provide		
7.	Reference IEC/BS standards	State		
8.	Transformer nominal capacity	MVA		
9.	Rated voltage and Frequency	kV/Hz		
10.	Vector Group as per given region	State		
11.	Nominal Voltage	kV		
12.	One-minute Power frequency Voltage withstand, 50Hz, 60 sec, wet			
	Primary winding Insulation level	kVrms		
	Secondary winding Insulation level	kVrms		
13.	Lightning impulse withstands voltage 1.2/50µs, wet +Ve	kVpeak		
	Primary winding	State		
	Secondary winding	State		
14.	Continuous maximum rating current on Nominal and extreme tapping at ambient temperature	A		
15.	Capacity during ONAN Cooling (Maximum)	MVA		
16.	Rated No-load voltage at rated frequency on:			
17.	HV, principal tapping	kV		
	HV, Highest tapping	kV		
	HV, Lowest tapping	kV		
	LV winding	kV		
18.	Tapping ranges from principal tapping			
	HV no of plus tappings	No		
	HV no of minus tappings	No		
	Neutral positions			
	HV steps in % of rated voltage	State		
19.	No-load losses at:			
	90 % rated voltage and frequency	kW		
	100% rated voltage and frequency	kW		
	110% rated voltage and frequency	kW		
20.	No-load current at rated voltage and frequency	A		
21.	Total No load loss (Core +Stray loss) at rated current at 75^{o} C (%)	kw		
22.	Total losses at 75^{o}C on principal tapping at unity power factor and rated currents (ONAN)	Kw		
23.	Impedance at rated current and frequency at 75^{o} C			
	Positive sequence at nominal tap	%		
	Positive sequence at Max. Voltage tap	%		
	Positive sequence at Min. Voltage tap	%		
	Maximum temperature rise on continuous operation at rated			

24.	MVA for:			
	Top oil (by thermometer)	^oC		
	Windings (by resistance)	^oC		
25.	Efficiency at 75^oC on principal tapping, at unity power factor and at 0.8 pf lagging			
	120% full load	%		
	100% full load	%		
	75% full load	%		
	50% full load			
26.	Regulation at full load at 75^oC on principal tapping			
	At unity power factor:	%		
	At 0.8 power factor Lagging	%		
27.	HV, LV and Neutral windings insulation type	State		
28.	Maximum working flux density at rated voltage on principal tapping and rated frequency:	T		
29.	Core design type	State		
30.	Grade of laminated and maximum thickness	mm		
31.	Magnetizing current at nominal voltage at principal tapping	A		
32.	Maximum hot spot temperature of winding	^oC		
33.	Equivalent resistance referred to HV side	ohms		
34.	Equivalent reactance referred to HV side	ohms		
35.	Maximum current carrying capacity of bushings			
	HV bushings	A		
	LV bushings	A		
36.	Maximum noise level	State		
	Transformer and tap changing equipment energized and at no-load with ONAN cooling	dB		
37.	Number of core legs	State		
38.	Type of windings:	State		
	HV	State		
	LV	State		
39.	Winding conductor material (HV/LV/Neutral)			
40.	Bushing's material (HV/LV/Neutral)	State		
41.	Principal bushing insulator materials (HV/LV/Neutral)			
42.	Creepage distance of Bushing (HV/LV)			
43.	Thickness of transformer tank (Sides/Bottom/Top)	mm		
44.	Thickness of tank paint coating	mm		
45.	Type of Gasket material and Manufacturer	state		
46.	Transformer color coating (Admiral grey)	State		
47.	Thickness of radiator plates	mm		
48.	Thickness of radiator hot dip zinc galvanizing coat	micron		
49.	Number of radiators	No		
50.	Total weight of the transformer with and without oil	kg		
51.	Inspection manholes and sizes	N0/mm		
52.	**On-load tap changer**			
53.	Model and manufacturer	state		
54	Type Vacuum (In-tank)	state		
55	Total number of tappings including principal	17		

56	Rated currents of			
57	Selector switch	A		
58	Diverter switch	A		
59	Resistors	A		
60	Driving motor power consumption	kW		
61	Driving motor (3-phase, 415Vac/50hz)	State		
62	Control cabinets with heaters	State		
63	Voltage regulating relay supply	Vdc /Vac		
64	Motor drive unit Control Voltage (230Vac/50Hz)	1-phase		
65	Paralleling circuit wired, Master–Follower Mode of operation	State		
66	RTCC Panel with AVR relay	State		
67	Overall dimensions of transformer (LXWXH)	mm		
68	Winding and Top oil temperature indicators	State		
69	Pressure relief device	State		
70	Silica gel breathers	State		
71	Buchholz relays	State		
72	Alarms and trip to be provided including;	State		
	Oil/gas flow transformer, alarm	State		
	Oil/gas flow transformer, trip	State		
	Oil gauge low level, alarm	State		
	Oil gauge low level, trip	State		
	Top oil temp. high, alarm	State		
	Top oil temp. critical, trip	State		
	Winding temp. high, alarm	State		
	Winding temp. critical, trip	State		
73	Temperature indicators required:	State		
	HV and LV winding	State		
78	Oil level gauges required	State		
	Main conservator tank	State		
79	Bushing CTS to be provided as per VOL. II Biding document works requirements	Required		

SCHEDULE 11: GUARANTEED TECHNICAL PARTICULTARS FOR AUXILIARY TRANSFORMER

AUXILIARY TRANSFORMERS 100 KVA, 11/0.42 KV				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
1	Transformer Make/Model	State		
2	Manufacturer and Country	State		
3	Minimum years of service outside country of origin (7 years min)	Years		
	Minimum manufacturing experience (13 years min)	Years		
4	Design Service operating condition (Altitude and temperature)	State		
5	Type test reports and accreditation certificate	Provide		
6	Reference IEC/BS standards	State		
7	Transformer capacity	MVA		
	Highest rated voltage (HV/LV)	kV		
8	Rated Frequency	Hz		
9	Vector Group (Dyn11)	State		
10	Nominal Voltage (HV/LV)	kV		
11	One-minute Power frequency Voltage withstand			
	Primary winding	kVrms		
	Secondary winding (0.42)	kVrms		
12	Lightning impulse withstands voltage 1.2/50µs - Primary winding	kVpeak		
13	Continuous maximum rating on any tapping when operation under the ambient conditions	KVA		
14	**Off- load tap changer**			
	Rated Off-load Voltage at rated frequency on:			
	HV, principal tapping	kV		
	HV, extreme plus tapping	kV		
	HV, extreme minus tapping	kV		
15	Tapping ranges from principal tapping:			
16	HV no of plus tappings	No		
	HV no of minus tappings	No		
	Total tap positions (5)	No		
17	HV steps in % of rated voltage (± 2 x 2.5%)	%		
18	No-load losses at 75^{o} C	kw		
19	Load losses at 75^{o} C			
	50 % loading, rated voltage and frequency	kW		
	75% loading, rated voltage and frequency	kW		
	100% loading, rated voltage and frequency	kW		
	125% Loading, rated voltage and frequency	kW		
21	No-load current at rated voltage and frequency	A		
22	Total No load loss (Core +Stray loss) at rated current at 75^{o} C (%)	kw		

AUXILIARY TRANSFORMERS 100 KVA, 11/0.42 KV TRANSFORMER				
Item	**Particular Specifications**	**Unit**	**Guaranteed Value**	**Refer. Doc.**
23	Total load losses at 75°C at rated currents	KW		
24	Impedance voltages at rated current, Unity power factor and frequency at 75° C at nominal tap	%		
25	Max temperature rise at			
	i) Top oil	°C		
	ii) Winding	°C		
26	Efficiency at 75°C on principal tap, at unity power factor and at 0.8 power factor lagging;			
	120% full load	%		
	100% full load	%		
27	HV and LV windings insulation type			
28	Maximum working flux density at rated voltage on principal tapping and rated frequency:	Tesla		
29	Core design type	State		
30	Grade of laminated CRGO and manufacturer	State		
31	Winding conductor material (HV, LV and Neutral)	Copper		
32	Bushing material (HV and LV)	State		
33	Total creepage distance for porcelain Bushing (HV/LV)	State		
34	Thickness of transformer tank (minimum)			
a	Corrugated sides	3.0mm		
b	Bottom	5.0 mm		
c	Top	5.0 mm		
35	Thickness of tank paint coating (minimum)	micron		
36	Finished transformer color (Admiral grey)	State		
37	Following devices shall be installed:			
	Pressure relief	State		
	Oil level indicator visible from ground	State		
	Non-standard Nuts/Bolts on top cover	State		
	Lifting lugs and Arcing horns	State		
38	Sound level at 100% Load	State		

SCHEDULE 12: GUARANTEED TECHNICAL PARTICULARS - PROTECTION IEDS (RELAYS)

GUARANTEES FOR DISTANCE PROTECTION RELAY				
Item	**Particular Specifications**	**Units**	**Guarat Value**	**Refer. Doc**
1.	Manufacturer's Name and Country	State		
	Type or designation name of Relay	State		
	Minimum of 10 years Manufacturing experience	state		
	Minimum of 5 years in service outside country of manufacture	state		
	Type test report and Accreditation certificate	Provide		
	Manufacturing reference standards	State		
	Ratings: Ac Inputs: 1-5Amp	State		
	Power Supply Voltage: 110VDC or (Universal 24-240Vdc).	State		
	Evidence of sales in 3 other continents outside the continent of manufacture (state Countries)	State		
	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
	Model design type (numerical)	state		
	Supported communication protocols 60870- 5-103, 61850-9-2	State		
	Mounting design (Flush)	State		
	suitable for use on a feeder in a 1&1/2 Breaker substation arrangement. (suitable/not suitable)	state		
2.	High speed output relays for circuit breaker opening (state no. of output relay).	State		
	Full Scheme Distance relay (scheme type)	state		
	Number of similar Relay sold to date to the export market: requirement; minimum number 1000	State		
	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
	Operating time for fast operating output relays	State		
	Operating time for other output trip relays	State		
3.	Tripping logic			
4.	Number of Zones of protection (state 1 or 2 or 3 or 4)	State		
5.	Zone Impedance Comparator Characteristics (state: mho, Quadrilatel.)	State		
6.	Impedance setting range for each Zone (state for Z1,Z2,Z3 and Z4)	State		
7.	Communication Aided Schemes for Distance Protection	state		
8.	Communication Aided schemes for Directional Earth Fault (DEF) Protection	state		
	Pick up setting range for the DEF element (state in amps)	state		
	Load Encroachment Discrimination feature(available/not available)	state		
9.	Fuse Failure Supervision (available/ not available)	state		
10.	Weak end in feed & Echo feature (available/not available)	state		
11.	Current reversal guard Feature(available/not available)	state		
12.	Power Swing Tripping & Blocking function(available/not available)	state		
13.	Voltage Memory Function (available/not available)	state		
14.	SOTF Function (available)	state		
	Settings range for the SOTF Function (time delay)	State		
15.	Back-up Overcurrent and Earth fault protection function	State		
	(available/not available)			

