



**Bidding Document for  
Procurement of Plant  
Design, Supply, and Installation**

**Procurement of:  
132kV UNDERGROUND CABLE NANYUKI –  
RUMURUTI TRANSMISSION LINE**

**Volume 2 of 2  
PART 2: EMPLOYER'S REQUIREMENTS**

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# **1. GENERAL**

## **1.1. General**

This specification covers the general technical requirements applicable to tests, materials, workmanship and standards involved in the design and manufacture of materials and equipment for overhead transmission lines and underground cables rated 132 kV and above. Supplementary requirements for the various line components are contained in the appurtenant sections of the Specifications. The specifications, designs and drawings of the previous contract have been provided an appendix to this specification.

It is not the Employer's intent to specify all technical requirements or to set forth those requirements adequately covered by applicable codes and standards. The Contractor shall furnish high quality design assuming that all supplied and installed equipment and materials meet the requirements of this specification and industry standards.

The Contractor shall bear full responsibility that the design used are in accordance with all standards and applicable regulations and perform under the condition and to the standards specified herein.

No deviations shall be made from this specification and standards unless waived or modified in writing by the Employer. The Contractor shall obtain from its sub-contractor a statement as to compliance with this specification without exception and/or if there are any exceptions, these shall be described in detail and included in the Contractor's Tender. The Contractor shall add a statement that no other exceptions are taken to this specification.

## **1.2. Services to be provided by the Contractor**

The Contractor shall provide the services specified in the Technical Schedules.

## **1.3. Services to be provided by Employer**

The Employer shall provide the services listed in the Technical Schedules.

## **1.4. Definitions**

In addition to the terms referred to in PART 3, Section VII, the General Conditions of Contract, the following, where used in this Specification, shall have the meanings listed below: -

“Specified” shall mean specified herein or in the Technical Schedules.

The present clauses refer to the general technical requirements for EPC (engineering – procurement – construction) contracts for electrical overhead lines.

The following directions, information and technical requirements for design, engineering, layout, manufacturing, erection, installation and testing shall be observed as far as they are applicable for the material and equipment to be delivered. The requirements stated in this Section of Technical Requirements are valid for all sections of the technical requirements, except where different, additional and/or special requirements are specified within the Guaranteed Technical Particulars (GTP).

Any changes on the design of any part of the Plant, which may become necessary after signing of the Contract, have to be submitted by the Contractor in writing to the Employer for approval, being sufficiently substantiated and justified.

The Plant shall be brand new and designed, manufactured and arranged so that it will have a functional design and a pleasant appearance.

## 1.5. Scope of Work

The scope comprises of

- a) design, supply, delivery to site, installation and commissioning of transmission lines for 132kV three phase High voltage (HV) underground (UG) cable for the following:
  - i. Approximately 16.8 km section of Nanyuki – Rumuruti Transmission Line (Double circuit).

The terminal points shall be the designated steel lattice towers along the respective transmission lines and the Rumuruti transmission line gantries at Nanyuki substation.

- ii. Approximately 4.2 km section of Nanyuki – Isiolo Transmission Line (Single circuit).

The terminal points shall be the designated steel lattice towers along the respective transmission lines above.

The contractor is required to familiarise himself with all utilities that will interact with the underground and overhead lines in order to provide a functional bid. Collaboration with the utility owners will therefore be required in order to identify services proximal to the construction site. The contractor will also be required to share designs and plans in advance. The contractor will avoid outages and damages to services. Design and work methodology will also be subjected to the review of the service provider. The contractor will also be required to make provide to provide alternative service route and compensate for the unavoidable outages and damages.

**Error! Reference source not found.** is an inconclusive list of some of the expected utilities. The contractor should undertake own enquiries and site inspections in order to capture all the services. The employer cannot guarantee the accuracy or the completeness of these crossings

*Table 1: An approximate listing of utility installations*

| Utility   | Details   |
|---|---|
| Water pipe to the Kenya Air Force Camp                            | 6-inch-wide pipes, 1 meter deep.<br>Between Tower 15 and 16   |
| Safaricom Line /Police Line/<br>NSIS                              | More than 2 meters deep,<br>Between Tower 15 and 16           |
| Water Pipes to Batuk  | 3 inches wide pipes, 1 meter deep,<br>Between Tower 15 and 16 |
| Water Tunnel from the NAWASCO sewerage plant<br>feeding the river | 24 inches in diameter, 2 meters deep                          |
| Sewerage Line from Batuk to the NAWASCO<br>Treatment Plant        | 2 meters deep   |
| Laikipia Airbase Road   | under KeRRA   |
| 50 mm water pipe between tower 17 and 18                          | Under NAWASCO management, less than 1<br>meter deep           |
| Nanyuki Rumuruti Road   | Under KENHA Management  |

## 1.6. Extent of Work

The contract Works to be supplied shall include all work incidental thereto whether specified in detail or not and shall be carried out by the Contractor in accordance with the Specification and Conditions of Contract and shall comprise the following: -

### 1.6.1. Definite Work

The supply and services to be performed by the Contractor shall comprise of the design, manufacture, factory testing, packing, transport, insurance, demurrage, delivery to and off-loading at site, storage, erection, site testing, commissioning, training of KETRACO personnel, warranty and maintenance of the following plant and materials and of the other work incidental thereto included in the Specification.

- a. The three-phase underground power cable having the technical particulars set out in the Technical Schedules and Drawings attached to the Specification, the lines being complete with the survey, route clearance, underground power cable, underground optic fibre, insulators and fittings, earthing (where required) and connections, and all other fittings at the total price for the estimated quantities stated under the Price Schedules in Section VII. Estimated quantities are for bid purposes only; final payment shall be made on the basis of quantities as finally erected and confirmed by measurement.

The overall underground cable system shall include

- 1.5 km of double circuit underground cable system with single pilot fibre in concrete trench installation
- 11.5 km of double circuit underground cable system with single pilot fibre in directly buried installation
- 3.8 km of triple circuit underground cable system with two pilot fibre in directly buried installation
- 0.4 km of single circuit system with single pilot fibre system in directly buried installation
- Three class 'B' road crossings via micro tunnelling
- Three access entrance (gate) crossings via micro tunnelling

The underground cable transmission line works include the following but not limited to;

- Preliminary / Alignment/ Detailed Survey
- Right-of-Way clearing and access roads
- Preparation of all schedules (listed under submittals)
- Underground to Overhead line transition systems designs
- Underground cable system design
- Geotechnical investigation
- Testing of Construction Materials and concrete mix
- Insulation Coordination Studies
- Surge arrestor sizing studies
- Design, Supply and installation and testing of one single circuit termination tower for Nanyuki Isiolo Meru transmission line.
- Design, Supply and installation and testing of conductor and line accessories for overhead line to underground cable transitions and terminations.
- Design, supply, installation, termination and testing of underground cable and cable accessories.
- Design, supply, installation and testing of underground optical fibre and their accessories including joint boxes and termination boxes, etc.



- Testing of underground optic fibre and provision of the OTDR test results for the overall complete lines i.e Rumuruti Nanyuki (end to end)
- Calculation of the underground cable parameters for System Protection.
- Design, supply of material and construction of foundations.
- Design, supply of material and construction of cable trench.
- Design, supply of material and installation of cable structures.
- Design, supply of material, installation and termination of underground fiber optic cable and accessories including joint boxes and termination boxes, etc.
- Supply of insulator and hardware sets and installation of insulator strings.
- Supply of spare parts and maintenance tools
- Final inspection, testing and commissioning, reinstatement and clean-up of site.
- Maintenance of the cable system of the transmission lines until the completion of the defects liability period.
- Design, supply, installation of smart anti vandalism surveillance system for the underground cable
- As built drawings and electronic records.
- Supply, testing, commissioning and training of unmanned aerial vehicles
- Design, Supply, testing, commissioning and training of remote data entry devices

## **1.6.2. NANYUKI -RUMURUTI SECONDARY ELECTRICAL WORKS**

### **1.6.2.1. NANYUKI –RUMURUTI**

There exists line protection in Nanyuki and in Rumuruti substations.

Scope of works in **Nanyuki SS**

The secondary scope of works in Nanyuki include:

1. Modification of the protection settings to include the cable section of the transmission lines. This should take into consideration the charging currents of the cable. This should involve a study to confirm suitability of auto reclosing functionality.
2. Retesting of the transmission lines existing protection schemes. In this case, there exists 2 bays for Rumuruti line. The contractor is required to reconfiguration and parameterize

the protection and control scheme with the new settings and any changes necessitated by the cable section for the 2 bays even if one is future.

3. Retesting of all of the transmission lines existing protection schemes.
4. Remote end to end testing.
5. Reconfiguration of SAS signals if required.

### Scope of works in **Rumuruti SS**

The secondary scope of works in Rumuruti include:

1. Modification of the protection settings to include the cable section of the transmission lines. This should take into consideration the charging currents of the cable. This should involve a study to confirm suitability of auto reclosing functionality.
2. Reconfiguration and Parameterisation of the protection and control scheme with the new settings and any changes necessitated by the cable section.
3. Retesting of all of the transmission lines existing protection scheme
4. Remote end to end testing.
5. Reconfiguration of SAS signals if required.

## **1.7. Terminal points**

### **Nanyuki Rumuruti**

The connections of OPGW, conductors and earth wire from the transmission line terminal towers to the underground cable and OPGW terminations on the cable structure including any jumpers or droppers and all other accessories required are included in this Specification.

The connections of OPGW, conductors and earth wire from the transmission line terminal towers to line gantry and OPGW terminations on the line gantry at Nanyuki substation including any jumpers or droppers and all other accessories required are included in this Specification. OPGW connection and all terminations from the line gantry to the substation control room are included in this specification

The down leads connections of conductors from the 132kV transmission line to ground anchors at the cable sealing ends compound are included in this Specification.

The termination of OPGW at the towers and cable structures, including all termination boxes where optical fibres are to be terminated, are included in this Specification.

The control and monitoring station for the smart anti vandalism surveillance system for the underground cable shall be located at Kenya Air force base in Nanyuki.

The programme for work and work at all the terminal points are required to be coordinated with other contractors/ parties at no additional cost to KETRACO.

## **1.8. Details of transmission line routes**

Details of the general routing of the underground lines shall be provided as route maps and given in soft copy together with the bid documents as Appendix 2. An overview of the proposed route is provided in Appendix 1.

The contractor is required to familiarise himself with the all services that will interact with the underground and overhead lines in order to provide a functional bid.

## **1.9. Access Tracks**

The Contractor shall provide at his own cost, all necessary local transport routes and access tracks and all labour, plant and materials necessary for unloading and erection, and shall be entirely responsible for their efficient and correct operation. The Employer will, however, permit the Contractor to use any of his existing access tracks subject to these being restored to the satisfaction of the Engineer in respect of any damage which may be caused during the period of the Contract and the subsequent maintenance period. For this purpose the Contractor shall agree with the Engineer suitable records indicating the initial condition of each access track prior to its use.

Where the crossing of pipelines by vehicles and equipment is necessary, whether the pipes are above or below ground, the Contractor shall obtain permission to cross from the appropriate company or authority. The measures to be taken to protect the pipelines shall be agreed upon with them. Existing tracks shall be jointly inspected prior to their use and their condition recorded and agreed.

Provision shall be made to establish a vehicle access track along the length of the cleared strip to for purposes of construction. Any alternative route for the track may be agreed with the Engineer.

On handing over any section of works, the Contractor shall hand over relevant access tracks in a condition suitable for the Employer's maintenance vehicles and, for those originally belonging to the Employer, in no worse condition than originally recorded

## **1.10. Climate**

Equipment design shall be based on the following conditions

### **1.10.1. Rainfall**

Annual rainfall ranges between 400mm and 750mm

### **1.10.2. Temperatures**

Minimum temperature 1° C

Maximum temperature 45°C

Max. Conductor temperature 80°C

(Include Maximum Cable temperature.)

Annual average temperature 25° C

### **1.10.3. Humidity**

Mean relative humidity (max/average) 94%/50%

Relative humidity 60%

### **1.10.4. Isokeraunic Level**

An isokeraunic level (storm) of 280 days/year shall be considered for design purposes.

### **1.10.5. Maximum Solar Radiation**

For design purposes a solar radiation value of 1200W/m<sup>2</sup> shall be considered.

### **1.10.6. Earthquake loading**

For design purposes an earthquake loading of 0.15g shall be assumed.

### **1.10.7. Wind load**

For design purposes a basic wind velocity (3sec gust wind) of 36m/s shall be assumed.

### **1.10.8. Altitude**

The height above sea level shall be considered as 2000m.

The insulation levels of external insulation shall be determined in accordance with

IEC 62271-1, Clause 2.2.1.

### **1.10.9. Pollution**

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

The site specific weather/service conditions shall be provided during detailed design.

It is the contractor's responsibility to confirm detailed site specific weather/service conditions during bidding.

### **1.11. Transport**

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

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

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

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

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

### **1.12. Units of measurement**

The Contract shall be conducted in the SI (Système International d'Unités) system of units in accordance with the provisions of ISO 31 and ISO 1000.

In all correspondence, technical schedules, drawings and instrument scales, the following units or multiples thereof shall be used:

*Table 2: Units of Measurement*

| Quantity | Name of Unit | Symbol |
|----------|--------------|--------|
|----------|--------------|--------|

|                                      |  |                    |
|--------------------------------------|--|--------------------|
| Length                               | Meter  | m                  |
| Mass                                 | Kilogram   | kg                 |
| Time                                 | Second   | s                  |
| Temperature                          | Degree Celsius   | °C                 |
| Temperature Difference               | Kelvin   | K                  |
| Electric Current                     | Ampere   | A                  |
| Luminous Intensity                   | Candela  | cd                 |
| Area                                 | Square meter   | m <sup>2</sup>     |
| Volume                               | Cubic meter  | m <sup>3</sup>     |
|                                      | Litre  | l                  |
| Force                                | Newton   | N                  |
| Pressure (absolute)                  | Bar  | bar                |
|                                      | Kilopascal   | kPa                |
| Pressure below 1 bar                 | Millibar   | mbar               |
| Stress                               | Newton per square millimeter   | N/mm <sup>2</sup>  |
| Velocity                             | Meter per second   | m/s                |
| Rotational speed                     | Revolutions per minute   | rpm                |
| Flow                                 | Cubic meter per day  | m <sup>3</sup> /d  |
|                                      | Cubic meter per hour   | m <sup>3</sup> /h  |
|                                      | Kilogram per hour  | kg/h               |
|                                      | Liter per second   | l/s                |
|                                      | metric ton per hour  | t/h                |
|                                      | For gaseous substance: standard cubic meter per hour (referred to 0°C and 1013 mbar) | Nm <sup>3</sup> /h |
| Density                              | Kilogram per cubic meter   | kg/m <sup>3</sup>  |
|                                      | Kilogram per standard cubic meter  | Kg/Nm <sup>3</sup> |
| Torque, moment of force              | Newton meter   | Nm                 |
| Moment of inertia (mr <sup>2</sup> ) | Kilogram square meter  | kgm <sup>2</sup>   |
| Work, energy or heat                 | Joule  | J                  |
| Heat capacity, entropy               | Joule per Kelvin   | J/K                |
| Calorific value                      | Joule per cubic meter  | J/m <sup>3</sup>   |
|                                      | Joule per gram   | J/g                |
| Power, radiant flux                  | Watt   | W                  |
| Heat release rate                    | Watt per square meter  | W/m <sup>2</sup>   |
| Thermal conductivity                 | Watt per meter Kelvin  | W/mK               |
| Dynamic viscosity                    | Newton second per square meter   | Ns/m <sup>2</sup>  |
| Kinematic viscosity                  | Meter squared per second   | m <sup>2</sup> /s  |
| Surface tension                      | Newton per meter   | N/m                |
| Concentration                        | Parts per million  | ppm                |
| Electrical conductivity              | Microsiemens per meter at 25°C   | μS/m               |
| Frequency                            | Hertz  | Hz                 |
| Electric charge                      | Coulomb  | C                  |
| Electric potential                   | Volt   | V                  |
| Electric field strength              | Volt per meter   | V/m                |

|                         |                       |          |
|-------------------------|-----------------------|----------|
| Electric capacitance    | Farad                 | F        |
| Electric resistance     | Ohm                   | $\Omega$ |
| Conductance             | Siemens               | S        |
| Magnetic flux           | Weber                 | Wb       |
| Magnetic flux density   | Tesla                 | T        |
| Magnetic field strength | Ampere per meter      | A/m      |
| Luminous flux           | Lumen                 | lm       |
| Illuminance             | Lux                   | lx       |
| Thermal resistivity     | Kelvin meter per Watt | Km/W     |
| Energy                  | Kilowatt hour         | kWh      |

### 1.13. Materials

All materials shall be new and of the best quality suitable for working under the conditions, variations in temperature and pressure encountered in service without undue distortion or deterioration or the setting up of undue stresses in any part, such as not to affect the efficiency and reliability of the plant.