16.	Under-Frequency and rate of frequency change Protection function	State		
17.	Settings range for the Backup Overcurrent and Earth Fault Protection	state		
18.	Circuit Breaker contact wear feature(available/unavailable)	state		
19.	Broken Conductor detection(available/unavailable)	state		
20.	Auto-reclose Function that is able to operate as per the specifications	State		
21.	Accuracy for Distance to Fault Location (in %)	State		
	Automatic display of fault details on the Relay- List the fault data displayed	State		
22.	Storage capacity for disturbance records, trip/fault records and events records (No. of events and No of records)	indicate		
23.	Fault Locator with automatic Distance to Fault indication on the LCD screen in km. (available/unavailable)	state		
24.	Relay configuration & parameter settings, Event & Fault records and LED status are retained upon loss of relay DC Power supply	State		
25.	Metering provided	State		
26.	Number of Binary Inputs	State		
27.	Number of Binary outputs	state		
28.	Ratings for output relay contacts (current and voltage)	State		
29.	Number of LEDs	indicate		
30.	Communication protocols	state		
31.	Communication ports provided	State		
32.	Type and size of connection terminals for cable termination at the back of relay (type and diameter size)	state		
33.	Relay to Laptop connection cables offered (number and type).	state		
34.	Software for relay configuration and parameter setting and fault data Analysis offered with the relay in CD form.	indicate		

Item	12 B: GUARANTEED TECHNICAL PARTICULARS FOR LINE DIFFERENTIAL RELAY			
	Particular Specifications	**Employers' requirement**	**Guar. Value**	**Refer. Doc**
1.	Country of manufacture/origin			
2.	Manufacturer's Name	State		
3.	Type or Designation name of Relay	State		
4.	Test reports and accreditation certificate of testing laboratory	provide		
5.	mounting design (Flush)	state		
6.	Design (Numerical, modular, others)	State		
7.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
8.	Experience in manufacture of Line Current Differential relay (minimum 13years)	state		
9.	Minimum of 7 years of relay service outside country of manufacture	state		
10.	Minimum operating voltage and current for impedance measurement/directional sensitivity	State		
11.	Minimum operating current /relay sensitivity	State		
12.	Minimum operating time	State		
13.	Simultaneous Tripping at both ends of the line even with no in feed at one end.			
14.	Phase segregated measurement of current magnitude and phase angle (phase segregation available/unavailable)	State		
15.	High Speed relay operation suitable for protection of Transmission Line (high speed relay available, time of tripping)	state		
16.	Transformer Inrush restraint and ratio and phase angle compensation (available/unavailable)	State		
17.	Direct Transfer of Trip Function between the relays via fibre optical cable (available/unavailable)	State		
18.	Operates with directly connected fibre cables (direct connection/via multiplexer)	state		
19.	Differential Protection blocks upon loss of communication to prevent mal-operation (blocks/does not block)	State		
20.	Auto-reclose Function: Available modes of Auto-reclose (SPAR+DAR)	State		
21.	Integrated Distance Protection (available/unavailable)	State		
22.	Number of Zones for integrated distance Protection	State		
23.	Zone Impedance Comparator Characteristics (mho, quadrilateral, both)	state		
24.	Impedance Settings range for each Zone	State		
25.	Automatic Display on the LCD screen of Distance to Fault in km (available/unavailable)	State		
26.	Back up Overcurrent and Earth Fault Protection (available/unavailable)	State		
27.	Settings range for Back up Overcurrent and Earth fault Protection Elements (current range)	state		
28.	Storage capacity for **disturbance records**, **trip records** and **events record**	capacity for each		
29.	Metering capability (U,I,P,Q,S,F,F&CosØ)	State		
30.	Number of Binary Inputs	State		
31.	Number of Binary outputs	state		

32.	Ratings for relay output contacts (current, voltage)	state		
33.	Ratings for relay input contacts	State		
34.	Number of LEDs	State		
35.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/unavailable)	State		
36.	Communication protocols	State		
37.	Communication ports provided	state		
38.	Type and size of connection terminals for cable termination	state		
39.	Relay to Laptop connection cables offered	State		
40.	Software for relay configuration and parameter setting and fault data Analysis offered for use with the relay. Software to be offered in CD form	Indicate		

12 C: GUARANTEES FOR RESTRICTED EARTH FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. doc**
1.	Manufacturer and country of origin name	State		
2.	Model and designation name of relay	indicate		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal24-240VDC).	State		
5.	Design type: Numerical conforming to protocol IEC 61850-8-1and Goose messaging	State		
6.	Number of similar Relay sold to date to the export market: Requirement; 1000	State		
7.	Relay must have been sold to other two continents outside continent of manufacture (give names of the continents)	state		
8.	Experience in manufacture of Restricted Earth Fault Relay (number of years of manufacture)	Years		
9.	Minimum of 10 years Manufacturing experience	state		
10.	Minimum of 5 years in service outside country of manufacture	state		
11.	Complete order number for offered Relay	State		
12.	Applicable for High Impedance operating principle	indicate		
13.	Minimum pick up & setting range	State range		
14.	Relay Operating time at 5 x setting current (time in seconds)	indicate time		
15.	Number of LEDs	State		
16.	Number of Binary inputs	State		
17.	Number of Binary outputs	State		
18.	Ratings of output relay contacts (current and voltage)	State		
19.	Keypad for relay parameter settings and data access (available/unavailable)	State		
20.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/unavailable)	State		
21.	Software for relay configuration and parameter setting. Software to be offered in CD form(yes/no)	Indicate		
22.	Connection cable from Laptop to Relay to be offered(yes/no)	Indicate		
23.	**Stabilizing Resistor**			
24.	Type and reference number of Stabilizing Resistor offered.	State		
25.	Setting Range of Offered resistor in Ohms (range in ohms).	State		
26.	Maximum through fault for the REF scheme calculation (in kA).	State		
27.	**Voltage Dependent Resistor (Metrosil)**			
28.	Type and reference number of Voltage Dependent Resistor (VDR) Metrosil offered. Rated voltage of VDR based on maximum fault current of 25kA.	State		
29.	Both Stabilising Resistor and Voltage dependent resistor are housed in a single box with external connection terminals suitable panel mounting.	State		
30.	Software for relay configuration and parameter setting	State		
31.	Communication cable from Laptop to relay offered	State		

SCHEDULE 12 D: GUARANTEES FOR 3PHASE UNIDIRECTIONAL OVERCURRENT & E/ FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or Model of the relay	type		
3.	Complete order number for offered Relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
7.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
8.	Experience in manufacture of Three Phase Overcurrent and Earth Fault relay (10 years minimum)	state		
9.	Years of Service outside country of Origin (Minimum 5 years)	state		
10.	Design (Numerical type)	State		
11.	Mounting design (Flush)	State		
12.	Protection Functions offered and parameters setting range for all protection elements	indicate		
13.	Time-current characteristics available for various Overcurrent, Earth fault elements and other protection elements	State		
14.	Broken Conductor Function (available/unavailable)	State		
15.	Under frequency Protection(available/unavailable)	state		
16.	Circuit Breaker contact wear feature(available/unavailable)	State		
17.	Number of LEDs provided	state		
18.	Number of Binary Inputs	state		
19.	Number of Binary outputs	state		
20.	Ratings of output relays contacts (current, voltage)	state		
21.	Communication ports (type and number)	state		
22.	Communication protocols	state		
23.	Circuit Breaker maintenance(available/unavailable)	state		
24.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/not available)	indicate		
25.	Configuration of Start and trip contacts (possible/not possible)	State		
26.	Storage capacity for disturbance, event and trip/fault records	State		
27.	Metering/Measurement capability (P,Q,I,V,CosØ)	Indicate		
28.	Size of LCD screen	State		
29.	Relay Keypad for relay parameter setting and data access	state		
30.	Software for relay configuration and parameter setting.	State		
31.	Connection cable from Laptop to Relay offered	state		
32.	Type and size of relay terminals for cable connection			

SCHEDULE 12 E: GUARANTEES FOR SENSITIVE EARTH FAULT RELAY				
Item	**Particular Specifications**	**Units**	**Guarat. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of relay	Type		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 30-300VDC).	State		
5.	Experience in manufacture of SEF Relay (10 years minimum)	state		
6.	Design type: Numerical conforming to protocol: IEC 61850-8-1	State		
7.	Years of Service outside country of origin (5 years Minimum)	state		
8.	Complete order number for offered Relay	State		
9.	Number of similar Relay sold to date to the export market: (Required minimum number is 1000)	Number		
10.	Current setting range for earth fault relay - 0.005In-0.8In	State		
11.	Definite time delay characteristic; Setting range, 0- 30 Seconds.	State		
12.	Circuit Breaker Maintenance function	State		
13.	Fault records, Event Records and disturbance records.	State		
14.	Drop off /pickup ratio >90%	State		
15.	Low transient overreach < 10%	State		
	Auto reclose function			
i.	Autoreclose function shall be enabled in the distance relay or in the overcurrent and earth fault rely	State		
ii.	Selectable 1 - 3 Autoreclose shots	State		
iii.	Independent set dead time for each shot	State		
iv.	Independent set dead time for each shot	State		
v.	Autoreclose inhibit after manual close	State		
vi.	Autoreclose inhibit for Overcurrent high set-element	State		
16	Connection cable from Laptop to Relay offered	state		
17	Software for relay configuration and parameter setting.	State		

12 F: GUARANTEES FOR BIASED DIFFERENTIAL RELAY FOR TWO WINDING TRANSFORMER PROTECTION				
Item	**Particular Specifications**	**Units**	**Quart. Value**	**Ref. Doc**
1.	Manufacturer and Country	State		
2.	Type or designation name of the relay offered	State		
3.	Complete order number of offered relay	State		
4.	Ratings: Ac Inputs: 1-5Amp	State		
5.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
6.	Mounting design (Flush)	State		
7.	Applicable protocol: IEC 61850-8-1and Goose messaging	State		
8.	Design type numerical	State		
9.	Number of similar Relay sold to date to the export market: (requirement minimum number 1000)	State		
10.	Evidence of sales in 3 other continents outside the continent of manufacture (state countries)	State		
11.	Experience in manufacture of Biased Differential Protection relay (minimum 10 years)	state		
12.	Minimum of 5 years in service outside country of manufacture	state		
13.	Minimum operating current for biased differential /relay sensitivity and setting range	Indicate		
14.	Minimum operating time at 2 x setting	Indicate		
15.	Provision of unrestrained High-set differential element and setting range	Indicate		
16.	Magnetizing Inrush detection method(s) and settings range	Indicate		
17.	Provision of Integral CT correction ratio feature and setting range(available/unavailable)	State		
18.	Integral Vector Group compensation feature(available/unavailable)	State		
19.	Display of HV & LV differential and bias currents on the LCD screen(available/unavailable)	State		
20.	Storage capacity for Disturbance, Event and Trip/Fault records (disturbance, events and trips)	Indicate		
21.	Display of Fault currents on the LCD (available/unavailable)	State		
22.	Provision of over-fluxing Alarm and Trip functions	State		
23.	5^{th} Harmonic restraint feature and settings range	Indicate		
24.	Dual- Bias characteristics (available/unavailable)	State		
25.	Relay trip Indication by Red LED (available/unavailable)	State		
26.	No of Binary Inputs and Binary Outputs	State		
27.	Ratings of relay output contacts (current and voltage)	State		
28.	Number of LEDs	State		
29.	Ability to latch output contacts (available/unavailable)	State		
30.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure(available/Unavailable)	Indicate		
31.	LCD screen and Keypad for programming relay parameter settings and data access(available/unavailable)	Indicate		
32.	Communication protocols	State		
33.	Communication ports provided	State		

34.	Type and size of terminals for cable connection	State		
35.	Software offered for relay configuration and programming	Indicate		
36.	Communication cable to Laptop (offered /not offered)	Indicate		
37.	Metering capability (U,I,P,Q,S,F,F&CosØ)	Indicate		

12 G: GUARANTEES FOR FEEDER PROTECTION AND BAY CONTROL IED				
Item	**Particular Specifications**	**Units**	**Guara Value**	**Refer. Doc**
1.	Manufacture and country	State		
2.	Applicable protocol IEC 61850-8-1and Goose messaging	State		
3.	Model of the IED	State		
4.	Manufacturing reference standards	State		
5.	Ratings: Ac Inputs: 1-5Amp	State		
6.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
7.	Number of similar Relay sold to date to the export market: Required minimum1000 pcs	State		
8.	Experience of 10 years in manufacture of BCU/BCPU	state		
	Years of Service outside country of Origin (5 years minimum)	state		
9.	Numerical design (numeric)	State		
10.	Protection functions and features in the IED i. Three phase overcurrent ii. Earth fault iii. Sensitive Earth Fault iv. Broken Conductor detection v. 3phase Autoreclose function vi. Under and Over Frequency Protection	State		
11.	Earth Fault and Sensitive Earth Fault Protection in separate element	State		
12.	Earth Fault and Sensitive earth fault elements shall have separate CT Inputs.	State		
13.	Two stages of High Set Element for both overcurrent and earth fault protection function-setting range of 1-20In (minimum) and a definite time delay setting of 0-60 seconds (minimum).	State		
	Current setting range for overcurrent 0.5In-2.0In (minimum)	State		
14.	Current setting range for earth fault 0.05In-0.8In (minimum)	State		
15.	Auto reclose function: i. Three phases auto reclose ii. Selectable 1-3 autoreclose shots iii. Independently set dead time for each shot iv. Autoreclose inhibit after manual close v. Autoreclose inhibition for over current high set element	State		
16.	Minimum of eight (8) each LEDs for alarms and trip annunciation.	State		
17.	Binary inputs and Outputs- minimum twelve (12 each)			
18.	Mounting design (Flush)	State		
19.	Number of CT inputs	State		
20.	Number of VT inputs	State		
21.	Protection and control Functions: Parameter setting range for each function including time-current characteristics O/C, E/F, SEF, etc.	State		

SCHEDULE 12 H: GUARANTEES FOR BUS BAR PROTECTION IED				
Item	**Particular Specifications**	**Employer's requirement**	**Guara. Value**	**Refer. Doc**
1.	Manufacturer and Country	State		
2.	Model of offered relay	State		
	Manufacturing reference standards	State		
3.	Ratings: Ac Inputs: 1-5Amp	State		
4.	Power Supply Voltage: 110VDC or (Universal 24-240VDC).	State		
5.	Design type: Numerical conforming to protocol: IEC 61850-8-1and Goose messaging	State		
6.	Protection principle (low impedance on numeric principle)	State		
7.	Minimum of 10 years' experience in manufacture of Bus bar protection Relay	state		
8.	Minimum of 5 years in service outside country of Origin	state		
9.	Bus bar protection- centralized and phase segregated	State		
10.	Dynamic bus replica feature for each zone of protection	State		
11.	Mounting design (Flush)	State		
12.	Reference standards	state		
13.	Number of similar Relay sold to date to the export market: - (Required minimum number is1000)	State		
14.	Evidence of sales in two other continents outside the continent of manufacture (state countries)	State		
15.	Minimum operating time	Indicate		
16.	Check criteria for trip (check relay, zone relay)	Indicate		
17.	Detection of CT saturation within a few milliseconds into an external fault	State		
18.	Integral CT correction ratio feature and setting range	required		
19.	CTs trouble monitoring for each protected zone	required		
20.	Display of differential and Line current on LCD screen	required		
21.	Storage capacity for disturbance, Event and Fault records and Oscillographs (Input analogue to cover 20nos. bays)	indicate for each		
	Relay trip Indication by Red LED	required		
22.	No of Binary Inputs	State		
23.	No. of Binary Outputs	State		
	Ratings of relay output contacts (current and voltage)	State		
24.	Number of LEDs	State		
25.	Ability to latch output contacts	required		
26.	Relay self-diagnostic with watchdog contact, relay healthy LED (green) and red LED for relay failure (available/Unavailable)	required		
27.	LCD screen and Keypad for programming relay parameter settings and data access (available/unavailable)	required		
28.	Communication protocols (IEC 61850-8-1)	State		

29.	Communication ports provided	State		
30.	Overcurrent back up and end-fault protection (available/Not available)	State		
31.	Type and size of terminals for cable connection	State		
32.	Software offered for relay configuration and programming	Indicate		
33.	Laptop to relay connection cable (offered /not offered)	Indicate		
34.	Metering capability (U,I,P,Q,S,F,F& Cos Ø)	Indicate		
35.	Connection cable from Laptop to Relay offered	State		
36.	Software for relay configuration and parameter setting.	State		

SCHEDULE 13: GUARANTEED TECHNICAL PARTICULARS FOR OPGW CABLE

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guart. Value**	**Refer. Doc**
1	Manufacturer and Country		State		
2	Minimum experience in manufacture of OPGW	Years	10		
3	Minimum years of service outside country of Origin	Years	7		
4	Number of fibers	OPGW	≥48		
	Single mode fiber type		G655		
5	Core diameter	µm	8.3/9 with 3% tolerance		
6	Fiber Cores per loose tube		12		
7	Fiber Color Coding –12 number		TIA-598 - C		
8	Clad diameter	µm	125.0 + 2		
9	Core-clad concentricity		< 2%		
10	Coating diameter	µm	250.0 + 15		
11	Coating concentricity	>	0.70		
12	Attenuation: 1310 nm 1550 nm	dB/km	< 0.40 < 0.25		
13	Bending attenuation: 1310nm 1550nm	dB/km	≤ 0.40 < 0.25		
14	Temperature dependence	dB/km	≤0.05 (-20°C to +85°C)		
15	Cut-off wavelength	nm	< 1250		
16	Chromatic dispersion:				
17	Zero dispersion at	nm	1310 ± 12 1550 + 15		
18	Zero dispersion slope (max.)	ps/nm^2 (km)	0.092 0.085		
19	Mode field diameter				
	1300 nm 1550 nm	m m	9.30 ± 0.50 10.50 ± 1.00		
20	IL-proof test level	g/m^2	35 x 106		
21	Splice attenuation	dB/ splice	0.02		
22	Connector loss	dB/connector	< 0.5		
	Approach Underground Cable				
23	Manufacturer's Name and country	-	State		
24	Type	-	Armoured		
25	Number of fibers	-	>48		
26	Fibers per tube	NO	12		
27	Long-term Loading tensile	IEC 60794-1-2-E1A	1200 N		
28	Short-term Loading tensile	IEC 60794-1-2-E1B	2700 N		
29	Crush Performance, Long term	IEC 60794-1-2-E3	800N/10 cm		

GUARANTEES FOR OPGW AND FO UNDERGROUND CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guarat Value**	**Refer. Doc/.**
30	Crush Performance, Short term	IEC 60794-1-2-E3	3000N/10 cm		
31	Minimal installation Bending radius	IEC 60794-1-2-E11	15 x OD		
	ODF				
32	Manufacturer's Name and country	-	State		
33	Type/model	-	State		
34	Number of fiber interconnections	-	≥48		
35	Connector loss	DB/connector	< 0.5		
36	Screw on type connectors	-	yes		
37	Wall mounted cabinet	-	yes		
38	Fiber Optic Cable routine tests as per IEC 60794-1-2E/F	No	State all tests		

SCHEDULE 14: GUARANTEED PARTICULARS FOR MEASURING INSTRUMENTS

GUARANTEES FOR MEASURING INSTRUMENTS				
Item	**Particulars**	**Unit**	**Guaranteed. Value**	**Refer. doc**
1	**Indicating Instruments**			
	AC and DC Ampere meter, and Voltmeter, Wattmeter, VAr - meter, Frequency-meter and other indicating instruments:	State		
i	Physical dimension Instrument for: (A, V (AC), V (DC), W, etc.)	(mm)		
ii	-Reference standard	list		
iii	- Error	%		
iv	- Max. admissible current	$\%.I_N$		
v	- Max. admissible voltage	$\%.I_N$		
2	**Energy meters (to be filled for each meter)**			
i	Meter for (MWh, MVArh) Physical dimension	mm		
ii	-Error with 5% load	%		
iii	-Error with 10% load	%		
iv	-Error with 20% load	%		
v	-Error with 100% load	%		
vi	-Max. admissible current	$\%.I_N$		
3	**Metering Converters (Transducers)**			
i	- Converter for (MW, MVAr, A, etc):			
ii	- Error	%		
iii	- Linearity	%		
iv	- Max. admissible current for 0.5 seconds	$\%.I_N$		
v	- Max. admissible current continuously	$\%.I_N$		
vi	- Max. admissible voltage for 0.5 seconds	$\%.I_N$		
vii	- Max. admissible voltage continuously	$\%.I_N$		
4	**Alarm/Trip Annunciators**			
i	- Reference standard	State		
ii	- Digital type	State		
	(i) Digital and Analogue inputs/output	State		
iii	- Number of windows per annunciators (minimum 8)	No		
iv	- Physical size of each annunciator (area of the cap)	mm		
	i) Reset and mute button	State		