Either, all materials shall conform to the approved standards and the respective code number, or exact analysis data and full information concerning properties, chemical and mechanical treatment shall be submitted.

Only materials which have been tried and tested in similar plants shall be used. Steel castings shall not have any casting defects which could compromise the function of the component and affect the appearance. The materials employed shall serve their purpose, according to the operation conditions. The Contractor shall be responsible for selecting, working, treating and quality assurance of the materials to suit the intended purpose.

Special attention shall be paid to the corrosion by galvanic effects or electrochemical corrosion. Design, selection of material and its combination as well as methods of erection shall be such as to exclude these effects.

It is not permissible to use gray cast iron for components containing pressure, unless the Employer expressly agrees to this beforehand.

Asbestos or materials containing asbestos for seals, expansion joints, etc. shall not be employed.

Likewise, it is not permissible to use mercury or oils containing Polychlorinated Biphenyl (PCB).

No welding, fitting or plugging of defective parts will be permitted without permission in writing from the Employer.

### 1.14. Guaranteed values

The Contractor shall guarantee that the data mentioned on the name plate of the equipment and given in the data sheets will not deteriorate during the life of this equipment under the specified operating and maintenance conditions.

The Contractor shall guarantee the values in the technical data schedule. The Employer reserves the right to reject any equipment that does not respect these values.

## **1.15. Standards and codes**

The work is to be performed according to the most recent relevant codes, standards, accident prevention regulations and legal regulations.

### **1.15.1. General**

EN 50341-1: “Overhead electrical lines exceeding AC 45kV, Part 1 - General requirements – Common specifications”

IEC 60038: “IEC standard voltages”

IEC 60060: “High voltage test techniques”

IEC 60270: “High voltage test techniques – Partial discharge measurements”

### **1.15.2. Conductors**

- EN 50182: “Conductors for overhead lines - round wire concentric lay stranded conductors”

- AScoTM B 232/ B 232M: “Specification for concentric-lay-stranded aluminium conductors, coated-steel

reinforced (ACSR)”

- EN 60889: “Hard-drawn aluminium wires for overhead line conductors”

- EN 50189: “Conductors for overhead lines - Zinc-coated steel wires”

- EN 50326: “Conductors for overhead lines - Characteristics of greases”

- EN 10244: “Steel wire and wire products - Non-ferrous metallic coatings on steel wire - Part 2: Zinc of zinc alloy coatings”

- IEC TR 61597: “Overhead electrical conductors - Calculation methods for stranded bare conductors”

- IEC 60468: “Method of measurement of resistivity of metallic materials”

- ISO 7802: “Metallic material - Wire - Wrapping test

- IEC 60104: Aluminium-Magnesium-Silicon Alloy Wire for Overhead Line Conductors



- IEC 60888: Zinc-Coated Steel Wires for Stranded Conductors
- IEC 60889: Hard-Drawn Aluminium Wire for Overhead Lines
- IEC 61089: Round Wire Concentric Laid Overhead Electrical Stranded Conductors
- IEC 61232: Aluminium-Clad steel Wires for Electrical Purposes
- IEC 61395: Overhead Electrical Conductors – Creep Test Procedures for Stranded Conductors
- IEC 62219: Overhead Electrical Conductors – Formed Wire, Concentric Lay, Stranded Conductors
- IEC 61284: Overhead Lines – requirements and Tests for Fittings

### **1.15.3. OPGW**

- IEC 60793: “Optical fibers - Part 1: Measurement methods and test procedures”
- IEC 60794-1-1: “Optical Fiber Cables - Generic Specification - General (Materials, Construction, Measuring Methods)”
- IEC 60794-1-2: “Optical Fiber Cables - Generic Specification - Basic Optical Cable Test Procedures”
- ITU-T G.655: “Transmission media characteristics – Optical fiber cables - Characteristics of a non-zero dispersion shifted single mode optical fiber cable”
- IEC 60304: Standard Colours for Identification and Coding
- IEC 60793: Optical Fibres. Measurement Methods and Test Procedures
- IEC 60794: Optical Fibre Cables. Specifications
- ITU-T G.650.1: Definitions and test methods for linear, deterministic attributes of single-mode and cable.
- ITU-TG.650.2: Definitions and test methods for statistical and non-linear related attributes of single mode fibre and cable.

### **1.15.4. Insulators/ Insulator Strings**

- IEC 60071-1: “Insulation co-ordination - Part 1: Definitions, principles and rules”
- IEC 60071-2: “Insulation co-ordination - Part 2: Application guide”
- IEC 60815: “Guide for the selection of insulators in respect of polluted conditions”
- IEC 61109: “Composite insulators for AC overhead lines with nominal voltage greater than 1000 V – definitions, test methods and acceptance criteria”

- IEC 61466-1: “Composite string insulator units for overhead lines with nominal voltage greater than 1000 V – Part 1: Standard strength classes and end fittings”
- IEC 61466-2: “Composite string insulator units for overhead lines with nominal voltage greater than 1000 V – Part 2: Dimensions and electrical characteristics”
- IEC 60120: “Dimensions of ball and socket couplings of string insulator units”
- IEC 60372: “Locking devices for ball and socket couplings of string insulator units: Dimensions and tests”
- IEC 60437: “Radio interference test on high-voltage insulators”
- IEC 60507: “Artificial pollution tests on high-voltage insulators to be used on A.C. systems”
- IEC 61 467: “Insulators for OHL >1kV - Power Arc Tests for Insulator Sets”

#### **1.15.5. Fittings**

- IEC 61284: “Overhead Lines - Requirements and tests for fittings”
- IEC 61854: “Overhead Lines - Requirements and Tests for Spacers”
- IEC 61897: “Overhead Lines - Requirements and Tests Stockbridge Type Aeolian Vibration Dampers”

#### **1.15.6. Towers**

- EN 1993-1-1: “Design of steel structures - Part 1-1: General rules and rules for buildings”
- EN 1993-1-8: “Design of steel structures - Part 1-8: Design of joints”
- EN 10025 (2004): “Hot rolled products of structural steels”
- EN 10029: “Hot rolled steel plates 3mm thick and above”
- EN 10056: “Structural steel equal and unequal leg angles - Part 1: Dimensions, Part 2: Tolerances”
- ISO 898: “Mechanical properties of fasteners”
- ISO 1461: “Hot dip galvanized coatings on fabricated iron and steel articles”
- IEC 60652: “Loading tests on overhead line structures”
- Paper 3B from IEE “Effects of Interacting Construction Deviations on 500 kV Power Line Structures” by F. Villa, Kuala Lumpur, Malaysia 1993.

### **1.15.7. Foundations**

- EN 1997-1-1: “Geotechnical design - Part 1: General rules”
- EN 197-1: “Cement – Composition, specification and conformity criteria”
- BS EN 12620: “Specification for aggregates from natural sources of concrete”
- EN 206-1: “Concrete – Specification, performance, production and conformity”
- EN 10080: “Steel for the reinforcement of concrete - Weldable reinforcing steel - General”
- EN 1992-1: “Design of concrete structures - Part 1-1: General rules and rules for buildings”
- EN 12350-1: “Testing fresh concrete”
- EN 12390-3: “Testing hardened concrete”
- IEC 61773: “Overhead lines – Testing of foundations for structures”.

All materials and equipment supplied and all work carried out as well as calculation sheets, drawings, quality and class of goods, methods of inspection, constructional peculiarities of equipment and parts and acceptance of partial plants, as far as these are beyond the special requirements of partial plants and as far as they are beyond the particular requirements of the technical requirements shall comply in every respect with the technical codes of the International Organization for Standardization (ISO). IEC recommendations apply to the electrical equipment.

The type and extent of inspection shall generally be in accordance with that specified in the standard used for design and construction of the item of equipment supplemented or amended by the requirements of this section of the technical requirements.

Additional design tests are also to be carried out as described in the other parts of this technical requirements.

Reference to special codes and standards, where designated either directly or as "relevant", is intended to provide a measure of performance, safety, in-shop and on-site testing, and methods of construction and/or installation which must be equal or exceeded in order to be considered acceptable for use under these technical requirements. If more than a single degree of quality or accuracy is permitted within the scope of particular code or standard, the highest quality shall be applicable and the degree of accuracy commensurate with the intended function shall be selected but with the understanding in either case that the decision as to degree will be made finally along with procedures by the Employer / Employer's Representative.

In all instances, the finally accepted applicable code or standard shall be the version last published prior to the date of submission of the Bid selected as the basis for this Contract.

Where no appropriate standard is available, tests shall be carried out in accordance with the manufacturer's standard practice, which needs the approval of the Employer / Employer's Representative. In such cases the Contractor shall submit to the Employer / Employer's Representative complete data and a suggested procedure for the testing to be performed before manufacture commences. If the proposed procedure is accepted, the Contractor shall provide the Employer / Employer's Representative with four additional copies in English before any test is performed.

The Contractor's attention is drawn to the climatic conditions in the site area. De-rating factors are to be in accordance with the relevant IEC codes and standards or an approved equivalent.

Goods and special guarantees beyond the scope of ISO and IEC shall conform at least to the following standards and codes in the following priority:

EN, BS, ASTM, IEEE;

Contractor, subcontractors, sub-suppliers and shops are to be certified according to ISO 9001:2015.

In case of differences between the specification and relevant standard the more stringent condition shall be applied.

### **1.15.8. Plant and equipment identification**

The Contractor shall apply a plant identification system showing the name and number of each item of plant and its respective arrangement drawing number and add any additional items necessary to fully identify the plant. There is to be only one description for any one item of plant and this must be used consistently for plant, electrical and instrumentation designations throughout.

IEC-Publication 61346-1 shall be applied.

The classification numbers shall appear in all drawings, lists, documents prepared by the Contractor for the project right from the initial stage of the contract execution.

The Contractor shall supply all labels, nameplates, instruction and warning plates necessary for the identification and safe operation of the plant. Their inscriptions shall be in the national language of the Employer's country if not otherwise mentioned.

All labels, nameplates, instruction and warning plates shall be securely fixed to items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives will not be permitted.

Nameplates for plant and equipment identification and record purposes shall be manufactured from stainless steel with a matte or satin finish, and engraved with black lettering of a size which is legible from the working position.

Warning plates shall be manufactured from stainless steel engraved with white lettering on a red background and sited in the position where they afford maximum safety of personnel.

All equipment within panels and desks shall be individually identified by satin or matte finish stainless steel labels, or laminated plastic labels where approved.

## **1.16. Marking, labelling and packing**

The Contractor shall prepare all equipment and materials for shipment in such a manner as to protect them from damage in transit, and shall be responsible for and make good any and all damage due to improper preparation or loading for shipment.

Before being packed for shipment to the site, all items of the equipment shall be carefully numbered and marked so that they can be readily assembled and erected in the correct relative positions at the site. Wherever applicable, these numbers and markings shall be punched or painted so that they shall be clearly visible.

Packing shall be done in convenient sections, so that the weight and size of sections are suitable for transport to the site and for handling at the site under the special conditions applicable there.

All individual pieces shall be marked with the plant identification number and the correct designation shown on the Contractor's detailed drawings and on other documents like packing lists, spare parts lists, operation and maintenance instructions, etc.

Marking shall be done identically on labels and by stamping the marks into the metal before painting, galvanizing, etc., and shall be clearly readable after painting, galvanizing, etc.

All parts of the plant shall be packed at the place of manufacture. The packing shall be suitable for shipment by sea and for all special requirements of the transportation to the site. Where necessary, double packing shall be used in order to prevent damage and corrosion during transportation, unloading, reloading and during intermediate storage.

All identical members shall be packed together, if reasonably possible, in a form convenient for shipment and handling.

Small items shall be packed in boxes and large items shall be protected, where necessary, by timber, straw and sacking.

All parts shall be suitably protected against corrosion, water, sand, heat, any adverse atmospheric conditions, shocks, impact, vibrations, etc. for later transport and storage.

Tube ends and other similar open ends shall be protected against external damage and ingress of dirt and moisture during transit and while awaiting erection at site. Flanged pipes shall have their open ends protected by adhesive tape or jointing and then be covered with a wooden blind flange.

Screws and not nails shall fix the lids and internal cross battens of all packing cases.

The contents of the cases shall be bolted securely to the case or fastened in position with struts or cross battens, and not wedged in place with wooden shocks, unless these are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the batten may rest. Cases shall be up-ended after packing to prove that there is no movement of contents.

Where parts are required to be bolted to the sides of the case, large washers shall be strengthened by means of a pad. Wood-shavings shall be avoided as far as possible for packing purposes.

Tower members shall be packed for shipment in bundles of the same size and weight containing pieces of the same or similar identifications mark and length. The individual members may be stacked to bundles and plastic spacers shall be placed in between the individual members, reducing the formation of wet storage stains. All bolts, nuts, washers, step bolts and minor fittings shall be shipped in wooden cases of suitable size and weight, with pieces properly separated according to size and type.

Bundles of steel angle sections shall be properly tied together by an approved method. The individual bundles shall be marked for identification by stamped metal labels. Particular care shall be taken by composing of bundles containing similar length of members and that the individual bundles do not have excessive weight for facilitate handling during shipment. Bundles may be as large as practicable to provide sufficient internal stiffness and resistance against excessive bending of deformation during lifting.

Unless the Contractor can offer an equally acceptable method, bundles of angles shall be arranged in rectangular formation with notched outer stout wooden battens to locate the angles, the battens being located sufficiently close intervals to form a strong homogeneous element.

Packing cases where used shall be strongly constructed and in no case is thinner than 25 mm in thickness to be used. The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens. Cross battens supporting weight in any direction shall not rely for their support on nails or screws driven lengthwise into the grain of the wood, but shall be supported by cleats secured from the inside.

Spare parts shall be packed for long duration storage. Individual steel members stacked in bundles as spare parts shall be spaced by plastic spacers. Wooden drums will not be accepted for the spare conductors, ground wires and OPGW.

Each crate or package shall contain a packing list placed in a waterproof envelope. All items of the crate or package shall be clearly marked for easy identification against the packing list.

All cases, packages, etc. shall be clearly marked on the outside to indicate the total weight, the position of the centre of gravity and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

All stencil marks on the outside of cases shall be either of a waterproof material or protected by shellac or varnish.

All packing shall be included in the scope of delivery and the cost shall be included in the prices. The packing materials remain the property of the Employer.

The Purchaser may require inspection and approval of the packing before the items are dispatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection shall not exonerate the Contractor from any loss or damage due to faulty packing.

## **1.17. Transport and storage of material**

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

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

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

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

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

Shipment by sea freight shall be made to the designated port of destination. Airfreight shall be made to the destination airport, as agreed with the Employer.

Shipments are to be made on a CIP basis according to Incoterms and explained in the commercial conditions.

Prior to shipment the Contractor shall furnish by air mail, telefax, telex or otherwise, as agreed the shipping documents to the Employer. Details will be fixed during the Kick-Off Meeting.

All cases and boxes shall be clearly and boldly marked and shall be sent to the Employer as per address details instructed by the Employer. When the actual transport has been completed, the Employer shall be notified accordingly.

In order to facilitate custom examination, all packages and transport documents shall regardless of other markings be clearly and indelibly marked.

It is the Contractors' responsibility to ensure that the packing and handling is made in such a way that neither the steel nor the galvanizing shall be damaged in transit and storing. Transporting vehicles shall be clean and free from foreign material which could in any way injure the steel or zinc coating and painting. All necessary measures shall be taken to prevent structural deformation to members, or damage to galvanized or painted coatings. Members shall not be dragged on the ground, or will the practice of throwing tower steel into piles on conveyances, or from conveyances onto the ground, and of skidding steel members over each other, be permitted.