Note: *To be filled in for each Instrument*

SCHEDULE 15: GUARANTEED TECHNICAL PARTICULARS FOR LV CABLES

GUARANTEES FOR CONTROL AND SIGNAL CABLE					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guant. value**	**Refer. Doc**
1	**Low Voltage Cables (Auxiliary Supply)**				
i	- Conductor material		Copper		
	Design type		Concentric and stranded		
ii	- Current carrying capacity at $75^{O}C$	A	State		
	(iv) Rated Voltage	kV	state		
	(v) 1min. power withstfrequency voltage	KVrms	state		
iii	(vi) Short circuit current withstands for 3secs	KA	State		
iv	- Insulation material		PVC		
v	- Steel wire Armoure and screen		Required		
vi	- Protective coating		Required		
vii	- minimum nominal diameter		$25mm^2$		
viii	- Weight of heaviest reel, including cable - Number of cores	Kg No	Kg four		
2	**Control, Protection and Measuring Cables**				
i	- Conductor material		Copper		
	ii) Design type		Concentric and stranded		
ii	- Insulation material		PVC		
	- Current carrying capacity at $75^{O}C$	A	State		
	(viii) Rated Voltage	kV	1		
	(ix) 1min. power frequency voltage withstand	KVrms	3		
iii	- Steel wire Armouring and screen		required		
iv	Protective coating		required		
v	- Nominal diameter per core		$2.5mm^2$		
vi	- Overall diameter of cable and number of core	mm/No	state		
vii	- Weight of heaviest reel, including cable	kg	state		
viii	- Size of biggest reel, diameter/width	mm/mm	state		
3	**Telecommunication and Relay/Control Panel internal wiring cables**				
i	- Conductor material		Copper		

ii	Design type		Concentric and stranded		
iii	- Rated voltage	V	600		
iv	- Insulation material		PVC		
v	-1min. power frequency voltage withstand	KVrms	state		
vi	- Flexible stranded single core		state		
vii	- Nominal diameter per core (minimum)		$1.5mm^2$		
viii	- Overall diameter of cable and number of cores	Mm/No	State		
ix	- Weight of heaviest reel, including cable	Kg	State		
x	- Size of biggest reel, diameter/width	mm	State		
4	**Special Cables (where applicable)**				
i	-Special signal and data applicable		state		
ii	-Conductor material		state		
iii	-Insulation material		state		
iv	-Mode of protection		state		
v	-Diameter per core		state		
vi	-Overall diameter of cable reel		state		

SCHEDULE 16: GUARANTEED TECHNICAL PARTICULRAS FOR EARTHING CONDUCTOR

GUARANTEES FOR EARTHING CONDUCTOR					
Item	**Particulars**	**Unit**	**Employer's requirement**	**Guar. Value**	**Ref. Doc**
1	Maximum Earth ground resistance desired values				
2	Under the Control building	Ohms	State		
	Under the Switchyard (HV Earthing system)	Ohms	State		
	LV Earthing system	Ohms	State		
3	Material for Main Grid and Risers earthing conductor		Copper		
4	Resistance of Main earth grid conductor at $20^{O}C$	Ω/km	State		
5	Minimum nominal cross section area of main grid and risers	mm^2	95		
6	Max. temperature of earth conductor during 3 Sec. rated phase - ground fault	$O^{0}C$	State		
7	Rated Phase to ground fault current of main grid conductor at rated maximum temperature	kA	State		
8	Material for Earth rods		Copper		
9	Maximum resistance of each Earth rod	Ohms	State		
10	Length and diameter of earth rods	m/mm	State		
11	Method of interconnecting earth grid conductors		State		

SCHEDULE 17: GUARANTEED TECHNICAL PARTICULRAS FOR RTU (SAS) EQUIPMENT

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particular Specifications**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
1.	Manufacturers Name and address	State		
2.	Country of Manufacture	State		
3.	Model or type of RTU	State		
4.	Equipment applicable standards	State		
5.	Minimum RTU Manufacturing experience (10 years)	State		
6.	Minimum years of service outside country of Manufacture (5years)	State		
7.	Service working conditions	Specify		
8.	Safety and environmental compliance	State		
9.	Free standing Panel dimension	Specify		
10.	Relays shall be encapsulated type	Specify		
11.	Accommodate signal from both Analogue and Digital transducers	Specify		
12.	Tele information plan requirement interfacing	required		
13.	single command outputs, double command outputs	Specify		
14.	regulation command outputs e.g. raise/lower command outputs for transformer tap changer control	Specify		
15.	analogue set point transmission and output	Specify		
16.	single, double and multiple state digital inputs	Specify		
17.	analogue measured inputs	Specify		
18.	metering pulse inputs for acquisition of energy meter values	Specify		
19.	Sequential Event recording (SER) with time stamping of events at the RTU	Specify		
20.	RTU time synchronization	Specify		
21.	Self-testing and diagnostic functions for detection and reporting of any error	Specify		
22.	Automatic re-starting function corresponding control centre with downloading function.	Specify		
23.	Support encryption and LAN/WAN Access	Specify		
24.	Shall support IEC 61850 protocol for process communication	Specify		
25.	RTU to be fully equipped for 8 substation bays plus spare capacity of 25% for each type of data	Specify		
	RTU shall be expandable in the field by at least 50% of the size of the initial point capacity by addition of Input and Output cards only	Specify		
	Addition of enclosures, internal cabling/wiring, chassis, or power supplies shall not be necessary when adding these I/O cards.	Specify		
26.	RTU shall be accessible through the communication network for the Supervisory Control & Data Acquisition (SCADA) System at the National Control Centre (NCC) and Regional Control Centres (RCC) to scan.	Specify		
27.	Plug-in type relays shall be used with sockets directly mounted on a DIN rail.	Specify		
	RTU firmware requirements			
28.	RTU firmware characteristics	Specify		
29.	Use of standard firmware	Specify		
30.	It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU	Specify		
31.	all firmware delivered must be up to date and in final form, including all standard firmware changes	Specify		

GUARANTEES FOR REMOTE TERMINAL UNITS (RTU) FOR SCADA INTERFACE				
NO.	**Particular Specifications**	**Employers' requirements**	**Guarat. Value**	**Refr. Doc**
32.	Firmware shall be loadable by service notebook locally at minimum, download of firmware and parameter sets trough SCADA system, using the data communication links.	Specify		
33.	Changing of EPROMs or similar devices shall not be necessary when updating RTUs firmware	Specify		
34.	230V AC power outlets	Provide		
35.	DC Power supply			
36.	Any hardware required to convert the 48 V battery voltage to the required internal voltages for the RTU hardware shall be provided and adequate	Specify		
37.	The RTUs shall be capable of operating with ungrounded or grounded (either polarity) input power.	Specify		
38.	Dielectric strength/Impulse voltage test (≥2.5kV, 1 minute)	Specify		
	Interposing Relays	Specify		
39.	Tele commands	Specify		
40.	Coil voltage shall be 48 VDC; Coil voltage variation shall be ±20%.	Specify		
41.	Signal voltage on the contact circuit shall normally be 110 VDC	Specify		
42.	The rated contact current shall be minimum 5ADC making/breaking.	Specify		
43.	Telecommunication indications	specify		
44.	Coil voltage shall be 110 VDC; Coil voltage variation shall be ±20%.	Specify		
45.	Signal voltage on the contact circuit shall normally be 48VDC	Specify		
46.	The rated contact current shall be minimum 3ADC making/breaking.	Specify		
47.	2NO and 2NC contacts for interposing relay	Specify		
48.	Relays shall be fitted with a visual operation indicator (either mechanical or LED)	Specify		
	Transducers			
49.	Electrical parameters – Current, voltage, active power, reactive power, apparent power, frequency and power factor transducers	requires		
50.	Four programmable analogue outputs, two digital outputs and RS-485 Modbus functionality for transducers.	Specify		
51.	programmed via easy-to-use software compliant with IEC 60688	Specify		
52.	Relays Characteristics of the digital programmable transducers	Specify		
53.	Measurement Accuracy Class (0.2 and 0.5)	specify		
54.	Current circuit (In)	1-5 A		
55.	Transducer supply- 40-120 VDC /110Vac	Specify		
56.	Communication Ports	Required		
	Serial USB port-USB Mini-B connector Modbus RTU 38400 baud (auto)	Specify		
	Serial RS485 port- Three screw terminals for ≤ 6 mm2 Modbus RTU 1200 – 38400 baud	Specify		
57.	Digital outputs (No)	2		
58.	Analogue outputs (No)	4		
59.	MFM devices	Required		

SCHEDULE 18: GAURANTEED TECHNICAL PARTICULARS - TELECOMMUNICATION SYSTEM

GUARANTEEES FOR SUBSTATION TELECOM SYSTEM					
No	**Particular Specifications**	**Unit**	**Employer's requirement**	**Guar Value**	**Refer . Doc**
1	Manufacturer's Name and Country		State		
2	Multiplexer type/Model		STM-1/4		
3	Nx2MBit Multiplexer		State		
4	Terminal equipment (State id provided)		State		
5	Minimum experience in manufacture of SDH Multiplexer	Years	10		
6	Minimum years of Service outside country Origin of the Multiplexer	Years	7		
7	Multiplexer technology		SDH, GBE & MPLS-TP		
8	SDH Capacity [STM-1]	Mbps	155.52MBps		
9	GBE Capacity	Gbps	1.25Gbps		
10	Maximum extension of transmission capacity of terminal equipment by adding plug in cards		State		
11	Maximum extension for multiplexer and terminal equipment racks.		State		
12	Maximum extension of transmission capacity for the multiplexer based on 2MBit-hierarchy		State		
13	Integration to existing KPLC NMS		Required		
14	Configurability from existing NMS		Required		
15	Telephony Voice Service capability		Required		
16	SCADA Data Service capability		Required		
17	CCTV data service capability		Required		
18	Teleprotection capability for HV substations as per IEC 60834-1		Required		
19	Craft Interface Connectivity to equipment		ITU-T G.773		
20	Optical interface for use between Teleprotection and digital Multiplexer		IEEE C37.94		
21	Data Communication channel to NMS and between nodes		ECC/ITU-T G.773		
22	Connection of PDH electrical tributary interfaces to the SDH equipment		ITU-T G.703		
23	Synchronous optical interface protection		1+1 Protection		
24	Timing and synchronization		ITU-T G. 783		
25	Supply of associated accessories and materials		Required		
26	Perpetual telecom equipment license		Required		
27	Supply of equipment wall mounted cabinet		Required		