The Contractor shall ensure that adequate handling equipment is available to unload the heaviest piece of equipment. Tower material damaged shall be replaced by the Contractor at no cost to the Employer. Small accidental damages to galvanized surfaces may be repaired by application of approved repair paint. Tower material damaged shall be replaced by the Contractor at no cost to the Employer. Larger damages to, or systematic defects of the galvanizing shall be repaired by hot-dip galvanizing only.

The attempt to repair shall not bind the Employer to accept the repaired part when this is re-offered for inspection. Acceptance by the Employer of any repaired galvanized steel does not release the Contractor from his responsibility of supplying galvanized steel to give satisfactory service in the prevailing corrosive atmosphere. The Employer reserves the right to reject any galvanized steel found rusty, damaged, bent or other-wise defective, before final acceptance.

Steel shall be stored on wooden supports of sufficient height, to avoid any ground contact or other contamination. Storage conditions shall be well ventilated, preventing the formation of wet storage stain form accumulation of humidity and sand. It shall be clearly understood, that white rust formation will lead to rejection of the affected material.

### **1.18. Standardization of Makes/Works**

The works shall be designed to facilitate inspection, cleaning, maintenance and repair. Continuity of supply is a prime concern. The design shall incorporate every reasonable precaution and provision for the safety of all those concerned in the operation and maintenance of the works.

Corresponding parts throughout shall be made to gauge and be interchangeable wherever possible.

All equipment performing similar functions shall be of the same type and manufacture, to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

The Employer reserves the right to ask for coordination of standardization to the extent reasonably possible, and no price variation will be allowed for this procedure.

### **1.19. Signs**

Safety colours, safety symbols and safety signs must comply in construction, geometrical form, colour and meaning with the ISO 7010 and ISO 3864.

Signs for plant identification during the erection period shall be to Employer's approval.

The signs should be of a material which is weather-resistant and of sufficient durability for the conditions prevailing on site.

### **1.20. Mounting and installation**

The positions for the signs shall be chosen so that they are within the field of vision of the persons to whom they apply. The signs should be permanently attached. Temporarily dangerous areas (e.g.



construction sites, assembly areas) may also be marked by movable signs. The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

### **1.21. Warning signs**

Warning signs should refer to the existence or possible existence of danger, e.g., general danger, high voltage and climbing prohibited.

In addition to warning signs, appropriate black-yellow strip markings should also be used where necessary.

### **1.22. Pre-service cleaning and protection of plant**

This clause covers mechanical and pre-service cleaning and protection of the plant items and equipment at the Manufacturer's workshop and at site that are not subsequently to be painted.

Cleaning of fabricated component items shall be carried out after fabrication and final heat treatment or welding at manufacturers' works or at site, as appropriate.

In the event of the surfaces not being cleaned to the Employer's satisfaction, such parts of the cleaning procedures or agreed alternatives as are deemed necessary to overcome the deficiencies shall be carried out at the Contractor's sole expense.

Mechanical cleaning as opposed to alternative chemical cleaning is the preferred method for workshop cleaning except where this is precluded by design or access considerations.

Machined surfaces shall be protected during the cleaning operations. For re-cleaning small areas, hand cleaning by wire brushing may be permitted. Wire brushes used on austenitic materials shall have austenitic steel bristles.

Austenitic stainless steels, copper and aluminium alloys, cast iron, bimetallic and metallic/plastic items, and components fabricated by spot welding or riveting shall not be chemically cleaned. All weld areas shall be suitably stress-relieved before chemical cleaning.

All necessary equipment, provisions, chemicals etc. are to be provided by the Contractor.

Besides this, the Contractor shall take over all responsibility for the treatment and disposal of wastes according to the local law and to the satisfaction of the Employer.

The Contractor shall take all necessary precautions to ensure that the internal surfaces of all plant are kept clean and free from injurious matter during erection.

## **1.23. Health, Safety and Security**

### **1.23.1. Safety of Personnel**

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

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

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

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

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

Prior to construction work commencing, the Contractor shall provide a Health and Safety Plan for review by the Employer's representative. This Plan shall cover all activities related to the execution of the Project.

### **1.23.2. Security measures**

The Contractor shall implement a program for security of his personnel in accordance to safety regulation applicable in Kenya.

The Contractor shall designate an officer in charge of security that has the training and the equipment to attend emergency situation. This officer will have the authority to stop the work at any time, if he judges that security of personnel is compromised or the method or equipment or machinery employed to perform the work is not convenient, and expel any individual that does not comply with safety rules.

### **1.23.3. Security Plan**

Within one month from the contract signature, the Contractor shall present a security plan for the Employer's representative's review and acceptance. The plan shall cover essentially the following aspects:

- Name of security officer and proof of adequate training;
- Safety rules for Contractor personnel and visitors;
- Means for fast transportation of injured personnel;
- Hygiene on site of works (Potable water supply, closets,...);
- Security against environmental conditions, animals and burglars;
- Security against electrical shock;
- First aid measures on site;
- Accessibility to nearby hospital and clinic at any time with arrangement for standby medical personnel;
- Supply to personnel of security hats, boots and glasses by Contractor at his own expenses.

#### **1.23.4. Prevention of Accidents**

All Contractor personnel shall be properly identified to control their access to the site of works. Unauthorized person shall be prevented from entering the premises. Identification shall also be shown to the Employer's representative and his representatives for inspection of the works.

As a matter of example, the following measures shall be implemented:

- There shall be at least two out of every 10 workers that is trained for first aid and have readily available a suitable first aid kit;
- Any worker responsible for manoeuvring electrical equipment used for the work shall be trained to cut power and attend any worker that has been electrocuted;
- Equipment of 40 kg or less shall be handled by a minimum of two workers. Otherwise, crane or hoist shall be used;
- All tools shall be provided with hard wood handle with no loose part or cutting edges;
- Cutting tools shall come with proper handle length, security lock and storing case;
- Wrenches shall have a lever of convenient length to avoid the use of external tube extension;
- Handling of conductors or metallic cables close to energized lines or substation bus shall be prohibited;
- Work shall be performed by a minimum of two workers;
- Metallic ladders shall be preferably used.

When working outside the substation area, no trenches and material stacks shall be left overnight to endanger pedestrians and other road users. Within the substation, these shall be secured off to prevent physical access.

### **1.23.5. Work in Energized Area**

When the work is in an existing substation where the workers will access energized area of the switchyard, the Contractor shall present to the Employer's representative, a detailed work plan where the Contractor explains the method he will be using to perform each operation. The Employer's representative will coordinate with the substation operator to obtain the permit for the Contractor to access the area and, when necessary, to put the corresponding section of the switchyard out of service. Work on energized part is strictly prohibited.

The Contractor will be responsible to implement safety measures for work in energized surrounding involving use of padlocks, temporary fences, signs, grounding tools, colored tape to limit the zone etc...

These measures shall be agreed with the Employer's representative and the operator of the substation.

The main aspects to be considered are:

- Procedure for applying safety rules:
  - Identification of electrical zone isolating points
  - Request for removing an equipment from service
  - Setting equipment out of service (padlocks, signs, grounding)
  - Work permit
  - Definition of work safe zone (Planning of safety measures, identification of dangerous points, application of safety measures...)
  - Limit of work safe zone
  - Instruction to personnel
  - Presence of person in charge of works
  - Interrupting the works
  - Test
  - End of work and leaving work zone
  - Take away of the protected zone
  - End of work advice

- Work ruling (authorization, self-protection, agreement, holding by operator...)
- Training of personnel
- Control of safety equipment

## **1.24. Compliance with regulations**

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

## **1.25. General particulars and guarantees**

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

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

The Contractor shall be responsible for any discrepancies, errors or omissions in the particulars and guarantees, whether the Employer's representative has approved such particulars and guarantees or not.

## **1.26. Compliance with standard specifications**

Except where otherwise specified or implied, the works shall comply with the latest applicable Standards or Recommendations of the International Electro Technical Commission (IEC) or to the standards of the Euro code/British Standards Institution (the said Specifications being hereinafter referred to as EN/BS), prior to the closing date of the bid.

No departures from the Specification are to be made without the written approval of the Employer's representative.

## **1.27. Variations from Conditions of Contract**

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

## **1.28. Subcontracted plant, materials and labour**

The Contractor shall also provide the Employer's representative with names and details of local subcontractors from the list of evaluated and approved subcontractors before such subcontracts are

placed. KETRACO reserves the right to withdraw its consent to local subcontract arrangements if such are considered unsuitable, but consent will not be unreasonably withheld.

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

### **1.29. Access to manufacturers' works**

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

### **1.30. Planning, progress reports and project progress meetings**

The Contractor shall submit for review, within 28 days of the starting date of the Contract, an outline design, manufacture, delivery and construction and erection chart. Within a further period of 28 days the Contractor shall provide a detailed programme in a format to be agreed by the Employer's representative; this programme shall also include details of drawing submissions.

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

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

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

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

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

All works tests and the test results shall be listed and a commentary provided. Any test failures shall be explained and the Contractor shall state his proposed actions to prevent delay to the project completion.

The shipping or transport of each order shall be monitored in the progress report and shall give the date when equipment is available for transport, the expected time of delivery to site and the dates actually achieved.

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

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

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

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

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

### **1.31. Quality assurance**

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

The quality assurance arrangements shall conform to the relevant requirements of ISO 9001:2015.

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

The Contractor shall operate systems that implement the following:

Hold point - "A stage in material procurement or workmanship process beyond which work shall not proceed without the documented agreement of designated individuals or organizations."

The Employer's representative 's written agreement is required to authorize work to progress beyond the hold points indicated in reviewed quality plans.

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

If the Employer's representative does not attend after receiving documented notification in accordance with the agreed procedures and with the correct period of notice then work may proceed.

### **1.31.1. Quality assurance requirements**

The Contractor and subcontractors, shall, for all phases of work to be performed under the Contract, establish and implement quality assurance arrangements which, as a minimum, meet the requirements of ISO 9001: 2015, “Quality Management Systems - Requirements”.

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

### **1.31.2. Quality assurance arrangements – quality plan**

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

The Quality Plan shall identify as a minimum:

- a. the Contractor’s organization and responsibilities of key management including quality assurance personnel;
- b. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;
- c. the prime project documents, specifications, codes of practice, standards;
- d. the correspondence and reporting interfaces, and liaison between the Employer’s representative and the Contractor;
- e. the procedures the Contractor intends to use to manage and control the Contract, including:
  - i. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;
  - ii. Hold and notification points;
  - iii. Submission of engineering documents required by the Specification;
  - iv. The inspection of materials and components on receipt;
  - v. reference to the Contractor’s work procedures appropriate to each activity;
  - vi. Inspection during fabrication/construction;
  - vii. Final inspection and test.

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

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



### **1.31.3. Monitoring by the Employer's representative**

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

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

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

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

The Employer's representative reserves the right to monitor the subcontractors and the Contractor shall ensure that all subcontracts include, and subcontractors are aware of, this requirement.

### **1.31.4. Contractor quality audits**

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

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

### **1.31.5. Control of subcontractors**

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

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

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

### **1.31.6. Inspection and tests**

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

Inspection and test plans shall be submitted for review.

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

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

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

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

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

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

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

The Contractor shall advise the Employer's representative of the readiness of inspection at least 6 weeks prior to a nominated inspection/surveillance witness or hold point. Work shall not proceed beyond a hold point without the written agreement of the Employer's representative or his nominated representative.

Inspection of the plant/equipment may be made by the Employer's representative and could include the following activities:

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

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

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

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

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

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

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

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

### **1.31.7. Construction/installation phase**

Within 30 days of mobilization of works, inspection and test plan(s), similar in form and content to that described in Clause 1.31.6 above, shall be submitted defining relevant inspection and test points for all stages of construction/erection, installation and commissioning. The inspection and test plans shall identify activities for which method statements shall be prepared.

Method statements shall be submitted to the Employer's representative for review.

Method statements for portions where the line is routed through road reserves (or other reserves) shall be prepared in consultation with Kenya National Highways Authority and other the relevant third parties. The works in this portion shall be undertaken under the joint supervision of both the employer and the third party. One-month notice to the third parties shall be provided. The contractor shall also arrange transport for the third party representatives.

Programmes of site construction works shall be submitted to the Employer's representative, giving notification of forthcoming test/inspections on a weekly basis.

## **1.32. Non-conformances**

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

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

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

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

The Employer's representative shall have complete authority to accept or reject any equipment or part thereof considered not to be in accordance with the specified requirements.

Approval of any concession applications is the prerogative of the Employer's representative, and approval of a particular case shall not set a precedent.

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

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

### **1.33. Records**

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

### **1.34. Method statements**

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

### **1.35. Design and standardization**

Corresponding parts of all material shall be made to gauge and shall be interchangeable. When required by the Employer's representative the Contractor shall demonstrate this quality by actually interchanging parts. As far as possible all insulators, fittings and conductor joints and clamps should be interchangeable with the equivalent items of the existing transmission system, details of which are obtainable from the Employer's representative.

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

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

**Note:** The contractor shall have all Engineering plans, designs, surveys, schemes, proposals, reports, studies, calculations and drawings signed off by a Professional Engineer registered in Kenya before submitting to KETRACO for review and approval. This is a mandatory requirement by the most recent Engineers Act under Kenyan law.

### **1.36. Quality of material**

All material used under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. No repair of defective parts including welding, filling and plugging will be permitted without the sanction in writing of the Employer's representative.

### **1.37. Language, weights and measures**

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

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

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

### **1.38. Testing and inspection**

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

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

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

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

Not less than 6 weeks' notice of all tests shall be given to the Employer's representative in order that he may be represented if he so desires. As many tests as in the opinion of the Employer's representative are possible shall be arranged together.

The original and copies of test records whether or not they have been witnessed by the Employer's representative shall be supplied to the Employer's representative.

Measuring apparatus shall be approved by the Employer's representative and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

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

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

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

### **1.39. Erection, supervision and checking of work on site**

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

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

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

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

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

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

## **1.40. Drawings, models and samples**

The drawings associated with the Specification are given in the Appendix 1.

A list of the drawings that are to be submitted by the Contractor with his Bid and a list of drawings to be submitted after the Commencement Date are given in the Drawings, Documentation and Samples section of this Technical Specification. The Contractor shall provide free of charge any additional drawings and/or copies of any reviewed drawings required by the Employer's representative.

The Contractor shall submit samples of materials as required from time to time by the Employer's representative.

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

The number of copies of each drawing or of any subsequent revision to be submitted to the Employer's representative is given in Volume 2, Section VII. Following review, further copies of the reviewed drawing shall be supplied to the Employer's representative for distribution to KETRACO and to Site.

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

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

Except as otherwise specifically approved, all drawings shall be of size not greater than A0 (normally 841 mm x 1189 mm) nor smaller than A4 (normally 210 mm x 297 mm).



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

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

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

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

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

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

The drawing format and the indexing system will be agreed at the first Contract meeting between the Contractor and the Employer's representative.

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

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

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

## **1.41. Responsibility of Contractor**

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

During the period of maintenance, the Contractor shall make such arrangements as to ensure the attendance on the Site, within a reasonable time of his being called upon to do so, of a competent representative for the purpose of carrying out any work of maintenance for which the Contractor

shall be liable and during such part or parts of the said period as the Employer's representative shall deem it necessary, the said representative shall be continuously available on the Site.

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

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

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

#### **1.42. Additional services of Contractor's staff**

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

#### **1.43. Contractor's employees**

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

The Contractor shall be responsible for the behaviour on site of all personnel employed by him.

#### **1.44. Alcoholic Liquor or Drugs**

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

#### **1.45. Packing and shipment**

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

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

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

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

Packing cases where used shall be strongly constructed and the contents shall be securely bolted or fastened in position with struts or cross battens. Cross battens supporting weight in any direction are not to rely for their support on nails or screws driven lengthwise into the grain of the wood, but are to be supported by cleats secured from the inside.

Bolts and nuts shall be crated for shipment.

Crating together of components of dissimilar metals is not acceptable.

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

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

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

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

Wood wool shall be avoided as far as possible.

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

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

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

## 1.46. Accommodation and site storage

**Living accommodation.** The Contractor shall make his own arrangements with regard to accommodation for his expatriate and locally recruited staff during the construction period. All dwellings and buildings existing or erected for the purpose by the Contractors shall comply with local regulations with regard to construction, water supply, sanitation and other requirements. The Contractor shall provide temporary construction camps complete with proper sanitation and other necessary facilities. The Contractor shall be responsible for the construction and provision of all electrical supplies, water supplies, living accommodation, catering, services and amenities required by his employees for the duration of the Works. The location of all such facilities will be subject to approval by the Employer's representative.

All accommodation shall serve as permanent residences and form future communities, if such use can be foreseen or be removed by the Contractor when no longer required and before the granting of the final certificate. After the removal of accommodation, the ground shall be left in a clean and tidy condition.

**Medical facilities.** The Contractor shall be required to make his own arrangements to avail required Medical and First Aid services, at all accommodation and work sites for his expatriate or locally engaged staff. The Contractor's particular attention is drawn to its obligations in respect of its staff and employees' health and related medical facilities under the General Conditions (GC) of Contract.

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

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

**Storage facilities.** The Contractor shall make his own arrangements for storage areas and campsites. The Contractor shall in all cases obtain the approval of the Employer's representative for the places along the route of the lines where he intends to store materials. In no case will this be outside the authorized area unless special arrangements are made with the owners of adjacent property, at the Contractor's own expense. All such arrangements for the use of land outside the line route and its RoW shall be subject to consultation with and to the approval of the Employer.

The Contractor is to provide any necessary protection and watchmen to safeguard materials in the areas allocated to him. The handling and storage of any equipment at the site is to be at the risk of the Contractor and without responsibility to KETRACO. The Contractor is to arrange for the protection to the satisfaction of the Employer's representative, of these materials against vermin attack, corrosion and mechanical damage during storage and erection at site.

The site storage areas shall be prepared with adequate hard-standing for the orderly storage of conductor drums, tower steel, insulators and fittings so that the material will not be damaged by the effects of adverse weather during storage. Items packed in flammable crates or drums shall be stored in such a manner as to limit the extent of any damage arising from fire. If any package or plant is unsuitable for outdoor storage, the Contractor shall arrange for indoor storage elsewhere.

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

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

### **1.47. Office accommodation for use of the Employer's representative**

The Contractor shall utilise appropriate existing buildings or provide such temporary buildings as may be necessary for office accommodation for Employer's representative staff during the erection of the works and the cost of these shall be deemed to be included in the Contract Price.

The Contractor shall also provide at his own cost, two furnished rooms in his site office to accommodate 4 representatives of the Employer's representative and KETRACO. The site office provided by the Contractor shall be fully furnished using a good standard of office furniture to be approved by the Employer's representative and fully equipped with:

- Four desks and chairs
- Four filing cabinets
- Two desktop computers suitable for use with PLS - CADD, PLS Tower and AutoCAD
- One AutoCAD network licence suitable for six simultaneous users.
- One common printer (with photocopying and scanning capabilities) for both A3 and A4. The minimum specifications of the printer/scanner and photocopier as approved by the Employer's representative.
- Shelving units
- Toilet and sanitary facilities (comprising WC set, separate for gents and ladies, urinals, wash basin as approved by the Employer's representative)
- Air conditioning
- Lighting
- Sufficient number of fire extinguishers of suitable size and type
- Clean and safe bottled drinking water.
- High Speed Wi-Fi (Minimum 15mbps) for internet access.
- Tea/coffee/beverages and refreshments

NB: All the above items shall remain the property of KETRACO during and upon completion of the project. All the software should be purchased under KETRACO's name and upgraded during the duration of the contract.

The desktop computers are to be provided with internet connection with service provided throughout the duration of the contract by a secure broadband internet service provider, for which the Contractor shall be responsible for all associated charges and costs. A UPS system shall be provided to support the computer system for a minimum of 30 minutes in the event of a power failure. A backup generator shall be provided to power the office accommodation services. The computers and printer shall be networked on a LAN with facilities to access the Internet (broadband) on a continuous basis. The Contractor shall be responsible for all associated charges and costs.

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

Adjacent to the Employer's representative 's offices, adequate parking space shall be provided by the Contractor. The office accommodation is to be provided with reliable and constant electricity supply and water supply.

## **1.48. Office Accommodation Services**

The Contractor shall be responsible for providing the following services to the Employer's representative s Office Accommodation:

## **1.49. Electricity Supplies**

The Contractor shall be responsible for providing, obtaining and making all arrangements for the use for the Works of supplies of electricity required, including the provision at his own cost of all apparatus necessary for such use. All precautions which are necessary to ensure the safety of every person on the Site shall be taken. The Contractor's installation shall be to the satisfaction of the Employer's representative who may require the disconnection or alteration of any parts that he considers may be dangerous. Such installation shall comply also with all appropriate statutory regulations and be in accordance with IEC 60364 and IEC/TR 61200-704.

As soon as any parts or whole of the Contractors installation is no longer required for carrying out the Contract Works, the Contractor shall disconnect and remove the same to the satisfaction of the Employer's representative.

The Contractor shall be responsible for the installation and maintenance of a backup generator which shall provide the office accommodation with an electricity supply during power outages. The generator shall have the capacity to meet all office loads including lighting and air conditioning. The Contractor shall provide fuel for the generator throughout the duration of the Contract. The use of the generator is at the discretion of the Employer's representative. The standby generator shall be available for immediate connection at all times.

## **1.50. Water Supplies**

The Contractor shall be responsible for providing, obtaining and making all arrangements for the use for the works of supplies of water required, including the provision at his own cost of all apparatus necessary for such use.

## **1.51. Employer's representative's transport**

### **1.51.1. Transport**

The Contractor shall provide, for the use of the Employer and the employers representative, on a 24-hour basis, the vehicles specified in the Price Schedules. The Contractor shall provide the services of one driver mechanic per vehicle whose remuneration shall be not less than Kshs. 35,000.00 per month per driver for the entire Contract duration and not less than Kshs. 3000.00 per night for travels outside Nairobi/permanent workstation as approved by Employer; maintain in efficient working condition. The Contractor shall provide the services of one driver mechanic per vehicle whose remuneration shall be approved by Employer

The Contractor shall maintain each vehicle in efficient working condition, repair, replace defective parts and tyres and provide fuel and oil and other consumables. The Contractor shall provide all documentation in accordance with Kenya Law, including full comprehensive insurance cover at all times for all vehicles and all drivers for unlimited Third Party claims, at the rates stated in contract forms. A fuel card from a reputable oil company shall be provided for each vehicle loaded with a minimum of Kshs. 30,000.00 per month.

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

The vehicles shall be new (zero mileage), purchased locally and shall be approved by the Employer before purchase. Each vehicle shall comply with all relevant road traffic laws and be right hand drive. The Contractor will be required to make the vehicles available at all times during the Contract Period and until completion of the specified maintenance period and to provide replacement vehicles when the servicing or repair time (including accidents) exceeds a period of 24 hours. The provision of such replacement vehicles will not be subject to additional payment. When a vehicle is out of action for any cause, the Contractor shall make a similar vehicle available for the Employer's representative use at the Contractor's expense.

The contractor shall handover the vehicles to KETRACO at the end of the specified maintenance period as specified in the contract.

Table 3: Vehicle Description

| Item   | Description   | Quantity |
|--------|---|----------|
| Type 1 | Double Cabin pick –up, 3.0 Litre Engine with air conditioning, full service and maintenance | 5        |

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

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

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

## **1.51.2. Project Management & Office Tools**

### **1.51.2.1. Laptops**

Three (3) Laptops shall be provided by the Contractor for use by the Employer. The laptops shall remain property of the employer upon completion of the project. The laptops shall have semi-rugged or business-rugged durability without compromising on style and affordability. The laptops should feature carbon fiber-reinforced frames, magnesium or aluminium alloy casing, break-resistant screens, spill-proof keyboards, hard drives be gel-mounted or protected by shock-absorbing dampers, and other such enhancement. The laptops, should have been tested against the 11 MIL-STD durability tests. The battery should last at least eight hours on full high performance.

The laptops shall meet the following minimum specifications:

- 2.9 GHz Intel i7 Gen 9 or equivalent



- 32 GB of RAM
- 3000 x 2000 Screen Resolution (267 ppi)
- 4Gb dedicated Graphics card (such as NVIDIA – Open GL 4.0 or later)
- 512 GB SSD
- 64 bit Windows 10 Pro
- 2-button mouse with wheel
- 1TB (7200RPM) Seagate Momentus 7200.4 ST9320423AS
- 802.11a/b/g/n Wi-Fi
- DVD R/W dual-layer LightScribe Optical Drive
- 2.0-megapixel webcam
- VGA and Display Port outputs
- USB 3.0 x 4; eSATA x 1
- RJ-45 (Ethernet 10/100/1000)
- SD / MMC / SDHC Multimedia Card Reader
- Removable 55WHr 6-Cell or 9-cell 100WHr Li-ion Battery
- Genuine leather Laptop carry bag.
- Key Board-Full size, spill-resistant keyboard with drains
- Warranty-1year
- Integrated Security- Security Lock Slot plus steel cable (5.5mm thick) with a combination lock

#### **1.51.2.2. Handheld Data Collectors**

Handheld Data Collectors as indicated in the schedule of rates and prices shall be supplied and handed over to the Employer. All required licences and software support (for proprietary software if required) minimum of six years must be provided. The specifications of the devices should be as follows:

### **System**

The system for the handheld data collector shall be open software based, preferably Android based. It shall come with multi-lingual operational options, with the standard United Kingdom English as a mandatory option.

The device shall have a minimum six (6) inch display. It shall have a minimum of 4 GB RAM, 64 GB storage memory with an option of upgrading the memory. It shall have integrated speaker and microphone. It shall have front and back cameras with the ability to take High Definition (HD) images.

It shall also include the Google Mobile Services.

### **Communication**

For communication purposes, the device shall have the following capabilities on the minimum:

- Integrated Cellular 4G data, text and voice
- Cellular: GSM (850/900/1800/1900), WCDMA (B1/B2/B5/B8), LTE-FDD (B1/B2/B3/B4/B5/B7/B8/B12/B13/B17/B20/B25/B28), LTE-TDD (B38/B39/B40/B41),
- TD-SCDMA (B34/B39)
- Wi-Fi IEEE 802.11 a/b/g/n/ac
- Bluetooth 4.1
- NanoSIM x 2
- USB 3.0 (Type-C)
- NFC

### **Standard Accessories**

The device shall be supplied with the following accessories

- Hand strap
- A/C charger
- USB cable
- Lanyard

### **Software**

The contractor shall provide software, server based licences (where available) and subscriptions for the client. The contractor shall provide licences for a period of six years. This software shall be as indicated in the Scope of supply document. The following, in addition to other software used by the contractor in the project design, shall be provided

- AutoCAD

## **1.52. Site Access and Port of Entry**

Mombasa Port in Kenya is recognised as the principal seaport for shipment of bulk materials and heavy construction plant for all project sites.

The Mombasa Port in Kenya is operated by Kenya Ports Authority and can handle any required loads landed by barge. Wharf crane capacity is reported to be limited to 70 tonnes.

The Contractor shall determine the port(s) of entry to be used and shall comply fully with all associated import, export and port entry procedures and regulations of Kenya, in respect of all Plant and materials.

From Mombasa, goods may be transported by rail for heavy materials such as steel structures and conductors; or by truck using the existing paved highway network. Rail freight is understood to be less costly to road/truck transport; however, road freight is more reliable and easier to monitor.

## **1.53. Facilities Program**

The Contractor shall provide an overall Program of Performance (Work Program) in line with Contract's General Conditions. This program shall be a management style, time-scaled and activity linked Gantt chart for the Facilities. Software such as the latest Microsoft Project would meet this criterion. It should present all activities/tasks to complete the specified Facilities and Plant in full. The program shall reflect all work items/phases and details related to all Facilities, Plant and manufacture, delivery and erection and all Contractor's Plant to be used in respect of completion of the Facilities, within the Time for Completion. Such a program may require concurrent programming of tasks across the specified HV cable works and commensurate resources.

The cable engineering, design and site surveys shall be substantially completed within 45(Forty-five) days from the Effective Date, or such other time that shall be agreed at contract negotiations, at which time the Contractor shall review and revise (if necessary) its Program of Performance accordingly in consultation with and with the approval of the Employer or Project Manager. The Contractor shall similarly ensure substantial completion of all engineering within 75(Seventy-five)

days of the Effective Date (excluding final cable trench design) at which time any needed review or revision of this Program of Performance by the Contractor shall be carried out in consultation with and with the approval of the Employer or Project Manager.

The Program of Performance shall be in the format indicated above and as a minimum provide for principal milestones as follows:

- Essential information to be delivered by Employer including Site access;
- Documentation for approval from Contractor to Employer including time allowance for such documentation approval;
- Release of factory and related quality assurance documentation;
- Factory Tests;
- Shipments;
- Site ready for erection;
- Start erection;
- Ready for pre-commissioning;
- Completion;
- Operational Acceptance;
- Submittal of Final Records and Documents.

The Employer or Project Manager's approved Program of Performance shall be used to monitor and determine progress and the Contractor shall include in each of his monthly progress reports the Facilities program annotated to indicate actual progress for each task at the end of the reporting month.

## **1.54. Facilities Design and Principles**

The Facilities shall be designed for reliable, long and continuous service and safe operation under all conditions, with high economy and low maintenance cost. Facilities shall be available to simplify inspection, testing, maintenance and repair of the Plant. The design shall also include all necessary provisions ensuring the safety of the operating and maintenance personnel.

All materials and plant used under this Contract shall be new and of the best quality; workmanship shall be of the highest class throughout the Facilities. All outdoor Plant including insulators/bushing, conductor, hardware and fittings shall be designed so that water cannot collect at any point. Welding, filling, plugging or any repairs to defective items of Plant or parts thereof shall not be permitted without the approval in writing of the Project Manager.

## 1.55. Insulation Levels and Clearances

The clearances shall be as follows.

Table 4: Clearances

| Situation  | Minimum clearance (metres) |
|--|----------------------------|
|  | 132 kV                     |
| Normal ground  | 6.10                       |
| *Roads – road level  | 8.60                       |
| Power transmission & Telecommunications lines:<br>- Lowest line conductor of upper line to highest conductor or earth wire of lower line | 2.0                        |
| - Lowest line conductor of upper line to support of the lower line on which a person may stand   | 4.60                       |
| Railway crossing<br>- Rail level   | 7.50                       |
| - Electrified Railway crossings, building, gantries, or other structures on which a man can stay   | 5.40                       |
| Ground level at roads or yards where road mobile cranes are likely to be employed  | 8.60                       |
| Any wall, building or other structure on which a man may stand, or on which a ladder may be placed                                       | 3.80                       |
| Street lighting  | 3.80                       |
| Creepage distance  | 31mm/kv                    |
| Minimum clearance between live metal and tower steelwork   |                            |
| a. with suspension insulator set swing, at 65°   | 500                        |
| b. with suspension insulator set swing, 0 - 10°  | 1550                       |
| c. with suspension insulator set swing 10 - 35°  | 1300                       |

The insulation levels shall be as follows

*Table 5: Insulation Levels*

| <b>Insulation level</b>                      | <b>Voltage at attitude less than 1000 m above sea level</b> |
|--|---|
| Power frequency voltage, kV rms              | 275   |
| Lightning impulse voltage withstand, kV Peak | 650   |

## **1.56. Cleaning up by contractor**

Throughout the conduct of all work at Site, the Contractor shall maintain the Facilities, Plant, its Contractor's Plant and all related Installation Services at all locations in a clean and tidy condition.

All Contractor's Plant and/or Plant and its component materials not in use and/or no longer required for the Facilities completion and related Installation Services, all condemned materials and all rubbish shall be removed from the Site at the least once per week. Combustible rubbish shall be removed daily and may be burned in an area designated by the Project Manager.

Upon completion of the Facilities, the Contractor shall deliver any surplus Plant to the Employer in a manner agreed with the Project Manager.

The Contractor shall also remove all its Contractor's Plant together with all manner of items or material associated to its Installation Services, whether specified or not, and any remaining rubbish which may have accumulated in the execution of the Contract and shall leave the whole of the Site in a clean and tidy condition.

If the Contractor fails to comply with any of the above requirements within 24 hours of notice in writing by the Project Manager, the work may be carried out by the Project Manager and the total cost to the Employer of the work will be charged to the Contractor.

## **1.57. Making good**

The Contractor shall take every reasonable care in the execution of the Facilities to avoid loss of or damage to any property of the Employer or of others, including landholders.