SCHEDULE 19: GUARANTEED TECHNICAL PARTICULARS FOR 11KV CABLE

11KV THREE CORE 300 mm^2 ALUMINIUM XLPE CABLE					
Item	**Particular Specifications**		**Unit**	**Guarant Value**	**Refer. doc**
1.	Manufacturer and country of origin				
2.	Minimum manufacturing experience (10 years minimum)		Years		
3.	Years of service outside country of manufacture (5 years minimum)		Years		
4.	Type test report and accreditation certificate of testing laboratory		Provide		
5.	Service condition (altitude and temperature)		State		
6.	Applicable IEC/BS standard(s)		State		
7.	Rated Continuous operating temperature		^{O}C		
8.	Short with withstand temperature for 5Secs.		^{O}C		
9.	Conductor material				
10.	Minimum insulation thickness and resistivity at 90^{O}C		mm/Ω		
11.	Insulation	Material (XLPE)	State		
		Minimum Thickness	mm		
		Screen tape around the conductor	State		
12.	Water barriers				
13.	Metallic Screen	Type and material	State		
		Min. Tape/Wires screen area	State		
		Thickness of separation layer	mm		
		Short time current of tape/Wire screen for 3sec at 90 - 200 ^{O}C	kA/3Sec		
14.	Extruded PVC Over sheath	Withstand power frequency at 90 ^{O}C for 1sec	kVrms		
		Over sheath min. thickness	mm		
		Anti-termite protection	State		
		Fire resistance	State		
		Marking	State		
15.	Wire Armour	Material of armour wire and tape	State		
		Nominal armour wire diameter	mm		
16.	**Ratings and Characteristics**				
	Conductor nominal cross-sectional area		Sqr mm		
	Voltage rating Uo/U(Um)		kV		
	Conductor shape		State		
	Maximum conductor DC resistance at 20^{o}C		Ω/km		
	Maximum conductor AC resistance at 90^{o}C		Ω/km		
	Minimum conductor diameter		mm		
17.	Current capacity	Buried underground	A		
		In air (trench)	A		
18.	Power frequency withstand test voltage for 5min		kVrms		
19.	Short Circuit rating of conductor for 3sec at (90-250 ^{O}C)		kA/3Sec		
20.	Maximum Capacitance/km		µF/km		
21.	Impedance @50Hz@90 ^{O}C		Ω/km		
22.	Inductance/km		mH/km		
23.	Maximum charging current/km		A/km		
24.	Impulse withstand voltage as per IEC60230		kVpk		
25.	Minimum bending radius (Static)		mm		
26.	Weight per Km (kg/km)		Kg/km		

SCHEDULE 20: GUARANTEED TECHNICAL PARTICULARS FOR 11KV SINGLE CORE CABLE

11KV 630mm^2 SINGLE CORE COPPER XLPE CABLE					
Item	**Particulars**		**Unit**	**Guaranteed Value**	**Refer. doc**
1.	Manufacturer and country of origin				
2.	Minimum manufacturing experience (10 years minimum)		Years		
3.	Years of service outside country of manufacture (5 years minimum)		Years		
4.	Service Condition		State		
5.	Applicable IEC/BS standard(s)		State		
6.	Rated Continuous operating temperature		^{O}C		
7.	Short with withstand temperature for 5Secs.		^{O}C		
8.	Conductor material				
9.	Minimum insulation thickness and resistivity at 90^{O}C		mm/Ω		
10.	Insulation	Material (XLPE)	State		
		Minimum Thickness	mm		
		Screen tape around the conductor	State		
11.	Water barriers				
12.	Metallic Screen	Type and material	State		
		Min. Tape/Wires screen area	State		
		Thickness of separation layer	mm		
		Short time current of tape/Wire screen for 3sec at 90 - 200 ^{O}C	kA/3Sec		
13.	Extruded PVC Over sheath	Withstand power frequency at 90 ^{O}C for 1sec	kVrms		
		Over sheath min. thickness	mm		
		Anti-termite protection	State		
		Fire resistance	State		
		Marking	State		
14.	Wire Armour	Material of armour wire and tape	State		
		Nominal armour wire diameter	mm		
15.	**Ratings and Characteristics**				
	Conductor nominal cross-sectional area		Sqr mm		
	Voltage rating Uo/U(Um)		kV		
	Conductor shape		State		
	Maximum conductor DC resistance at 20^{o}C		Ω/km		
	Maximum conductor AC resistance at 90^{o}C		Ω/km		
	Minimum conductor diameter		mm		
16.	Current capacity	Buried underground	A		
		In air (trench)	A		
17.	Power frequency voltage withstands for 5 min		kVrms		
18.	Short Circuit rating of conductor for 3sec at (90-250 ^{O}C)		kA/3Sec		
19.	Maximum Capacitance/km		µF/km		
20.	Impedance @50Hz@90 ^{O}C		Ω/km		
21.	Reactance /km@50Hz		Ω/km		
22.	Inductance/km		mH/km		
23.	Maximum charging current/km		A/km		
24.	Impulse withstand voltage as per IEC60230		kVpk		
25.	Minimum bending radius (Static)		mm		
26.	Weight per Km (kg/km)		Kg/km		

SCHEDULE 21: GUARANTEED TECHNICAL PARTICULRAS FOR SUBSTATION STEEL STRUCTURES.

GUARANTEES FOR SUBSTATION STEEL STRUCTURES					
NO.	**Particulars**	**KPLC Requirements**	**Unit of measure**	**Guarat. Value**	**Refr. Doc**
1.	Manufacturer Name and address		State		
2.	Country of manufacture		State		
3.	Type/design of steel structures (hot-rolled and complies with the requirements of Kenya Standard ES 02-572 angle channels/tubular)		State		
4.	Applicable standards		State		
5.	Minimum Manufacturing experience (7 years)		State		
6.	Years of service outside country of manufacture (Mini.5 years)		State		
7.	Delivery time				
8.	Production capacity				
9.	Operating environmental service conditions		State		
10.	Type test report and accreditation certificate		Provide		
11.	Surface integrity of hot-rolled sections for use in the manufacture of steel structures		State		
12.	Mechanical Properties (steel Gauge and Class)		State		
13.	Tensile strength of the steel		N/mm2		
14.	Yield stress of the steel		N/mm2		
15.	Tolerances for Mass/Thickness (max. ± 3)		mm		
16.	Elongation		%		
17.	Galvanizing Thickness (Min. ≥ 110 µm)		µm		
18.	Modulus of Elasticity		State		
19.	Density		State		
20.	Nominal length (mm)		mm		
21.	Finished materials surface (smooth and free from spots, dross and flaking, uneven and coating grey and Ash deposits)		state		
22.	Materials before and after fabrication are straight and free from twists				
23.	Sheared or cropped edge are dressed to clean finish and free from distortion		State		
24.	Type of Welding and Mode of cleaning of welds		State		
25.	A.ANGLES, CHANNELS, HOLLOW SECTIONS				
	Tensile strength	>430<460 N/mm2			
	Yield strength	255 N/mm2			
	Tolerances				
	Length	± 1mm to 3mm			

	Thickness	± 0.5mm			
	Out of square	Max deviation 2mm			
	Straightness	0.3 % of length			
	Elongation	24-26%			
	Galvanising thickness	>110 Microns			
	Modulus of Elasticity	20 x 10*9			
	Density	7860kg/m3			
	Nominal length	±0.4%			
	B. BOLTS/NUTS/WASHERS				
a	Safe working shear stress	120 N/mm2			
b	Grade of (Bolts/Nuts)	8.8			
c	Thread tolerances - threads	0.01mm			
d	Galvanizing Thickness	>85			
26	**Holes**				
	All holes are drilled in one operation and burrs are removed				
	Holes are not formed by a gas cutting process				
	All matching holes for bolts register with each other so that a gauge 2mm less in diameter than the diameter of the bolt passes freely through the assembled members in a direction at right angle to such members				
	Erection clearances for cleated ends of members connecting steel to steel				
	Bending of flat straps are carried out cold				
27	**Welding**				
	Type of welding				
	Mode of cleaning of welds				
28	**Galvanizing**				
	All punching, cutting, drilling, screw tapping and the removal of burrs are completed before the galvanising process commences				
	Type of galvanization				
	Galvanisation thickness				
	Bolts are completely galvanised including the threads, and the threads are left uncoated in the case of nuts				
	Uniformity of the zinc coating				
	Post-treatment after galvanization (chromating)				
28.	**Testing**	State			
	Tests to be performed during FAT	Required			
	Standards for Inspection and FAT testing	State			
	Copies of previous test certificates	State			

	All manufactured steel structures shall be offered for FATs and inspection in the presence of KPLC engineers at the manufacturers premises				
	Supplier shall replace without charge to KPLC items that do not meet specifications				
29.	**Markings**				
	"Property of KPLC" and grade of steel				

SCHEDULE 22: GUARANTEED TECHNICAL PARTICULARS- INDOOR MV SWITCHGEAR

17.5 KV (MV) INDOOR METAL CLAD SWITCHGEAR BOARD					
Item	**Particular Specifications**		**Unit**	**Guarat. Value**	**Refer. doc**
1.	Manufacturer's Name and Country of origin		State		
2.	Switch Board Model/type		State		
	Switchgear board rated Voltage (kV)		17.5		
	Switchgear board rated short circuit withiest (kA/3Secs)		31.5		
3.	Reference Standards		State		
4.	Copies of type test reports for the Switchboard		Provide		
5.	Accreditation Certificate of the testing laboratory accredited to ISO/IEC 17025		Provide		
6.	Minimum Manufacturer's experience (15 Years)		State		
7.	Minimum years of service outside country of Origin (10 Years)		State		
8.	Type/Model Number of item	Arc Flashover protection system	State		
		Circuit breaker	State		
		Voltage Transformer	State		
		Current Transformer	State		
		Relays/IEDs	State		
9.	List of Switchgear Panels to be supplied (to make complete Board)		List		
10.	Applicable IEC/BS Standards	Complete Panel	List		
		Circuit breaker	List		
		Voltage Transformer	List		
		Current Transformer	List		
		Relays/IEDs	List		
		ARC Flashover protection system	List		
11.	Service conditions Requirement (a.s.l and temperature)		Specify		
12.	Circuit breakers (CB) shall be horizontal withdrawable type		Specify		
13.	Circuit breaker Arc quenching mode		Vacuum		
14.	Complete switchboard is of flush-front design		Specify		
15.	Low voltage section shall be separate from the high voltage section		State		
16.	Cubicles over pressure vent		Required		
17.	Arc Flashover compartment protection system		State		
18.	Front cubicle door provided with a window		State		
19.	Degree of protection of panels		State		
20.	Copper Bus bars, connections and support		Required		
21.	Copper Bus bar Voltage and current ratings		Specify		
22.	Switchgear electrical and mechanical interlocks		Specify		
23.	Door Electrical and mechanical interlocks		Specify		
24.	Provision for integral circuit earthing with mechanical interlock		Specify		
25.	Panels wiring completely done and all connections wired up to the terminal block		State		
26.	Type and final colour shed of the Switchboard		State		
27.	Interchangeability of CBs		Specify		
28.	Motor wound spring operated mechanism		required		