Where, in the performance of its obligations under the Contract, the Contractor causes loss of or damage to any property of the Employer or others, he shall make good such loss or damage to the reasonable satisfaction of the Project Manager.

## **1.58. Fire protection and fire fighting**

The Contractor shall be responsible for the fire protection of its Site facilities at all locations, whether living or office accommodation, storage facilities, Facilities, shops or other work areas, all Plant and Contractor's Plant at any of these locations and any place at which it has Facilities.

Portable firefighting plant shall be available at work sites at all times, when the Contractor's employees are present and shall be kept available at other times as directed by the Project Manager.

The Contractor shall maintain the firefighting plant in a condition satisfactory to the Project Manager and shall re-charge extinguishers after use, regardless of by whom they were discharged. Adequate stocks of fresh extinguisher charges including chemical charges shall be kept in readiness by the Contractor.

All firefighting plant provided under this Clause shall be the property of the Contractor and shall be removed by the Contractor when requested by the Project Manager.

## **1.59. Health services, first aid and safety**

The Contractor shall comply with all the relevant statutory regulations of Kenya with respect to safety and occupational health. Particular attention is drawn to the Contractor's obligation under the General Conditions in respect of health and safety.

All working areas shall be deemed safety helmet and safety boots areas and the Contractor shall provide all his employees with safety helmets, safety boots, and subject to task, safety gloves, disposable air/fume filtering facial masks and safety glasses or goggles.

Contractor's personnel working at heights and aerial work of any kind must be equipped with safety belts/harness and their associated straps and safety rope lines and shall make available such plant to the Project Manager for associated inspections.

In the performance of the Facilities, the Contractor shall exercise every reasonable precaution to protect persons or property from injury.

The Contractor shall co-operate fully with the Project Manager's supervising staff on all matters affecting safety.

The Project Manager may require the immediate removal from the Facilities of any person who in the opinion of the Project Manager fails properly to observe these provisions and such person shall not be employed upon the Facilities without the permission of the Project Manager.

## 1.60. Training

### 1.60.1. General

The Contractor shall instruct the Employer's nominated staff in the operation and maintenance of the Facilities and plant. Such instruction shall be at the Contractor's design office and Plant manufacturers' factories during the manufacturing period and at Site. The training shall include lectures, demonstrations and practical training as required.

The cost for training at the manufacturer's premises including fares, accommodation and living allowances as well as the cost for site training shall be included in the Contract Price.

Training at the Contractor's design office shall provide a sound appreciation of the design principles of HV cables and support structures and their foundation and design with the contemporary design software used. Training at a manufacturer's factory facilities shall include a sound appreciation of the manufacturer's facilities, including witnessing of type or routine tests of related facilities, as well as manufacturing processes.

The cost for training of the following nominated Employer's staff at the Contractor's Head Office, and/or manufacturer's premises including visa fees, airfares, full board accommodation, ground transport and an individual incidental allowance of US\$120/day, as well as the cost for site training, shall be included in the Contract Price.

| <b>Description</b>  | <b>Duration</b> | <b>Participants</b> |
|---|-----------------|---------------------|
| Underground cable planning and design for Planning & Design Engineers | 3 weeks         | 8                   |
| Operation and Maintenance for Engineers/Technicians                   | 3 weeks         | 6                   |

Note: The contractor shall also organise for one week PSCAD training for 10 Engineers at a venue within the Employer's country as agreed with the Project Manager. The cost of the training, training venue and per diems for the participants shall be borne by the contractor. The contractor shall submit the qualification and experience of the training company ( the proprietary owner of the software is preferred) with bidding documents.

These instruction services are to be provided for under the Schedule of Rate and Prices for Installation and Other Services and may or may not be used, at the Employer's discretion

The Contractor shall instruct the Employer's nominated staff in the planning, design, operation and maintenance of the Facilities and their key component Plant. Such instruction shall be at the contractor's office during design, manufacturer's factory during the manufacturing period and at the Site as appropriate. The training shall include lectures, demonstrations and practical training as required.

The training shall include formal lectures covering planning, theory and design, installation, testing, commissioning, maintenance and troubleshooting.



Training at the manufacturer's Facilities can include witnessing of type or routine tests of towers, as well as their manufacturing processes and/or major performance testing such as that of complete insulator/bushing and hardware assemblies.

### **1.60.2. Site training**

Cable jointing, operation and maintenance training at Site shall consist of formal lectures and practical on-the-job training of the Employer's staff during erection, testing and commissioning.

The Employer may nominate staff to be seconded to the Contractor to participate in the site training. The Contractor shall train such staff during erection activities and ensure that erection Facilities of important plant components involve the Employer's nominated staff.

The site training shall be provided for up to 20 (twenty) staff and shall include detailed explanations based on the cable jointing, operation and Maintenance instruction manuals issued by the Contractor related to dismantling, assembly of equipment and troubleshooting shall be provided. Instructions on maintenance intervals, minimum spare and wear and tear parts shall be provided.

The Contractor shall satisfy himself and the Project Manager that the Employer's staff is fully capable of operating and maintaining the Plant. During the final inspection, the Contractor and Project Manager will make a joint assessment of the effectiveness of training and shall develop recommendations for further training, if this be appropriate.

### **1.60.3. Student Internship**

The Contractor shall accommodate at least Six (6) students on internship/apprenticeship at all times for the entire duration of the Contract. The internship shall be for diploma and degree level of education and shall cover students in the following disciplines.

- Electrical engineering
- Civil and Structural engineering
- Telecommunication engineering
- Any other relevant course

A monthly stipend allowance of Kshs 10,000 shall be provided to each intern. While undergoing internship, the contractor should ensure the interns obtain maximum practical training on the various fields within the scope of works. The contractor should provide a training plan for approval. KETRACO shall provide details of the interns in the course of the project.

#### **1.60.4. Quality assurance**

The Contractor shall have a documented quality assurance program which is accredited as complying with ISO9001 and which is capable of providing assurance that all plant, materials and services meet the specified requirements.

The Contractor shall have a quality assurance section responsible for establishing and conducting the quality assurance program. The program shall describe the quality assurance management, their responsibility and authority. Quality assurance personnel shall be independent from those personnel performing assigned activities and shall have the organisational freedom required to resolve quality assurance problems.

The program shall cover, as a minimum, the following areas:

- Design control
- Procurement control
- Document control
- Control of inventory, including component identification
- Control of special processes; e.g. Cable storage and handling, cable laying, jointing, welding, etc.

The Contractor's quality assurance system shall apply to all work undertaken by subcontractors. The Contractor shall perform periodic documented reviews of his Facilities and quality controls to assure conformance to the program and contract requirements. The Contractor shall provide the Project Manager with access to its records so that the Project Manager may undertake quality audits and inspections.

#### **1.61. Environmental protection**

The Contractor shall comply with all local and international laws and regulations applicable to the project area with respect to environmental matters.

The Contractor shall prepare and implement an environmental management plan which includes, but is not limited to, the following:

- The operation of the Contractor's accommodation facilities
- The operation of any manufacturing facilities at site
- Operation of the site erection Facilities
- Waste management
- Storage of fuel, oil and other hazardous substances

- Internal environmental audit plan
- Emergency response plan.

The Contractor shall obtain all approvals required from Government authorities and agencies for his operations and activities.

The Contractor's environmental management plan and associated records may be audited by the Project Manager or by a third party agency appointed by the Employer.

## **1.62. Inspection and Testing**

### **1.62.1. Inspection and tests at supplier's Premises**

All materials and plant used in the Facilities may be inspected by the Employer or Project Manager at any time.

All plant shall be subjected to all routine tests set out in relevant IEC standards, including any optional tests which the Project Manager deems to be applicable.

One item of each type of plant shall be subjected to all type tests set out in relevant IEC standards. Such tests may be waived in cases where the Contractor submits reports of type tests conducted by third-party independent international testing agencies and which are accepted by the Project Manager as adequately demonstrating that the plant complies with the relevant IEC requirements.

Mandatory factory acceptance tests (FAT) shall be performed for all major electrical plant such as UG cable, accessories, Surge Arrestors, ADSS cable and any other such equipment that the Employer deems to require FAT. The specifications of individual equipment that form part of these contract documents provide all equipment requiring FAT. From these specifications, the Contractor shall prepare a comprehensive list of equipment that shall be subject to FAT and shall submit for approval an inspection and test plan, and associated procedures and record sheets, at least one month before the date of any planned factory tests.

The Contractor shall submit for approval an inspection and test plan, with associated procedures and record sheets, at least one month before the date of any planned factory tests.

Factory test reports shall include current calibration records of all measuring apparatus used in the tests.

No plant shall be despatched from the factory to site prior to receiving the Project Manager's notification that the factory tests were satisfactory. The Project Manager may request that additional tests be conducted if he is not satisfied that the factory tests have demonstrated that the plant is acceptable.

The Contractor shall provide for (3) three representatives of the Employer two (2) and the Project Manager one (1), to attend each factory test **per lot**. The Contractor shall meet all associated travel, accommodation and living costs, which shall be deemed to be included in the Contract Price.

For each inspection, the following are to be provided for each representative:

- Economy class returns air ticket (from Nairobi or the Engineer's home office to Places of Test and/or Inspection).
- Visa expenses, airport taxes and other incidental travel expenses as required.
- Hotel accommodation, including full board plus daily allowances of US\$ 100/day for incidental expenses for a minimum of 5 days for each trip. (US\$100/day for KETRACO staff only)

At least 45 days' notice of the date, time and place of all tests shall be given to the Employers so that arrangements can be made to have the test witnessed.

Three (3) weeks prior to the tests, the Contractor shall submit an outline of the procedures and tests in its plans to demonstrate fulfilment of the requirements specified in the subsequent sections of the detailed technical specifications.

Any costs incurred by KETRACO and/or Engineer in attending a repeat type test brought about as a result of a failure of the subject under test and postponement of the test programme shall be to the account of the Contractor.

### **1.62.2. Tests at site and commissioning**

The Contractor shall perform site tests to demonstrate that plant and systems comply with the specified requirements. They shall include all site tests included in relevant IEC standards. They shall include functional tests of all plant and systems.

The Contractor shall submit for approval an inspection and test plan and associated procedures and record sheets at least one month before the date of any planned site tests. Site test reports shall identify all measuring apparatus used in the tests. Current calibration records of all measuring apparatus used on site shall be included in a separate report.

The Contractor shall provide all plant, materials and facilities needed for the site tests.

Testing at site shall be carried out by experienced test personnel and shall be witnessed by the Project Manager and/or Employer.

All site tests shall have been completed to the satisfaction of the Project Manager prior to commissioning.

The Contractor shall submit for approval a commissioning plan, and associated procedures and record sheets, at least one month before the date of any planned commissioning. The Contractor shall coordinate with the Employer and the Project Manager to identify all third party involvement in commissioning and to develop any necessary switching sequences. The first stage of any commissioning shall be functional tests to confirm that plant operates correctly prior to energising

## 2. XLPE UNDER GROUND CABLE

This section covers the technical specifications and requirements for design and installation of single core XLPE insulated power cables and their accessories (the Plant) for operation at 50Hz ac voltages of 76.2kV between any conductor and sheath or earth, 132kV between phase conductors and maximum sustained power frequency voltage between phase conductors of 145kV.

The specification stipulates the minimum requirements for 132kV single core XLPE insulated underground cables and their accessories acceptable for use in the company and it shall be the responsibility of the Manufacturer to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the cables for KETRACO.

Equipment design, engineering and installation shall strictly be in accordance with requirements.

The relevant Technical Data Sheets shall be completed in full to verify or clarify compliance or otherwise with these Employer requirements. All data will be filled out in the forms.

### 2.1. Particulars of Electrical System

The Plant shall be capable of operation under the general electrical parameters as specified in the technical schedules.

### 2.2. Particulars of Environment

The Plant shall be capable of operation under the atmospheric conditions as specified in below

| Description   | Design Value |
|---|--------------|
| <b>Ambient Air Temperature, Outdoor</b>               |              |
| Maximum   | +36°C        |
| 24 Hour Average Maximum                               | +31.5°C      |
| Minimum   | +1°C         |
| <b>Ambient Air Temperature, Indoor</b>                |              |
| Maximum   | +40°C        |
| 24 Hour Average Maximum                               | +30°C        |
| Minimum   | +10°C        |
| <b>Rainfall</b>                                       |              |
| Average Annual  | 750 mm       |
| Maximum Monthly                                       | 120 mm       |
| <b>Thunderstorm days per year (isokeraunic level)</b> | 280          |
| <b>Wind</b>   |              |
| Maximum wind velocity                                 | 36m/s        |

|   |                      |
|---|----------------------|
| Maximum wind pressure on cylindrical objects  | 834N/m <sup>2</sup>  |
| Maximum wind pressure on conductors and earth wire/optical ground wire (OPGW)                         | 667N/m <sup>2</sup>  |
| Maximum wind pressure on steel members on 1.5 times projected area                                    | 1898N/m <sup>2</sup> |
| <b>Relative Humidity</b>  |                      |
| Outdoor   | 60-95%               |
| Indoor  | 90%                  |
| Humidity 13 mg/m <sup>3</sup> absolute and 90% relative before storms with vapour pressure of 17 mmHg |                      |
| <b>Altitude above Mean Sea Level</b>  | 2000 m               |
| <b>Typical Air Pressure</b>   | 860 mbar             |
| <b>Seismicity</b>   |                      |
| Peak Ground Acceleration  | 0.15g                |
| <b>Environment EMC Class (IEC 61000)</b>  | Industrial           |
| <b>Maximum Temperature Rise of Conductors Above Ambient (40°C)</b>                                    | +40°C                |

The de-rating factor as per IEC 60071 shall be applied to ensure that supplied plant and equipment operates correctly at this altitude.

It is jointly the Contractors and manufacturer's responsibility to be familiar with any other climatic and physical conditions pertaining to the specific sites as defined and to allow for all conditions in designs.

Particular attention should be paid in the design of all equipment to ensure that there is no damage to working parts or insulation through the ingress of dust, insects, vermin which are prevalent for long periods in the year. All orifices and air vents should be covered by easily replaceable weather resisting, fine mesh wire where practicable.

## 2.3. Standards, Units and Language

All equipment shall be designed, constructed and tested in accordance with requirements of the latest version of the standards specified herein except to the extent explicitly modified in this specification:

SI Units of measurements and the English language shall be used throughout.

IEC 60840: Power cables with extruded insulation and their accessories for rated voltages above 30kV (Um = 36kV) up to 150kV (Um = 170kV) – Test methods and requirements

IEC 60228: Conductors of insulated cables.

IEC 60287: Calculation of the continuous current rating of cables

## **2.4. General Requirement**

The cable shall comply with the requirements of IEC 60840, IEC 60228 plus any additional requirements specified hereafter.

The cable shall be designed for reliable service life of at least 40 years.

All materials used shall be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 seconds duration).

## **2.5. Conductor**

Conductors shall be stranded, annealed, high conductivity Aluminium. The Aluminium wire before shaping shall be smooth, uniform in quality, free from scale, inequalities, spills, splits and other defects and should comply with the requirements of international application IEC 60228.

The term ‘annealed’ signifies that the wire before stranding is capable of at least 15 per cent elongation without fracture, the test piece being not less than 150mm and not more than 300mm.

When made of from shaped wires the conductor shall be clean and uniform in size and shape and its surface shall be free from sharp edges and unless otherwise approved shall be taped with a layer of conducting a layer of conducting or semi- conducting material.

Not more than two joints shall be allowed in any of the single wires forming each length of conductor and no joint shall be within 300mm of any other joint in the same layer. The jointing of the wires shall be by brazing, silver soldering cold welding or electrical welding. No joint shall be made in the wire after it has been formed up into the required length.

The conductor will be water blocked to meet the requirements of IEC 60840, using water blocking tapes and / or yarns. The use of water blocking powder on its own is not permitted.

## **2.6. Conductor Screen**

A conductor screen shall be used to provide a smooth interface between the conductor and the cable insulation. A suitable semi- conducting binder tape will be applied over the conductor to prevent the extruded screen from falling between the interstices of the conductor strands.

The semi-conducting screen will have a spot minimum thickness of 1.0mm

The conductor screen will be made from semiconducting cross-linked polyethylene

(XLPE) using either acetylene black or carbon black material and will be applied as part of a triple extrusion process.