29.	All required mechanical and electrical interlocks provided		Specify the interlocks		
30.	Mechanical indication provided		required		
31.	**Current transformers for the Switchboard**				
	Incomer & Bus Coupler CTs Ratings	Short Time Current with stand (STC)	State		
		Maximum Continuous Thermal Rating	State		
		Impulse Withstand Voltage	State		
		One-Minute Power Frequency Withstand Voltage	State		
		CT ratio and Burden	State		
		CT A accuracy class (Protection and metering)	State		
32.	**Voltage transformer for the Switchboard**				
	Incomers and Bus PT ratings	Ratio	State		
		Burden	State		
		Accuracy Class	State		
		Impulse Withstand Voltage	State		
		One-Minute Power Frequency Withstand Voltage	State		
		Short Time Current with stand (STC)	State		
		Maximum Continuous Thermal Rating	State		
33.	**Current transformers for the Switchboard**				
	Feeder outs CTs Ratings	Short Time Current with stand (STC)	State		
		Maximum Continuous Thermal Rating	State		
		Impulse Withstand Voltage	State		
		One-Minute Power Frequency Withstand Voltage	State		
		CT ratio and Burden	State		
		CT A accuracy class (Protection and metering)	State		
34.	LV compartment Terminal Block has a test switch (block)		Specify		
35.	Relays shall be flush mounted and of Numeric Design as per IEC 60255		Specify		
36.	Protection Relays /IEDs for the Incomers		State		
37.	Protection Relays /IEDs for the feed outs		State		
38.	Protection Relays /IEDs for the Bus coupler		State		
39.	Auxiliary Trip relays maximum pick-up times		State		
40.	Relays provided with clearly inscribed labels		Specify		
41.	110Vdc Switch board Control Voltage		required		
42.	Single phase 240Vac AC auxiliary Voltage		required		
43.	Circuit breaker Charging motor control voltage (110Vdc)		state		
44.	**Panel Indications**		Specify		
	Indications in Each cubicle	i. Inscription on the mechanical ON/OFF indicator	Specify		
		ii. Inscription on the indicating lamp	Specify		
		iii. State of the spring inscription details	Specify		
		iv. Breaker closed position indicator and colour	State		
		v. Breaker closed position indicator and colour	State		
45.		vi. Mimic diagram			
46.	Mechanical Operation (opening/closing) of Circuit breakers		Required		

47.	Electrical operation (Opening/Closing) of circuit breaker using discrete switches	Required		
48.	Design of Arc flashover protection (optical sensor, arc protection relay and arc sensors)	state		
49.	Maximum Arc fault/protection clearing time	state		
	Incomer and Bus Coupler Switchgear Panels			
	Panel and Switchgear voltage rated voltage (17.5kV)	State		
	Rated power frequency withstand voltage, rms	State		
	Rated lightning impulse withstand voltage, peak	State		
	Rated short-time withstand current (31.5KA/3Secs)	State		
	Internal Arc protection in accordance to IEC 62271-200	State		
	Circuit breaker type (Vacuum) withdrawable	Specify		
	Circuit breaker quenching medium	Specify		
	Circuit breaker Rated Voltage (17.5Kv)			
	Circuit breaker Rated power frequency withstand voltage, rms	Specify		
	Circuit breaker Rated lightning impulse withstand voltage, peak	Specify		
	Circuit breaker Rated short-time withstand current (31.5KV/3Secs)	Specify		
	Circuit breaker Rated peak withstand current	Specify		
	Panel dimensions and height	Specify		
	Main bus bar rating	State		
	Joints and terminal points (Bus bar) plating material	state		
	Joint and terminal point polyethylene sleeves	state		
	Protection Relay model	state		
	IP Protection degree	State		
48	**Feeder outs Switchgear Panels**			
	Panel and Switchgear voltage rating (17.5Kv)	State		
	Rated power frequency withstand voltage, rms	State		
	Rated lightning impulse withstand voltage, peak	State		
	Rated short-time withstand current (31.5KV/3Secs)	State		
	Internal Arc Protection in accordance to IEC 62271-200	Specify		
	Circuit breaker type (Vacuum) horizontal withdrawable	Specify		
	Circuit breaker quenching medium	Specify		
	Circuit breaker Rated Voltage (17.5Kv)	Specify		
	Circuit breaker Rated power frequency withstand voltage, rms	Specify		
	Circuit breaker Rated lightning impulse withstand voltage, peak	Specify		
	Circuit breaker Rated short-time withstand current (31.5KV/3Secs)	Specify		
	Circuit breaker Rated peak withstand current	Specify		
	Protection relay/EIDs model	State		
	Panel dimensions and Height	Specify		
	Feeder ring core CT rating and diameter for SEF	Specify		
	Main bus bar rating	State		
	Joints and terminal points (Bus bar) plating material	Specify		
	IP Protection degree	State		
49	Joint and terminal point polyethylene sleeves	required		
50	Complete assembled switchgear board inspection and testing	required		
51	The CBs inspection and testing required	required		
52	Relays inspection and testing	required		
53	The CTs and VTs inspection and testing	required		

54	Factory Acceptance Tests to be witnessed by 3 Kenya Power Engineers	State		
55	Copies of manufacturer's catalogues, manufacturing drawings, technical data (required)	State		
	Copy of accreditation certificate to ISO/IEC 17025 for the testing laboratory	Required		
	Manufacturer's warranty and guarantee	State period		
56	Earthing Switches			
	- Rated short-time current for 3sec.			
	- Rated dynamic short-circuit current			
	- Rated breaking Capacity			
	- Manual operated			
	- Close and open electrical and Mechanical interlocks			
57	All operating accessories provided (CB withdrawal trolleys, Racking handles, Charging handles, Keys, Earth switch operation handles etc.)	state		

SCHEDULE 23: GUARANTEED TECHNICAL PARTICULARS- HIGH CONDUCTIVITY ALUMINIUM ALLOY TUBES FOR ELECTRICAL PURPOSES

Clause	Description		Bidder's offer
-	Name of the Manufacturer, address and Country of manufacturing		
	Name & address of Bidder		
	Type/Model Reference Number of items offered		
1	Scope: It shall be the responsibility of the supplier to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the aluminium alloy tubes for Kenya Power		
2	Applicable Standards		
3	Terms and Definitions		
4.1	General Requirements: 4.1.1 & 4.1.2		
4.2	Materials and Construction		
	4.2.1		
	4.2.2		
	4.2.3		
	4.2.4		
	4.2.5		
	4.2.6		
	4.2.7		
4.3	Dimensions	Outside diameter (mm)	
		Wall thickness (mm)	
		Length (m)	
4.4.1	Chemical Composition to BS EN 573-3	Silicon, Si (%)	
		Iron, Fe (%)	
		Copper, Cu (%)	
		Manganese, Mn (%)	
		Chromium, Cr (%)	
		Zinc, Zn (%)	
		Titanium, Ti (%)	
		Others – each (%)	
		Others – total (%)	
		Aluminium, Al (%)	
4.4.2	Mechanical Properties (to BS EN 755-2)	Temper	
		Yield stress (MPa)	
		Tensile strength (MPa)	
		Hardness (HB)	
		Elongation A (%)	

		Elongation A50mm (%)	
4.4.3	Physical Properties, 20 °C	Density (kg/m³)	
		Melting range (°C)	
		Electrical conductivity (MS/m)	
		Thermal conductivity (W/m.K)	
		Co-efficient of thermal expansion (10□⁶/K)	
		Modulus of elasticity (GPa)	
	Mass per unit length, kg/m (at 20 °C)	40mm o.d., 4mm thickness	
		50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	
	Second moment, cm⁴ (at 20 °C)	40mm o.d., 4mm thickness	
		50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	
	Current carrying capacity, A (busbar temperature of 80 °C, ambient of 35 °C)	40mm o.d., 4mm thickness	
		50mm o.d., 8mm thickness	
		80mm o.d., 10mm thickness	

SECTION VI

5.1 QUALITY ASSURANCE MANAGEMENT REQUIREMENT

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5.1 QUALITY ASSURANCE MANAGEMENT REQUIREMENT

1. General

The Contractor shall carry out the Contract Works in accordance with sound quality management principles, which shall include such controls as are necessary to ensure full compliance with all requirements of the Specifications. The Contractor's activities will be monitored by the Engineer to ensure that they are being implemented correctly.

2. Scope

These quality management requirements shall apply to all activities during design, procurement, manufacturing, inspection, testing, packaging, shipping, inland transportation, storage, site erection and commissioning.

The Contractor shall have sole responsibility for ensuring compliance with each of these requirements as applied to the whole of the Contract Works, and shall ensure that subcontractors implement those quality control activities that are appropriate to the extent of their supply.

3. Documentation Required with the Bid

The Contractor shall submit quality manuals; typical standard QC plans for main items of equipment, installation procedures, and other such documents, sufficient to indicate the Contractor's ability and intention of controlling the quality of the whole of the Contract Works in accordance with these requirements.

PLEASE NOTE: Failure to submit the above documents with the bid shall be taken to indicate that control of the Contract would not be satisfactory and may result in disqualification of the Bid.

4. Documentation required within one month of Award of contract

Documents shall be supplied to indicate the following:-

(a) Firming up of main items to be supplied, with names of Contractor and manufacturer (if different from Contractor) and location of place of manufacture.

(b) Manufacturing programs for each major item of equipment, showing main stages of design, procurement, manufacture, inspection and testing.

(c) The Contractor shall prepare a quality plan for the complete Contract Works, and shall require individual manufacturers to prepare detailed quality plans for all main items of equipment.

Quality plans shall identify all inspections and tests, which are to be carried out, including those necessary to verify compliance with particularly specified requirements.

5. Particular Requirement

These particular requirements identify the elements of quality control considered necessary to ensure compliance with specified Contract requirements and it is these elements that the Engineer will examine to verify that compliance has been achieved.

Details of the structure and methods used for establishing and implementing these control elements are not stated, since there are many acceptable ways of achieving a satisfactory system of control. Contractor's established structure and methods shall be used whenever these are capable of complying with the particular requirements stated in the following clauses: - GCC Clause 4.2

6. Organization

The Contractor shall establish an organization for the control of quality, and appointed personnel so designated shall have defined responsibilities and the authority to identify and evaluate quality problems, and to ensure that adequate remedial actions are implemented.

The Contractor shall ensure that responsibilities are assigned for advising the Contract requirements to subcontractors and manufacturers, and the monitoring of compliance with those requirements.

7. Planning

The Contractor, immediately after award of Contract, shall perform a complete review of the Contract and take timely action to ensure that the necessary quality control procedures and provisions are established in accordance with this Specification, purchase order, applicable codes and standards, or other Contract documents.

Particular care shall be taken to identify any specified requirements that are different from or additional to a contractor's normal design or quality control practice, and to initiate the necessary measures to ensure that such additional requirements are implemented satisfactorily.