The conductor screen shall be extruded and consist of a black, semi-conducting thermoset material fully compatible with the conductor and extruded insulation. The outer surface of the semi-conducting screen shall be super smooth, cylindrical and firmly bonded to the overlying insulation.

The extruded conductor screen shall be applied in the same operation as the insulation and be fully bonded to the insulation

## **2.7. Insulation**

The insulation shall be cross-linked polyethylene (XLPE) conforming to the requirements of IEC 60840.

The insulation shall be an extruded cross-linked polyethylene (XLPE) material forming a concentric dielectric surrounding the conductor.

The use of insulation based on pure LDPE is preferred to the use of insulation based on Co-polymer.

The materials for the manufacture of 132kV cables shall be delivered in clean bulk containers.

The preferred manufacturing process is the vertical continuous vulcanisation (VCV) line however cable manufactured with either MDCV or CCV lines will also be considered. The cable shall be manufactured using low viscosity, ultra clean grades of material.

Every effort is to be made by the manufacturer to ensure the purity of the insulation extruded on the cable core. The preferred method for material handling is the use of fully integrated and enclosed material filtration and compounding facilities that are connected directly to the extrusion line. Frequent sampling during compound manufacture should take place.

The insulation shall be applied by extrusion and cross-linked to form a compact and homogeneous layer.

The colour of the insulation shall be such that it is easily distinguishable from the screening materials.

## **2.8. Insulation Screen**

The insulation screen shall be extruded and consist of a black, semiconducting thermoset material fully compatible with the extruded insulation. The interface between the insulation and the semiconducting screen shall be super smooth, cylindrical and firmly bonded.

## **2.9. Water Barriers**

The core shall be taped overall with semiconducting cushioning tapes to prevent possible mechanical damage of the cable core caused by thermal expansion during normal operation of the cable.

Provision should be made to prevent the longitudinal penetration of water along the interface between the cable core and the metallic sheath by the application of suitable water swellable tapes applied over the cable core.



## **2.10. Metallic Sheath**

The sheath is required to fulfil the following requirements;

- To provide a radial watertight barrier to the ingress of moisture into the extruded cable core.
- Provide low resistance path for cable charging current
- Provide protection against minor accidental damage caused by third party interference with the cable during installation or service
- Be capable of sustaining the specified earth fault currents for the time stipulated by the user.

The water impervious sheath shall consist of a seamless and continuously extruded tube of lead alloy. The lead alloy used for the sheath shall be alloy 1/2C. A thin layer of bitumen shall be applied over the sheath.

Lead alloy sheath of best quality metal, free from pinhole flaws and other imperfections shall be tightly extruded over the water blocking layer.

The minimum thickness at any point shall not fall below the specified nominal thickness by more than 0.1mm or 5% of the nominal thickness.

For the purpose of increasing the total short circuit current rating of the cable, an Aluminium wire screen of suitable cross-sectional area shall be applied between the core bedding layer and the lead sheath. An Aluminium tape shall be applied directly over the Aluminium wires in an opposite lay to the lay of the Aluminium wires, to ensure equal current sharing in the Aluminium wire screen. A suitable binder tape shall be applied over the Aluminium wire screen.

## **2.11. Oversheath**

The cable serving shall be robust enough to prevent unnecessary damage during installation and shall insulate the cable from earth.

The outer covering shall preferably be of medium density polyethylene, except for the closing sections that enter buildings, which shall be of a low smoke, zero halogen material (LSOH).

The minimum average thickness and minimum thickness at a point shall comply with IEC 60840 and not less than the value stated in the schedule.

An outer conductive coating (graphite coating or extruded layer) shall be applied to the covering to serve as an electrode for the voltage test on the outer covering.

## **2.12. Anti- Termite Protection**

All cables installed in concrete troughs shall have suitable anti-termite protection, to be approved by KETRACO

## 2.13. Fire Resistance

All cable sections installed in air will have an over sheath with a fire performance that conforms to the requirements of,

- IEC 60332-1 (Fire)
- IEC 60332-3A (Fire)
- IEC 61034 (Smoke)
- IEC 60754 (Minimal Halogen)

Ideally, over sheath materials will also have an oxygen index of less than 30% and a temperature index of greater than 260.

## 2.14. Electrical System Design Parameters

The standard sizes and characteristics of the cables shall be as follows:

The following electrical design parameters shall be used in the design of the 132kV cable circuit.

|  |                 |
|--|-----------------|
| Nominal System voltage:                        | 132kV           |
| Max. / Min voltage variation                   | +10% / -10%     |
| Loading capability of each 132kV cable circuit | 115 MVA         |
| Short circuit level                            | 31.5kA for 1sec |

## 2.15. Thermal Rating design parameters

The environmental parameters shall be as advised in clause 22

The following installation parameters should be used unless otherwise stated in the project specification

- Depth to the top of cable 1100mm (minimum)
- Phase spacing: 250mm
- Circuit Spacing: thermal independence

## 2.16. Ground Thermal Resistivity

The area around Nanyuki is generally made up of predominantly red soil with few pockets of black cotton. It is however, the responsibility of the contractor to determine the actual ground conditions of the project area and design accordingly.

All cable circuits are to be installed using a selected sand backfill that has a guaranteed dried-out TR of no greater than 2.7Km/W. The contractor will advise the guaranteed dried-out TR of the selected sand backfill that they choose.

## 2.17. Continuous Ratings

Continuous rating calculations are to be performed in accordance with **IEC 60287**.

Contractors are required to state clearly the value of ac resistance used for XLPE cable conductors and justify the value used.

Contractors are required as part of their site survey works to identify any utilities in close proximity to the new cable circuit that may derate the cable circuit and to calculate the derating effect and propose a solution to negate this effect.

Cable rating calculations shall be submitted along with the offer based on the data provided under Clause 2.14. The calculations shall be reconfirmed and approved after the site investigations and before the manufacture.

## 2.18. Short Circuit Rating

Short circuit ratings must be calculated using the adiabatic methods described in **IEC 60949**. Short-circuit levels for the different system voltages are as follows;

| System Voltage | Short Circuit level  |
|----------------|----------------------|
| 132Kv          | 31.5 kA for 1 second |

## 2.19. Cyclic Ratings

Cyclic ratings should be calculated in accordance to IEC 60840

## **2.20. Emergency Rating**

Emergency or overload rating should be calculated in accordance with IEC 60840

## **2.21. Calculation of Induced Voltages**

### **2.21.1. Effects on auxiliary cables**

Contractors are required as part of site survey works identify any existing conductor auxiliary cables e.g. pilot & telephone cables that run in close proximity to the new cables circuits and calculate the induced voltages that could be imposed on the insulated cores of the auxiliary cable.

### **2.21.2. Effects on Pipelines**

Contractor are required as part of their site survey works to identify any metallic pipelines running in close parallel proximity to the new cable circuits and to :

- i. Calculate any induced voltages that could be imposed on the pipeline, both under steady state and fault conditions.
- ii. Determine the influence of any such induced voltages on the cathodic protection system used on the pipeline

## **2.22. Calculation of Other Cable System Parameters**

- i. Positive, Negative and zero sequence impedances and,
- ii. Thermal time constant (for the setting of cable overload protection).

## **2.23. Requirements for 132KV XLPE Cable Accessories**

### **2.23.1. Outdoor Terminations**

Termination insulators must be manufactured from Porcelain materials, all materials shall be fully factory tested during production. In accordance with IEC 60815 the pollution level specified is ‘very heavy’.

The stress control method must allow for the thermal expansion of the cable and the tenderer must state how this is achieved. The sealing ends shall be filled with high viscosity polyisobutylene, silicone oil, or equivalent and expansion devices shall be provided where necessary.

Corona shields and arcing rings or horns shall be provided at the top of each open type termination and a horn or ring at the base. The base itself shall be insulated from supporting steelwork by mounting upon porcelain pedestal type insulators.

### **2.23.2. Gas Immersed termination**

Gas immersed terminations at the SF6 switchgear shall comply with the requirements of the latest version of IEC 60859. The Supplier shall demonstrate that terminations meet the mechanical loading of IEC60859. The terminations may be of "dry type" or "wet type" construction, containing an epoxy resin insulator and an elastomeric stress cone. The insulator shall have a blind-ended construction to eliminate the possibility of SF6 gas leaking into the cable termination via the conductor connection.

The cable glands of the sealing ends shall be insulated from the SF6 switchgear, and transformers

### **2.23.3. Straight joints**

The conductor connection will be made using a compression ferrule.

The following types of joint only will be considered for offer;

- Premoulded One – Piece
- Extrusion Moulded
- Prefabricated Three – Piece

The design of joint will accommodate insulation retraction and expansion.

The design of joint will include an internal partial discharge (PD) sensor.

The joint shall be provided with an Aluminium joint shell suitable for a metallic seal to the extruded metallic sheath of the cable.

Cable joints buried in the ground shall be enclosed in a fibreglass casing and the space between the joint and casing shall be completely filled with bituminous compound of approved grade. Alternative methods of insulating and protecting the joint e.g. heat shrink sleeve, rubber tape, may be offered subject to demonstration of development tests and type tests.

## **2.24. 132kV Cable System Tests**

### **2.24.1. General**

132kV cable and cable accessories shall be tested together as a complete system for type test and prequalification test purposes. Commissioning tests will inherently test these components as a complete system.

## **2.24.2. Type Tests**

The appropriate type tests specified in this clause shall be made before the manufacturer supplies on a general commercial basis the type of cable described in this specification in order to demonstrate satisfactory performance requirements.

These tests excepting those which are also required as additional regular tests need not be repeated once they have been performed successfully, unless alterations are made to cable design or materials which might affect the performance.

The accessory manufacturer must demonstrate by type test approval tests on the specific cable that any joint or termination that it is intended for use with the cable supplied for a specific contract is compatible with that cable.

Tests are required to demonstrate satisfactory performance characteristics of the basic accessory design.

Designs suitably tested may be used for applications where the electrical design stresses are the same or lower than those tested.

Type Testing will be in full accordance with IEC 60840.

### **2.24.2.1. Schedule of Type Tests**

The type tests shall comprise electrical tests on complete cable and the appropriate tests on cable components.

The electrical tests shall be carried out in sequence on one sample of cable. The bending test shall be included in this sequence of tests to check that the electrical properties of the cable after bending are satisfactory.

### **2.24.2.2. Electrical Tests**

The normal sequence of tests shall be:

- Bending test followed by partial discharge test (IEC Publication 60840)
- Tan delta measurement (IEC Publication 60840)
- Heating cycle voltage test, followed by partial discharge measurement (IEC Publication 60840)
- Impulse withstand test followed by power frequency voltage test (IEC Publication 60840)
- An AC withstand test on cable only of  $5U_0$  for 1 hour.

### **2.24.2.3. Tests on Cable components**

The following tests should be completed on the cable components:

- Measurement of thickness of insulation
- Measurement of insulation concentricity
- Measurement of insulation purity
- Measurement of moisture content in extruded insulation and screens
- Hot set test for XLPE insulation
- Shrinkage test
- Measurement of resistivity of semiconducting screens
- Measurement of screen protrusion
- Tests for determining the mechanical properties of the insulation before and after ageing (IEC Publication 60840)
- Ageing tests on pieces of complete cable to check compatibility of materials (IEC Publication 60840)
- Impact test on metallic sheath
- Water penetration test (IEC Publication 60840)

### **2.24.2.4. Additional Tests for Accessories**

Upon completion of the Type Test the joint will be fully dismantled and examined for any signs of distress or disruption not detected by the Type Test.

The sheath insulation used to enclose the joint will be subjected to the following tests;

- Impulse tests in accordance with Engineering Recommendation C55/4 'Insulated Sheath Power Cable Systems' from the Electricity Council, UK.
- Water penetration tests in accordance with CENELEC HD 632 S1:1998 PART 2, section 6.2.9 (page 2-61).

### **2.24.3. Routine Test Requirements for 132 KV XLPE Insulated Cable**

#### **2.24.3.1. General**

The following tests shall be carried out on every dispatch drum of cable, to check that the whole of each length complies with the requirements.

- Voltage test
- Partial discharge test
- Dielectric loss angle
- Conductor examination
- Measurement of electrical resistance of conductor
- Over sheath voltage withstand test

#### **2.24.3.2. Voltage Test**

The voltage test shall be conducted in accordance with the IEC publication 60840.

#### **2.24.3.3. Partial Discharge Test**

The partial discharge test shall be conducted in accordance with IEC Publication 60840. Measurements shall be made at least after initial voltage energization and at the end of the specified test period.

#### **2.24.3.4. Dielectric loss angle**

This shall be measured at  $1.5U_0$ . The value complies with the relevant IEC publication.

#### **2.24.3.5. Conductor Examination**

Compliance with the requirements of IEC Publication 60228 for conductor construction shall be checked by inspection and measurement.

#### **2.24.3.6. Measurement of the Electrical resistance of the Conductor**

The measurement of the electrical resistance of the conductor shall be made in accordance with IEC Publication 60840. The measured resistance of the conductor should comply with the value specified in IEC Publication 60228.



#### **2.24.3.7. Over sheath Voltage withstand test**

Each drum length of completed cable shall withstand a voltage of 25kV DC for one minute between the metal sheath and the external conducting surface

#### **2.24.3.8. Additional Regular Tests**

The following tests shall be made on each completed cable length (or dispatch drum length):

- Measurement of thickness of insulation
- Measurement of insulation concentricity
- Measurement of insulation purity
- Measurement of moisture content in extruded insulation and screens
- Hot set test for XLPE insulation
- Shrinkage test
- Measurement of resistivity of semiconducting screens
- Measurement of screen protrusions
- Measurement of capacitance
- Measurement of crosslinking by product concentration in XLPE cables
- XLPE Material Characterisation
- Corrosion spread test (as per IEC 60229)
- Metallic wire screen diameter of wires
- Water Penetration Tests

#### **2.24.3.9. Frequency of Tests**

Additional tests 1, 2, 3, 4, 5, 6, 8 and 10 will be performed on both ends of every dispatch drum.

#### **2.24.3.10. Repetition of Tests**

If the samples from any length selected for the tests should fail in any of the tests in this clause, further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. Should both additional cables pass the tests, the other cables in the batch from which they were taken shall be regarded as having complied with the

specified requirements. Should either fail, this batch of cables shall be regarded as having failed to comply.

Further re-sampling and testing should then become a matter for negotiation between KETRACO and the manufacturer.

#### **2.24.3.11. Measurement of Insulation Thickness**

The thickness of the insulation shall be measured in accordance with IEC Publication 60840.

The minimum thickness of the insulation measured at any point shall not fall below the specified minimum average thickness by more than 10% of the minimum average thickness.

#### **2.24.3.12. Measurement of Insulation Concentricity**

A 50mm sample shall be taken from the cable core. The sample shall be cut into wafers approximately 12.5mm thick and viewed under magnification. The samples shall be examined at six points equally spaced around the cable with one of the points corresponding to the point of minimum insulation thickness,  $t_{min}$ . The maximum allowable deviation between the thickness at the point of minimum thickness,  $t_{min}$ , and the maximum measured thickness value,  $t_{max}$ , shall be less than 8% of the measured minimum average thickness.

$$t_{max} - t_{min} < 0.1 \times \text{minimum average thickness}$$

#### **2.24.3.13. Measurement of Insulation Purity**

A sample approximately 50mm long shall be taken from the cable core. This sample shall be cut into 25 wafers approximately 2mm thick. The entire area of each wafer shall be examined with a minimum 15 power magnification microscope by transmitted light.

The insulation shall be free from:

- Any void larger than 0.02mm, and no more than 10 voids in any area of 10mm x10mm
- Black and metallic particles larger than 0.08mm
- Any contaminant (opaque material that is not homogeneous cross-linked polyethylene) larger than 0.125mm
- Any translucent material that is larger than 0.6mm.

#### **2.24.3.14. Measurement of Insulation & Screen Moisture Content**

The moisture content of the insulation and screens shall be measured using the Karl Fischer titration method. Three measurements shall be taken from each of the two screens and insulation.

- Less than 150ppm of moisture should be detected in the extruded insulation.

- Less than 500ppm shall be detected in the screens.

#### **2.24.3.15. Hot Set Test for XLPE Insulation**

The hot set test shall be conducted in accordance with IEC Publication 60840.

The results of the test shall comply with the requirements of IEC Publication 60840.

#### **2.24.3.16. Insulation Shrinkage Test**

The shrinkage test shall be conducted in accordance with IEC Publication 60840 Clause 5.6.14.

The results of the test shall comply with the requirements of IEC Publication 60840 Clause 5.6.14.

#### **2.24.3.17. Measurement of the Resistivity of the Semi Conducting Screens**

The resistivity of the semiconducting screens shall be completed in accordance with IEC Publication 60840.

The results of the test shall comply with the requirements of IEC Publication 60840.

#### **2.24.3.18. Measurement of Semi Conducting Screen Protrusion**

The semiconducting conductor and insulation screens shall be examined on the wafer samples produced for Clause 1.8.13 of this Specification. The contact surface between the screen and the insulation shall be cylindrical, smooth and free from protrusions and irregularities which extend more than 0.03mm into the insulation.

The outer screen of the cable core shall be removed from a 0.5m sample length. The sample shall be rendered transparent by immersion in a suitable heated fluid. The screen shall be examined for the presence of screen defects.

#### **2.24.3.19. Measurement of Capacitance**

The capacitance of the completed cable shall be measured between the conductor and the metallic sheath.

The measured value shall not exceed the nominal value specified by the manufacturer by more than 8%.

#### **2.24.3.20. Measurement of Crosslinking by- Product Concentration in XLPE Cables**

Excessive by-product concentration adversely affects the electrical performance of the cable and could diffuse out of the cable core and pressurise external cable protection/accessories.

The test is to be conducted using TGA (Thermo-Gravimetric Analyser) apparatus. A 20mg insulation sample is required. The test is to be conducted for 30 minutes at 150°C. The % loss of weight of the sample is to be recorded. Five samples are to be taken, the result being the average of five tests.

The cable is at a stable by-product level if:

- The total weight change of the test sample after a period of 30 minutes is less than 1.25% of the original sample weight.
- The rate of change is less than 0.14% minimum in the first five minutes of the test.
- Between the time period of 15-30 minutes the average rate of change of sample weight does not exceed 0.01%.

#### **2.24.3.21. XLPE Material Characterisation**

All insulating and semi-conducting XLPE materials used to manufacture all cables to be supplied into Kenya as part of this contract shall be identical to those used to manufacture the Type Test Cable. In order to demonstrate compliance, the Contractor shall 'finger print' samples from the Type Test Cable and all cables manufactured under the contract. The characterisation shall include the following methods;

- i. Fourier Transform Infrared Spectroscopy (FTIR) to characterise the insulating polymer.
- ii. Differential Scanning Calorimetry to characterise the material processing.
- iii. Fourier Transform Infrared Spectroscopy (FTIR) to characterise the insulating polymer.
- iv. Differential Scanning Calorimetry to characterise the material processing.
- v. Thermogravimetric Analysis (TGA) on the incoming semiconducting material to
  - characterise the carbon black content.
- vi. Cleanliness measurement on the incoming insulation material.
- vii. Thermogravimetric Analysis (TGA) on the incoming semiconducting material to
  - characterise the carbon black content.

Test i) and ii) will be conducted on both ends of every despatch drum. Tests iii), iv) and v) will be conducted on every batch of incoming material.

#### **2.24.3.22. Sample Tests**

The sample test requirements of IEC 60840 shall be performed with the following exceptions;

- Tests that are already specified under preceding sections 'Additional Regular Tests' shall not be repeated as a Sample Test.

- The lightning impulse followed by power frequency voltage test shall be replaced with just a power frequency voltage test of  $5U_0$  for 1 hour. The frequency of this test shall be on one 20m sample from every extrusion run or every 6km, whichever is the lower.

#### **2.24.4. Routine Test Requirements For 132kV XLPE Insulated Cable Accessories**

##### **2.24.4.1. One- Piece Premoulded Joints and three piece Prefabricated joints**

The insulation and screening material used for all one-piece premoulded joints and rubber stress cone components of three-piece prefabricated joints shall be identical to those used to manufacture the Type Test accessories. The characterisation of the insulation and screening material shall include

- Fourier Transform Infrared Spectroscopy (FTIR) to characterise the insulating polymer.
- Cleanliness measurement on the incoming insulation material
- DLA measurement of insulation at 90°C.
- Thermogravimetric Analysis (TGA) on the incoming semiconducting material characterise the carbon black content

The above tests will be carried out on one joint in every ten manufactured for the contract.

The following, additional tests, will be conducted on everyone piece joint or rubber stress cone;

- HV Withstand Test at  $2U_0$  for 30 minutes.
- Partial Discharge Measurement at  $2U_0$ . Discharge to be  $< 10\text{pC}$  with background noise level of  $2\text{pC}$

##### **2.24.4.2. Additional Tests on One Piece joints**

The following, additional tests, will be conducted on every one piece joint only;

- Mechanical stretch of each rubber component over a mandrel equal in diameter to the Contractors site assembly mandrel
- Resistance of outer semi-conducting screen  $< 20\text{kohms}$ .
- Integrity of insulated gap 25kV dc for 15 minutes

#### **2.24.5. Commissioning Tests**

For each completed circuit, the following site tests shall be carried out:

#### **2.24.5.1. Measurement of conductor resistance and circuit impedance**

The Contractor shall measure and record the following as-installed circuit data:

- As-installed circuit length in km
- DC conductor resistance
- AC conductor resistance

(Measured and/or derived)

#### **2.24.5.2. Tests on Sheath Protective covering**

A voltage of 12kV DC for one minute shall be applied between the sheath and ground on each length of cable sheath, with all sheath voltage limiters disconnected.

A sheath integrity test shall be done after installation (prior to termination) to verify that cable damage during installation has not occurred, and repeated when terminations are complete.

#### **2.24.5.3. Insulation resistance Test**

Insulation resistance (IR) tests shall be performed after laying and prior to jointing each section of cable. IR tests shall be applied for a period of 1 minute for cables less than 100m and 3 minutes for cables greater than 100m in length.

#### **2.24.5.4. High Voltage AC Field Acceptance Test**

An AC overvoltage, of  $1.7U_0$ , will be applied to each phase of the cable system for a period of not less than 1 hour. The cable system will be monitored for partial discharge activity during the HV test and will be PD mapped for future reference.

Any accessory exhibiting PD activity greater than 10pC will be remade

#### **2.24.5.5. Additional Tests**

The following additional tests need to be carried out on all power cables during commissioning:

- Circuit phasing check.
- Capacitance of circuit
- Sheath continuity checks
- Cross-bonding configuration checks

## **2.25. Marking**

The following information will be clearly printed with indelible ink on the semiconducting XLPE screen of every cable;

***‘132kV XLPE Cable – KETRACO – Cable No.XXXXXX - Date’***

The over sheath should be legibly embossed along its length with the following information:

***‘132000V Electric Cable, (Manufacturer), (Year of Manufacture) PROPERTY OF KETRACO’***

The embossed letters and figures shall be raised and consist of upright block characters along two or more lines, approximately equally spaced around the circumference of the cable.

For both the semiconducting XLPE screen and the oversheath, the maximum size of the characters shall be 13 mm and the minimum size not less than 15 per cent of the nominal or specified external diameter of the cable or 3 mm, whichever is the greater.

For both the semiconducting XLPE screen and the oversheath, the spacing between the end of one set of embossed characters and the beginning of the next on the legend shall not exceed 150 mm. Any additional information embossed on the sheath (e.g. the Manufacturer’s name) shall not affect the spacing between repetitions of the legend.

## **2.26. Dispatch**

Both ends of the cable shall be rendered fully watertight by fitting a metallic end cap and a pulling eye which are plumbed to the cable metallic sheath. The pulling eye shall be directly connected to the conductor and be capable of withstanding a tensile load of 100N/mm<sup>2</sup> of conductor area up to a maximum of 6 tonnes. When requested by the user, pulling eyes shall be fitted to both ends of the cable.

The cable shall be dispatched on a drum of suitable construction of minimum hub diameter 20D (where D is the overall diameter of the cable). The drum shall be fully enclosed by either adjacent fitting wooden battens or continuous metallic cladding.

## **2.27. Site Survey**

The Contractor shall carry out, at his own expense, moisture content, water table level, and soil thermal resistivity tests along the 132kV cable route and such other tests as he may consider necessary, sufficiently in advance of the manufacture of any cable, to satisfy him/herself that the conditions on site and his proposed arrangement of cables and method of installation are such that the maximum current carrying capacity can be maintained. If the Contractor considers that the conditions and the proximity to other power cables, spacing and method of installation are likely to reduce the maximum current carrying capacity below the declared value he shall immediately notify KETRACO as to what the maximum current carrying capacity would be

under these conditions and shall not proceed with the work on that portion of the route affected until KETRACO has given its permission.

Within a reasonable time after the Contract has come into force, the Contractor shall agree a final route with KETRACO and confirm the arrangements.

The Contractor shall open trial pits at approved positions, to determine the most suitable detailed route and position for the trenches. The width of trial pit shall be sufficient to determine the cable route, but not smaller than that of cable trench.

All routes shall be defined precisely, and shown in drawings at a scale of 1:500. The stable structures shall be indicated clearly as well as distances. The crossings with roads and underground installation shall be shown. Joint locations shall be identified clearly and sufficient section views shall be provided where necessary. The dates of installation of cable joints, cable drum serial numbers, name of jointers, shall be included in the “AS-BUILT” drawings. Cable section lengths shall also be given.

All drawings shall be subject to KETRACO’s approval.

The quantity of cables, accessories etc. to be supplied shall be based upon this survey. The programme for route survey works shall be agreed upon with KETRACO prior to commencement of works.

## **2.28. Crossing with Other Utilities and Interference with Pipelines**

In case of crossings with the other installation the following shall be observed:

- The service authorities may imply additional requirements (mechanical protection, etc.) through a work permit procedure. The Contractor shall comply with this requirement, and it is considered included in the Contract Price.
- In cases where other heat sources are to be crossed special attention shall be paid to cable current rating calculations, and additional measures shall be applied

At crossings with existing installations the new cable shall be preferably installed beneath, always taking into account the current rating requirements. If necessary, the phase spacing could be increased at the crossing point.

After opening existing installations and before cable laying and installation, the sketch of the final arrangement shall be approved.

Each crossing point shall be clearly marked with the route markers, after backfilling.



During installation, when crossing other heat sources, or laying at depths deeper than 1.1 m at the crossings or such similar conditions, the Contractor shall maintain the specified rating, either by application of the special stabilised backfill or by increasing the phase spacing. For every situation the arrangement with relevant calculations shall be submitted to KETRACO for approval, prior to installation

## **2.29. Testing and Commissioning**

Tests shall be in accordance with applicable international standards and related provisions.

## **2.30. Compliance with Specification**

If the technical requirements are not met or the performance of the equipment during test do not meet the guarantees stated in the technical particulars subject to tolerances specified in relevant IEC Standards, the Employer shall have the right to reject the faulty component or the entire item. The Contractor shall replace the same in full compliance with the specification at no extra cost to the Employer.

## **2.31. Antivandalism**

Design of the manhole for the link box / ground box (secondary box) will be designed so that those secondary boxes lay aside the main junction box. Target is to prevent any LV cables to be buried directly in the ground in between the main junction box and the secondary boxes. They will be sized up to include the earth pit for ground connection.

The area above the junction box and secondary box will be covered by heavy concrete tiles (2.5m width, at least 5000kg each tile) that cannot be moved by hand tools. Only a crane should be able to remove these tiles. It will prevent any digging in the junction boxes area.

Furthermore, a vandalism monitoring system that detects intrusion on the cable trench, tampering of the cable and accessories shall be provided. The system should provide early detection and alert the employer and security services to mobilise to the particular location of cable under attack. The system should combine, among others, video, vibration and sound monitoring systems. The number system should provide multiple human machine interfaces for viewing and controlling. Multiple HMI should be provided (minimum of three) at the terminal substations to monitor the system. This should be accessible through the KETRACO KPLC CCTV fibre network. Security alerts should be provided through mobile phones as well as the SCADA system

## **2.32. Storage Instruction for Cable Accessories**

### **2.32.1. General**

All materials shall be stored in a dry warehouse protected from sunrays. Cases must be laid on a flat floor without loads over them. Room temperature shall be controlled, less than 32 degrees Celsius and humidity also shall be less controlled to less than 50%.

### **2.32.2. Guaranteed period**

For other items which are not shown in the table below, two years shall be guaranteed unless its explicitly stated.

#### *Epoxy Resin Components*

Epoxy resin components could absorb moisture if exposed directly to air for long time; an under vacuum heating treatment (90 degrees Celsius for 48 hours) must be carried out before the installation of the component. Even if the epoxy resin components are not exposed to air directly, vacuum heating is recommended before installation.

#### *Rubber Components*

Stress cone and joint sleeve components, which have rubber components as main insulators shall be kept away from direct sunrays. Direct sunrays affect the original nature of rubber.

### 2.32.3. Storage time

Some components, in particular tapes and putties, could have a decay of physical characteristics due to storage time and ambient temperature. Assuming the ambient temperature of the warehouse between 0° C and 35° C, the following storage time could be guaranteed:

| <b>Material</b>                | <b>Usage period after date of production</b> |
|--------------------------------|--|
| Metal parts                    | 5 years or more                              |
| Porcelain/ Composite insulator | 5 Years or more                              |
| Epoxy components               | 5 years                                      |
| Silicone rubber sleeve         | 5years                                       |
| Heat shrinkable tubes          | 2years                                       |
| Stress relieve cone            | 5 years                                      |
| Gasket/ O-ring                 | 5 years                                      |
| Tapes and putties              | 2 years                                      |
| Silicone grease                | 2 years                                      |
| Insulating oil                 | 2 years                                      |
| Waterproof compound            | 3 years                                      |

## 2.33. Documentation

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals.

### 2.33.1. Documentation with Bid

The Bid shall contain at least the following information and documents:

- i. Detailed cross sections giving dimensions and construction of 132kV XLPE cables;
- ii. Cable joints;
- iii. Cable sealing end;
- iv. Schematic diagram of the proposed installation;
- v. Proposed joint bay arrangement;
- vi. Detailed calculation confirming selected conductor cross section;
- vii. Detailed calculation confirming selected metallic sheath cross section;
- viii. Proposed work schedule, giving tentative timing and phasing of manufacture, testing, shipment, cable laying, jointing and other erection works;
- ix. Proposed cable laying procedure, cable protection covers;

- x. Manufacturing specification of the proposed cables;
- xi. Catalogues, literature and reference lists of proposed equipment;
- xii. Type test certificates from an independent testing authority or independently witnessed;
- xiii. Quality Management System Manual and ISO Certificate of the equipment manufacturer.

### **2.33.2. Documentation after Award of Contract**

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

## **3. SHEATH BONDING & EARTHING EQUIPMENT FOR 132KV CABLES**

### **3.1. Scope of Works**

This specification details all the design, performance and testing requirements for all items of sheath bonding and earthing equipment (link boxes, sheath voltage limiters, bonding leads) required for 132kV cable systems.

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

### **3.2. General**

Cable circuits may be installed as either solidly bonded systems or insulated sheath systems with special bonding to reduce sheath losses. The design of all specially bonded systems shall be such as to ensure that there is a continuous metallic return path of adequate cross-section for the specified fault current.

All required direct inter-sheath and sheath-to-earth connections shall be made via disconnecting links enclosed in link boxes. Inter-sheath and sheath-to-earth connections through sheath voltage limiters shall be disconnectable within link boxes. Bonding leads and link boxes shall be of approved design.

### **3.3. Bonding Arrangements**

Special terminal bonding arrangements may be necessary where cables terminate into gas insulated switchgear. The Contractor shall recommend the appropriate measures where appropriate.

### **3.4. Induced Sheath Voltages**

For system design purposes, the magnitude of sheath voltages induced under balanced maximum full load conditions and also under prospective short-circuit fault conditions shall be calculated by the methods and formulae recommended by CIGRE. Details of such calculations shall be submitted to KETRACO and recommendations for cable section lengths.

At terminations, the base metal work of the cable sealing end shall be shrouded against accidental contact if the sheath voltage exceeds 10V.

### **3.5. Sheath Voltage Limiters**

In order to minimize transient over-voltages on sheath insulation, sheath voltage limiters (SVLs) of approved design shall be installed at unearthed ends of single point bonded sections. Under certain circumstances, SVLs may be necessary at earthed terminations into SF<sub>6</sub> switchgear.