8. Design control

The Contractor shall be responsible for the control of all design functions for the Contract Works. When design responsibility is shared by subcontractors, the Contractor shall establish interface control measures which co-ordinate the control of the whole design process.

The Contractor shall provide controls to ensure that specified design requirements, codes and standards are correctly incorporated into specifications, drawings, procedures, and instructions. All designs and drawings, including those produced

by subcontractors, shall be checked and approved by Contractor's personnel, other than the originator.

PLEASE NOTE: Drawings and design submitted for the Engineer's approval will not be accepted if there is no evidence of checking by the Contractor, or if the quality of the document's contents clearly indicates that any checking carried out was not competent.

9. Procurement document control

The Contractor is responsible for ensuring that all procurement documents issued to subcontractors contain or refer to all applicable requirements specified in the Specifications which are necessary to enable the Contractor to fulfil those requirements. The Contractor shall also verify that all sub contractor's purchase orders onto manufacturers or other contractors similarly identify all applicable requirements.

10. Documentation and change control

The Contractor shall establish measures to control all documentation that relates to the quality requirements specified in the Specifications. The measures shall ensure that only current issues of documents are used at all manufacturing and control points.

11. Control of purchased materials, equipment and services

The Contractor shall be responsible for ensuring that all purchased materials, equipment and services conform to Contract requirements.

All purchased materials or equipment shall be subjected to inspection control by the Contractor, either on receipt or before dispatch from the manufacturer's works.

The Contractor or his subcontractors shall obtain no material or component from any source, which has not been previously audited by a responsible party and designated as an approved contractor. The Engineer may, at his own discretion, require evidence that such audits have been satisfactorily made and/or evidence of the competence of the designated contractor to meet the necessary quality requirements.

12. Control of inspections and tests

The Contractor shall ensure that all manufacturer's inspections and tests are satisfactorily carried out, in accordance with the planned program and that the data recorded are correct.

The Engineer shall be entitled during manufacture to inspect, examine and test, on the manufacturer's premises, all plant to be supplied under the Contract

13. Handling storage and delivery

The Contractor shall ensure that adequate and controlled measures are established for cleaning, protection, preservation, packing, handling, storage and shipping, to protect items from damage, deterioration or loss. When the nature of the item dictates the need for special handling equipment, this shall be specified and verified by the Contractor.

The identification, marking and labeling of items for shipping shall comply with contractual requirements, and shall be applied in a manner that will ensure no loss of identity and permit permanent and easy recognition of special handling and storage requirements.

14. Environment

The Contractor shall adhere to the recommendations of the Environmental Impact Assessment (EIA), the Environmental Mitigation Plan (EMP) and the requirements of Section VI – Environmental Guidelines for Contractors.

Permanent re-settlement has already been dealt with and compensation paid. However, if any matter arises during the contract with regard to re-settlement and associated compensation, this will be a matter to be dealt with by KPLC and the Engineer should be informed.

15. Implementation

In order to achieve the Quality Management Requirements specified above, the Contractor should designate two senior engineers with sufficient authority who will be solely responsible for Quality Management of the Project. These engineers shall be independent of any other design, manufacturing, inspection, testing and site erection activities associated with this Contract.

One engineer will be responsible for all activities associated with design, procurement, manufacture, inspection, testing, packing and shipping whether undertaken by the Contractor, or by his designated subcontractor or supplier and will normally be resident at the Contractor's Head Office or principal place of work. The other engineer will be responsible for all activities associated with site erection and will be resident at the Contractor's Site Office.

The main responsibilities of the Quality Management engineers are given below:-

<u>Quality Management engineers at Head Office</u>

1. Production and implementation of all Quality Manuals, Quality Standards and test and inspection programs for all materials ordered. All Quality Manuals and Quality Standards and programs shall be submitted for approval to the Engineer prior to implementation.

2. Verifying/Certification that all design and drawings prior to submission to the Engineer are in accordance with the Specifications and all relevant Standards/Codes of Practice.
3. Verifying that all orders placed for materials are in accordance with (1) above and that only the latest revision of approved drawings are used in the course of manufacturing.

4. Verifying that all manufacturers/suppliers have acceptable Quality Control procedures and that these have been implemented throughout the execution of the Works. All Quality Controls shall be submitted for approval to the Engineer prior to their implementation.

5. Verifying that all tests and inspections are undertaken to agreed Standards and Codes of practice.

Quality Management engineers at Site Office

1. Production and implementation of all Quality Manuals, Quality Standards and tests and inspection programs for all materials ordered. All Quality Manuals and Quality Standards and programs shall be submitted for approval to the Engineer prior to implementation.

2. Verifying that only the latest revision of approved drawings are used during the execution of the work and that no drawings stamped “Not Approved” or “Approved with comments” is available for use at Site.

3. Verifying that all orders placed for local materials are in accordance with paragraph (1).

4. Verifying that all works are executed in accordance with the requirements of the Specifications and all relevant Standards/Codes of Practice.

5. Verifying that all tests and inspections are undertaken to agreed Standards/Codes of Practice

SECTION VI

5.2 ENVIRONMENTAL GUIDELINES FOR CONTRACTORS

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5.2. Environmental Guidelines for Contractors

5.2.1. General

The project has been classified as Category 2 in accordance with the Bank's new Integrated Safeguards System (ISS) and the environmental assessment instrument for this type of program is the Environmental and Social Management Framework (ESMF). The ESMF Summary has been prepared and is posted on the Bank website since September 25th 2014.

Consistent with economy and efficiency in the execution of the project, the Contractor must prevent, minimize, or mitigate environmental damage during all erection activities. The natural landscape should be preserved to the extent possible by conducting operations in a manner that will prevent unnecessary destruction or scarring of the natural surroundings. Except where required for permanent works, storing and processing areas and camps, all trees, saplings, and shrubbery should be protected from unnecessary damage by Contractor's operations. After unavoidable damage, relocating, replanting, or restoration are required promptly to prevent further damage (e.g., erosion), and to restore quasi-original conditions where appropriate.

The Contractor's facilities, such as warehouses, labour camps, and storage areas, should be planned in advance to decide what the area will look like upon completion of work. These facilities should be located so as to preserve the natural environment (such as trees and other vegetation) to the maximum extent possible. After project completion, camps and buildings should either serve as permanent residences and form future communities, if such use can be foreseen, or be torn down and the area restored to its quasi-original condition in order to avoid deterioration into shanty-areas.

The Contractor shall comply with any specific Environmental Management Plan (EMP) for the works he is responsible for. The Contractor shall inform himself about such an EMP, and prepare his work strategy and plan to fully take into account relevant provisions of that EMP. If the Contractor fails to implement the approved EMP after written instruction by the Employer/ Engineer to fulfil his obligation within the requested time, the Employer/ Engineer reserves the right to arrange for execution of the missing action by a third party on account of the Contractor.

Notwithstanding the Contractor's obligation under the above clause, the Contractor shall implement all measures necessary to avoid undesirable adverse environmental and social impacts wherever possible, restore work sites to acceptable standards, and abide by any environmental performance requirements

specified in an EMP. In general these measures shall include but not be limited to:

(a) Minimize the effect of dust on the surrounding environment resulting from earth mixing sites, asphalt mixing sites, dispersing coal ashes, vibrating equipment, temporary access roads, etc. to ensure safety, health and the protection of workers and communities living in the vicinity dust producing activities.

(b) Ensure that noise levels emanating from machinery, vehicles and noisy construction activities (e.g. excavation, blasting) are kept at a minimum for the safety, health and protection of workers within the vicinity of high noise levels and nearby communities.

(c) Ensure that existing water flow regimes in rivers, streams and other natural or irrigation channels is maintained and/or re-established where they are disrupted due to works being carried out.

(d) Prevent bitumen, oils, lubricants and waste water used or produced during the execution of works from entering into rivers, streams, irrigation channels and other natural water bodies/reservoirs, and also ensure that stagnant water in uncovered borrow pits is treated in the best way to avoid creating possible breeding grounds for mosquitoes.

(e) Prevent and minimize the impacts of quarrying, earth borrowing, piling and building of temporary construction camps and access roads on the biophysical environment including protected areas and arable lands; local communities and their settlements. In as much as possible restore/rehabilitate all sites to acceptable standards.

(f) Upon discovery of ancient heritage, relics or anything that might or believed to be of archaeological or historical importance during the execution of works, immediately report such findings to the Employer/ Engineer so that the appropriate authorities may be expeditiously contacted for fulfilment of the measures aimed at protecting such historical or archaeological resources.

(g) Discourage construction workers from engaging in the exploitation of natural resources such as hunting, fishing, and collection of forest products or any other activity that might have a negative impact on the social and economic welfare of the local communities.

(h) Implement soil erosion control measures in order to avoid surface run off and prevents siltation, etc.

(i) Ensure that garbage, sanitation and drinking water facilities are provided in construction workers camps.

(j) Ensure that, in as much as possible, local materials are used to avoid importation of foreign material and long distance transportation.

(k) Ensure public safety, and meet traffic safety requirements for the operation of work to avoid accidents.

(l) Ensure not to recruit children below the age of 16 years for the works he is responsible for.

(m) Ensure to pay daily rates of reasonable amount for the daily labourers depending on their skills.

The Contractor shall indicate the period within which he shall maintain status on site after completion of civil works to ensure that significant adverse impacts arising from such works have been appropriately addressed.

The Contractor shall adhere to the proposed activity of the implementation schedule and the monitoring plan / strategy to ensure effective feedback of monitoring information to project management so that impact management can be implemented properly, and if necessary, adapt to changing and unforeseen conditions.

Besides the regular inspection of the sites by Employer/ Engineer for adherence to the contract conditions and specifications, the Employer may appoint an Inspector to oversee the compliance with these environmental conditions and any proposed mitigation measures. State environmental authorities may carry out similar inspection duties. In all cases, as directed by Employer/ Engineer, the Contractor shall comply with directives from such inspectors to implement measures required to ensure the adequacy rehabilitation measures carried out on the bio-physical environment and compensation for socio-economic disruption resulting from implementation of any works.

Transformers or equipment containing polychlorinated biphenyls (PCBs) or PCB contaminated oil should not be installed, and existing equipment involving PCBs or PCB contaminated oil should be phased out and disposed of in a manner consistent with the requirements of the host country.

Processes, equipment and central cooling systems involving the use or potential release to the environment of chlorofluorocarbons (CFCs), including halon, should not be installed, and their use in existing processes and systems should be phased-out and disposed of in a manner consistent with the requirements of the host country.

5.2.2. Worksite/campsite waste management

All vessels (drums, containers, bags, etc.) containing oil/fuel/surfacing materials and other hazardous chemicals shall be bundled in order to contain spillage. All waste containers, litter and any other waste generated during the construction shall be collected and disposed off at designated disposal sites in line with applicable government waste management regulations.

All drainage and effluent from storage areas, workshops and camp sites shall be captured and treated before being discharged into the drainage system in line with applicable government water pollution control regulations.

Used oil from maintenance shall be collected and disposed off appropriately at designated sites or be re-used or sold for re-use locally.

Entry of runoff to the site shall be restricted by constructing diversion channels or holding structures such as banks, drains, etc. to reduce the potential of soil erosion and water pollution.

Construction waste shall not be left in stockpiles along the road, but removed and reused or disposed off on a daily basis.

The disposal sites for spoiled materials shall be located in areas, approved by Employer/ Engineer, of low land use value and where they will not result in material being easily washed into drainage channels. Whenever possible, spoiled materials should be placed in low-lying areas and should be compacted and planted with species indigenous to the locality.

5.2.3. Material excavation and deposit

The Contractor shall obtain appropriate licenses/permits from relevant authorities to operate quarries or borrow areas.

The location of quarries and borrow areas shall be subject to approval by relevant local and national authorities, including traditional authorities if the land on which the quarry or borrow areas fall in traditional land.

New extraction sites:

a) Shall not be located in the vicinity of settlement areas, cultural sites, wetlands or any other valued ecosystem component, or on high or steep ground or in areas of high scenic value, and shall not be located less than 5km from such areas.

b) Shall not be located adjacent to stream channels wherever possible to avoid silting to river channels. Where they are located near water sources, borrow pits and perimeter drains shall surround quarry sites.

c) Shall not be located in archaeological areas. Excavations in the vicinity of such areas shall proceed with great care and shall be done in the presence of government authorities having a mandate for their protection.

d) Shall not be located in forest reserves. However, where there are no other alternatives, permission shall be obtained from the appropriate authorities and an environmental impact study shall be conducted.

e) Shall be easily rehabilitated. Areas with minimal vegetation cover such as flat and bare ground, or areas covered with grass only or covered with shrubs less than 1.5m in height, are preferred.

f) Shall have clearly demarcated and marked boundaries to minimize vegetation clearing.

Vegetation clearing shall be restricted to the area required for safe operation of construction work. Vegetation clearing shall not be done more than two months in advance of operations.

Stockpile areas shall be located in areas where trees can act as buffers to prevent dust pollution. Perimeter drains shall be built around stockpile areas. Sediment and other pollutant traps shall be located at drainage exits from workings.

The Contractor shall deposit any excess material in accordance with the principles of the general conditions, and any applicable EMP, in areas approved by local authorities and/or the Employer/ Engineer.

Areas for depositing hazardous materials such as contaminated liquid and solid materials shall be approved by Employer/ Engineer and appropriate local and/or national authorities before the commencement of work. Use of existing, approved sites shall be preferred over the establishment of new sites.

5.2.4. Rehabilitation and soil erosion prevention

To the extent practicable, the Contractor

a) shall rehabilitate the site progressively so that the rate of rehabilitation is similar to the rate of construction.

b) shall always remove and retain topsoil for subsequent rehabilitation. Soils shall not be stripped when they are wet as this can lead to soil compaction and loss of structure.

c) shall not store the top-soil in large heaps. Low mounds of no more than 1m to 2m high are recommended.

d) shall re-vegetate stockpiles to protect the soil from erosion, discourage weeds and maintain an active population of beneficial soil microbes.

e) shall locate stockpiles where they will not be disturbed by future construction activities.

f) shall reinstate natural drainage patterns where they have been altered or impaired.

g) shall remove toxic materials and dispose of them in designated sites. Excavated areas shall be backfilled with soils or overburden that is free of foreign material that could pollute groundwater and soil.

h) shall Identify potentially toxic overburden and screen with suitable material to prevent mobilization of toxins.

i) shall ensure reshaped land is formed so as to be inherently stable, adequately drained and suitable for the desired long-term land use, and allow natural regeneration of vegetation.

j) shall minimize the long-term visual impact by creating landforms that are compatible with the adjacent landscape.

k) shall minimize erosion by wind and water both during and after the process of reinstatement.

l) shall compact the surfaces deep rip to relieve compaction unless subsurface conditions dictate otherwise.

m) shall re-vegetate with plant species that will control erosion, provide vegetative diversity and, through succession, contribute to a resilient ecosystem. The choice of plant species for rehabilitation shall be done in consultation with local research institutions, forest department and the local people.

5.2.5. Water resources management

The Contractor shall at all costs avoid conflicting with water demands of local communities.

Abstraction of both surface and underground water shall only be done with the consultation of the local community and after obtaining a permit from the relevant Water Authority.

Abstraction of water from wetlands shall be avoided. Where necessary, permission has to be obtained from relevant authorities.

Temporary damming of streams and rivers shall be done in such a way to avoid disrupting water supplies to communities downstream, and maintains the ecological balance of the river system.

No construction water containing spoils or site effluent, especially cement and oil, shall be allowed to flow into natural water drainage courses.

Wash water from washing out of equipment shall not be discharged into water courses or road drains.

Site spoils and temporary stockpiles shall be located away from the drainage system, and surface run off shall be directed away from stockpiles to prevent erosion.

5.2.6. Traffic management

Location of access roads/detours shall be done in consultation with the local community especially in important or sensitive environments. Access roads shall not traverse wetland areas.
Upon the completion of civil works, all access roads shall be ripped and rehabilitated.
Access roads shall be sprinkled with water at least five times a day in settled areas, and three times in unsettled areas, to suppress dust emissions.

5.2.7. Blasting

Blasting activities shall not take place less than 2km from settlement areas, cultural sites, or wetlands without the permission of Employer/ Engineer.

Blasting activities shall be done during working hours, and local communities shall be consulted on the proposed blasting times.

Ambient noise levels reaching the communities from blasting and other activities shall not exceed 55dB in the daytime and 45dB in the night times.

5.2.8. Disposal of unusable elements

Unusable materials and construction elements such as electro-mechanical equipment, pipes, accessories and demolished structures will be disposed off in a manner approved by Employer/ Engineer. The Contractor has to agree with Employer/ Engineer which elements are to be surrendered to the Employer's premises, which will be recycled or reused, and which will be disposed off at approved landfill sites.

As far as possible, abandoned pipelines shall remain in place. Where for any reason no alternative alignment for the new pipeline is possible, the old pipes shall be safely removed and stored at a safe place to be agreed upon with Employer/ Engineer and the local authorities concerned.

AC-pipes as well as broken parts thereof have to be treated as hazardous material and disposed of as specified above.

Unsuitable and demolished elements shall be dismantled to a size fitting on ordinary trucks for transport.

5.2.9. Health and safety

In advance of the construction work, the Contractor shall mount an awareness and hygiene campaign. Workers and local residents shall be sensitized on health risks particularly of AIDS.

Adequate road signs to warn pedestrians and motorists of construction activities, diversions, etc. shall be provided at appropriate points.

Construction vehicles shall not exceed maximum speed limit of 40km per hour.

The Contractor must ensure that his construction crew are equipped with the necessary safety materials (helmets, gloves, boots, etc.).

Adequate first aid facilities shall be provided at all sites where construction activities are being undertaken.

5.2.10. Repair of private property

Should the Contractor, deliberately or accidentally, damage private property, he shall repair the property to the owner's satisfaction and at his own cost. For each repair, the Contractor shall obtain from the Owner a certificate that the damage has been made good satisfactorily in order to indemnify the Employer from subsequent claims.

In cases where compensation for inconveniences, damage of crops etc. are claimed by the owner, the Employer has to be informed by the Contractor. This compensation is in general settled under the responsibility of the Employer before signing the Contract. In unforeseeable cases, the respective administrative entities of the Employer will take care of compensation.

5.2.11. Contractor’s environment, health and safety management plan (EHS-MP)

Within 6 weeks of signing the Contract, the Contractor shall prepare an EHS-MP to ensure the adequate management of the health, safety, environmental and social

aspects of the works, including implementation of the requirements of these general conditions and any specific requirements of an EMP for the works. The Contractor's EHS-MP will serve two main purposes:

For the Contractor:, as an internal use, to ensure that all measures are in place for adequate EHS management, and as an operational manual for his staff.

For the Employer:, supported where necessary by an Engineer, to ensure that the Contractor is fully prepared for the adequate management of the EHS aspects of the project, and as a basis for monitoring of the Contractor's EHS performance.

The Contractor's EHS-MP shall provide at least:

i. a description of procedures and methods for complying with these general environmental management conditions, and any specific conditions specified in an EMP;
ii. a description of specific mitigation measures that will be implemented in order to minimize adverse impacts;
iii. a description of all planned monitoring activities (e.g. sediment discharges from borrow areas) and the reporting thereof; and
iv. the internal organizational, management and reporting mechanisms.

The Contractor's EHS-MP will be reviewed and approved by the Employer/ Engineer before start of the works. This review should demonstrate if the Contractor's EHS-MP covers all of the identified impacts, and has defined appropriate measures to counteract any potential impacts.

As part of the monthly progress report, the Contractor shall prepare an EHS Report on compliance with these general conditions, the project EMP, and his own EHS-MP. It is expected that the Contractor's reports shall include information on but not limited to:

a) EHS management actions/measures taken, including approvals sought from local or national authorities;
b) Problems encountered in relation to EHS aspects (incidents, including delays, cost consequences, etc. as a result thereof);
c) Lack of compliance with contract requirements on the part of the Contractor;
d) Changes of assumptions, conditions, measures, designs and actual works in relation to EHS aspects; and
e) Observations, concerns raised and/or decisions taken with regard to EHS management during site meetings.

It is advisable that reporting of significant EHS incidents be done “as soon as practicable”. Such incident reporting shall therefore be done individually. Also, it is advisable that the Contractor keep his own records on health, safety and welfare of persons, and damage to property. It is advisable to include such records, as well as copies of incident reports, as appendixes to the monthly reports. Example formats for an incident notification and detailed report are given below. Details of EHS performance will be reported to the Employer/Engineer.

5.2.12. Training of contractor’s personnel

The Contractor shall provide sufficient training to his own personnel to ensure that they are all aware of the relevant aspects of these general conditions, any project EMP, and his own EHS-MP, and are able to fulfil their expected roles and functions. Specific training should be provided to those employees that have particular responsibilities associated with the implementation of the EHS-MP. General topics should include:

a) EHS in general (working procedures);
b) emergency procedures; and
c) Social and cultural aspects (awareness raising on social issues).

5.2.13. Cost of compliance

It is expected that compliance with these conditions is already part of standard good workmanship and state of art as generally required under this Contract. The item “Compliance with Environmental Management Conditions” in the Bill of Quantities covers this cost. No other payments will be made to the Contractor for compliance with any request to avoid and/or mitigate an avoidable EHS impact