SVLs shall be of zinc oxide type and shall consist of three non-linear resistors housed in the link box, the star point being earthed normally to local earth points. SVLs installed at metalclad terminations shall be encapsulated and mounted directly across the insulating flange of the termination. The SVLs shall be capable of withstanding the voltages and currents impressed upon them and of limiting transient voltages to acceptable levels.

The units shall be able to withstand the voltages induced by fault currents for a period of 2 seconds without damage. However, it is accepted that the units may be unable to withstand the duty imposed upon them by an internal cable system fault.

### **3.6. Link Boxes**

All links and SVLs, other than those directly connected across sectionalizing insulation at metalclad equipment terminations, shall be enclosed in stainless steel boxes which shall be earthed. SVLs and associated links shall be accommodated in a common housing unless otherwise approved by the Engineer.

The boxes shall be provided with a means of preventing incorrect link positioning and shall also be provided with a label showing the normal link arrangement. The terminal posts and links shall be suitable for the specified short circuit requirements.

The link housing shall be designed to confine the effects of the failure of SVLs and link insulation to withstand the duty imposed upon them by an internal cable fault due to the high system fault levels. The Contractor shall recommend ways of containing these effects.

All link boxes shall be of horizontal type with bolted-on lids suitable for installation in shallow pits below ground surface unless otherwise agreed by the Engineer. Pits shall be provided with removable cast iron covers.

The link box shall have a label fitted externally bearing the legend:

**DANGER - ELECTRICITY**

The label shall also give circuit identification details. Appropriate warning labels shall also be affixed inside the box. A phase identification label shall be provided adjacent to each terminal.

### **3.7. Bonding Leads**

Bonding leads shall have PVC or polyethylene insulated stranded plain copper conductors and shall be of concentric construction. The type of PVC or polythene used shall be suitable for a short-circuit temperature of 160°C.

Bonding leads shall comply with BS 6346.

The outer insulation of the bonding lead shall be embossed with the legend:

#### **ELECTRIC CABLE-BONDING LEAD**

Joints in bonding leads are not acceptable in new installations, but may be used in subsequent alterations e.g. diversions, subject to the approval of KETRACO.

### **3.8. Sheath Connections**

For ease of maintenance and to facilitate testing of cable over sheaths, all bonding and earthing connections shall be made via disconnecting links accommodated in underground box or gantry-mounted boxes. Where sheath voltage limiters are necessary, they shall be enclosed in the same housing as the associated links.

All connecting leads shall be as short as possible and of the concentric type. Except for connections to the SVLs at unearthed sheath positions, bonding and earthing leads shall be of sufficient cross section to meet the prospective system fault and transient duties.

### **3.9. Test Regime for Sheath Voltage Limiters and Link Boxes used on HV Cable Systems**

#### **3.9.1. Sheath Voltage Limiters**

Sheath Voltage Limiters (SVLs) shall be of zinc oxide type and shall consist of three non-linear resistors housed in the link box, the star point being earthed normally to local earth points. Connections to SVLs shall be of substantial cross section to withstand electro-mechanical forces and to exhibit low inductance.

The SVLs shall limit transient voltages to acceptable levels both at the insulated flanges of joints and terminations and within link-boxes. The SVLs shall be capable of withstanding the voltages and currents impressed upon them in normal service and system through faults. SVLs installed at metalclad terminations shall be encapsulated.

The SVL units shall be able to withstand the 50Hz voltages induced in the cable sheath by fault currents for a period of 2 seconds without damage. However, it is accepted that the units may be unable to withstand the duty imposed upon them by an internal cable system fault.

The Peak Residual Voltage (PRV) is defined as the peak value of voltage which appears across the SVL device when it is conducting the SVL's normal discharge current rating.

The cable contractor is required to measure the PRV of the Sheath Voltage Limiter device at 10kAp, 15kAp and 40kAp fully assembled within its housing and with the connecting leads attached. Details of these measurements are required to be submitted to KETRACO as part of the Type Approval Test Report for the Link Box. These tests shall be undertaken for each type

of SVL employed. It shall not be acceptable for the cable contractor to merely quote the PRV as given to them by their SVL supplier.

All SVLs provided shall be able to withstand repeated in-situ 5kV DC testing during maintenance checks on the cable sheath. This shall be demonstrated by a 5kV DC test for one minute and the leakage current recorded and demonstrated to be less than 0.1mA.

### **3.9.2. Voltage Withstand Tests on Link Boxes**

#### **3.9.2.1. The Impulse Voltage Withstand Test**

The Impulse Voltage Withstand of the Link Box, between each combination of links and between the links and earth, shall be measured and declared. The Impulse Voltage Withstand value shall be greater than or equal to twice the value of the PRV of the SVL device (including connections) multiplied by the Insulation Co-ordination Design Margin. The Insulation Co-ordination Design Margin shall be greater than or equal to 120% of the twice the value of the PRV. The cable contractor shall state the value for the Insulation Co-ordination Design Margin.

The pass criteria for the Impulse Voltage Withstand Test are that it shall successfully withstand ten positive and ten negative shots of a 1/50 microS wave-form on a completed link-box with the bonding leads fully terminated and the lid fully assembled. The Impulse Voltage Withstand Test shall be conducted with the SVL assemblies in position but utilizing insulating discs instead of Zinc Oxide discs. For information purposes only the test shall be repeated with the Zinc Oxide SVL assembly in place (Note: It is understood that the Withstand Voltage may be influenced by the energy characteristics of the particular Impulse Generator employed and the Zinc Oxide discs).

The impulse voltage shall be applied between the inner and outer of each bonding lead in turn with all floating bonding lead terminations and the link box body connected to earth.

#### **3.9.2.2. The DC Voltage Withstand Test**

The DC Voltage Withstand of the Link Box, between each combination of links and between the links and earth, shall be measured and declared. The DC Voltage Withstand value shall be 25kV DC for 5 minutes.

The pass criteria of the DC Voltage Withstand Test is that it shall successfully withstand the applied voltage on a completed link-box with the bonding leads fully terminated and the lid fully assembled but without the Zinc Oxide SVLs. The voltage shall be applied between the inner and outer of each bonding lead in turn with all floating bonding lead terminations and the link box body connected to earth.

### **3.9.3. Short Circuit Test on Link Boxes**

The Short Circuit Test shall successfully withstand the applied current without damage, distortion or impairment on a completed link-box with the bonding leads fully terminated, the Zinc Oxide SVLs connected and the lid fully assembled. The current shall be applied through



each link in turn with all floating bonding lead terminations and the link box body connected to earth. The terminal posts and links shall be suitable for the system short circuit requirements.

#### **3.9.4. Internal Power Arc Test on Link Boxes**

The Internal Power Arc Test shall successfully contain the violent effects of the internal power arc on a completed link-box with the bonding leads fully terminated, the Zinc Oxide SVLs connected and the lid fully assembled.

The link housing shall be designed to confine the effects of the failure of SVLs and link insulation to withstand the duty imposed upon them by an internal power arc. It is permissible for the link box to be distorted during this test but the box should not rupture.

The arc shall be initiated by connecting a suitably sized link of copper wire between the terminals of any two adjacent inner posts. Only one test is required for the link box. The voltage shall be sufficient to sustain the internal power arc magnitude during the test without appreciable attenuation (e.g. 1,500 volts). During the Internal Power Arc test all floating bonding lead terminations and the link box body [shall be] connected to earth.

#### **3.9.5. Site Tests on Earth Resistance**

Sheath voltages during external single phase to earth short circuit conditions are greatly affected by the earth resistance at the cable terminations. The cable contractor shall measure and record the earth resistance at the points where the bonding cable lead is connected to the earth.

After the cable contractor has completed the earth resistance test he shall demonstrate that the measured earth resistance will not result in SVL rated voltages being exceeded during the specified external single phase to earth short circuit conditions.

Where the earth resistance is measured at more than 0.2 ohms then this result must be brought to the immediate attention of KETRACO.

#### **3.9.6. Commissioning Tests on Link Boxes and Sheath Voltage Limiters**

Link contact resistance at all link positions shall be measured and recorded.

The leads of the SVL's shall be disconnected from the bonding links and a DC voltage applied between each of the three terminals of the SVL and earth. The voltage applied shall depend on the type of SVL used and shall be subject to approval. The current taken by the SVL shall be recorded.

The insulation resistance, with the surge arrestors connected, between the bonding leads when isolated from earth and the casing shall be measured at 1,000 volts DC. The value shall not be less than 10 mega ohms.

For cross-bonded systems, the configuration of the bonding connections shall be checked: With the links in the link box in their correct positions, a three-phase current of approximately 100A shall be applied to the main conductors. The currents and voltages shall be measured and agreed with theoretical values supplied by the Contractor.

### **3.10. Packaging, Shipping and Transport**

Packing, shipping and transport shall be arranged according to the requirements in General Technical Requirements

### **3.11. Performance Guarantees**

The performance of the cross-bonding system shall be confirmed by the appropriate site tests after installation. If the Contractor fails to meet the performance requirements, KETRACO shall decide either to reject the installation completely or to accept compensation appropriate to the extent of deficiency.

## **4. DIRECT BURIED FIBER OPTIC ARMoured CABLE TECHNICAL SPECIFICATIONS**

### **4.1. General**

#### **4.1.1. Scope**

This listed specification covers the design requirements and performance standard for the supply of fully armoured 48 core optical fibre cable to be used for the communication purposes of the Nyahururu-Rumuruti transmission line underground cable section.

#### **4.1.2. General Specifications**

- i. The equipment to be supplied shall conform in all respects to this specification. Unless another standard is specifically mentioned in this specification, all material and practices employed in the works must be in accordance with such other authorised standard appropriate to the country of manufacture, which in the opinion of this company shall ensure an equivalent or higher quality.
- ii. 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.
- iii. The cable shall be a fully armoured all dielectric, Non-Zero Dispersion Shifted Single Mode (G.655), 48 fibres, Optical Fibre Cable Specifically manufactured for underground Installation. The cable is to be laid inside a High Density conduit, the same place there shall be high voltage transmission line power cables. A written confirmation must be obtained from the cable manufacturer giving an assurance that the cable so offered is suitable for underground installation alongside the HV power cables and that it will give a reliable communication link suitable for Protection of the power cable, Speech and Data Transmission.
- iv. The Manufacturer shall also submit a list showing Locations where similar cables have been laid underground alongside similar HV power cables or of higher voltages and the duration over which the cables have been in Operation.

**NOTE:** It should have the pre-requisite Mechanical Protection to prevent damage during installation and due to other Human activities such as excavation. The cable should also be Rodent resistant. The cable must be specifically manufactured for underground installation and must be all dielectric fully armoured, hence unaffected by Electromagnetic induction from the HV power cables. This must be specifically stated in the Tender Offer.

### 4.1.3. Reference

The cable shall be designed, manufactured and tested according to the following international standards:

|                |   |
|----------------|---|
| IEC 60793-1    | Optical fibre Part 1: Generic specifications  |
| IEC 60793-2    | Optical fibre Part 2: Product specifications  |
| IEC 60794-3-10 | Outdoor cables- family specification for duct and directly buried optical telecommunication cable |
| ITU-T G.650    | Definition and test methods for the relevant parameters of single-mode fibres                     |
| ITU-T G.655    | Characteristics of Non Zero Dispersion Single-Mode Optical Fibre and cable                        |
| EIA/TIA 598    | Colour code of fibre optic cables   |

### 4.1.4. General Construction

- Cable core Assembly: Primary coated fibers shall be placed in loose tubes which are around the central strength member. It shall be protected by means of filling compound having properties of non-hygroscopic dielectric material or swelling tape.
- Secondary Protection: Loose packing within a tube, which shall be filled with thymotic jelly to protect the coated fibers.
- Strength member: Fiber reinforced plastic or non-metallic member which will be provided strength, and flexible enough in order to keep the fiber strain within the permissible values.
- Filling Compound: It shall be compatible to the fiber, secondary protection, core wrapping etc., and preferably thymotic jelly. It shall be removable easily for splicing of the fibers. It should inhibit generation of hydrogen within cable filling compound and should remain stable for ambient temperatures & should not drip, leak or flow. Drip point should not be less than 70 deg C. It should be non-toxic homogeneous water proofing compound that is free of dirt, ant- hygroscopic, electrically non-conductive.
- Inner Sheath: The Fiber Optic Cable shall be covered with tough weather resistant Black High Density Polythene Compound (HDPE) of thickness not less than 1.2mm. It shall be circular, free from holes, joints, mended pieces and defects.
- Armouring: Armouring shall be provided over inner sheath by Corrugated Stainless Steel Armouring Tape to make the cable rodent and Termite Proof. The steel tape should be both side coated with transparent polymer coating of minimum thickness of 0.05mm. The height of the corrugations shall be minimum 0.6 mm and the pitch of the corrugated tape shall be max. 2.5mm.

- **Outer Sheath:** The armour shall be covered with tough weather resistant non-nylon High Density Polythene Compound (HDPE) of thickness not less than 1.6mm. It shall be circular, free from joints and other defects.

## 4.2. Technical Characteristics

The technical characteristics of the cable shall follow the following requirements:

### 4.2.1. Mechanical Characteristics

The expected life of the cable is at least 25 years. The supplier shall submit necessary statistical calculation to prove this requirement.

#### **Mechanical/Environmental requirements:**

- Proof test: Entire length of the fibre should be subject to a tensile proof stress of  $> 100$  (0.7 Gpa)
- Strip ability force:  $1.3 \leq F \leq 8.9\text{N}$
- Dynamic tensile strength:  $>3.8$  Gpa (Nominal 5.26 Gpa) For both Unaged/Aged (30 days at 85 degrees Celsius and 85% RH)
- Dynamic fatigue:  $\geq 20$  (Nominal 22)
- Static Fatigue:  $\geq 20$  (Nominal 25)
- Fiber curl:  $\geq 4\text{m}$  radius of curvature
- Fiber micro-bend:

| Mandrel Dia mm | No of Turns | Wave length nm | Induced attenuation in dB |
|----------------|-------------|----------------|---------------------------|
| 32             | 1           | 1550           | $<0.5$                    |
| 50/75          | 100         | 1550           | $<0.05$                   |
| 50             | 100         | 1550           | $<0.10$                   |
| 60/75          | 100         | 1550           | $<0.05$                   |

The induced attenuation due to fiber wrapped around a mandrel of a specified diameter.

- Induced Attenuation at 1550nm:  $\leq 0.05$  Db/km
- Temp Humidity Cycling -10 degree Celsius to 85 degree Celsius:  $< 0.05$  dB/km up to 98%RH where ref Temp is +23 degree Celsius
- Water Immersion 23 degree Celsius:  $\leq 0.05$  Db/km
- Heat Aging, 85 degrees Celsius, where Ref Temp is +23 degree Celsius:  $\leq 0.05$  Db/km

### Mechanical Requirement of the cable:

After each mechanical tests below, the change in attenuation shall be  $\leq 0.05$  dB/km for each individual fiber.

- i. Tensile strength: The cable shall withstand a load of value  $\leq 9.81 \times 2.5 \times W$  is the weight of 11km of the cable @ strain  $\leq 0.25\%$
- ii. Crush load: The cable shall sustain a compressive load of 4 KN/100x10mm.
- iii. Impact load: Shall withstand an impact caused by a mass of weight of 50N
- iv. Torsion load: Shall withstand a load of 100N for 2m cable length.
- v. Water penetration: Shall meet or exceed the limit as per latest. TEC specification.
- vi. Cable bend: Minimum-bending radius will be 20D, where 'D' is outer dia of the Cable.
- vii. Others: Shall meet the latest TEC specification

### 4.2.2. Optical Fiber Characteristics

The optical fibre shall be made of high pure silica and germanium doped silica. UV curable acrylate material shall be applied over fibre cladding as optical fibre primary protective coating. The detail data of optical fibre performance are shown in the following table.

| Category               | Description   | Specifications  |
|------------------------|---|---|
|                        |   |   |
| Optical Specifications | Attenuation between 1525-1625nm   | $\leq 0.25$ dB/km   |
|                        | Attenuation between 1565-1625nm   | $\leq 0.28$ dB/km   |
|                        | Attenuation discontinuities @ 1550nm  | $\leq 0.05$ dB  |
|                        | Attenuation coefficient at water Peak (at $1385 \pm 3$ nm)  | $\leq 1.00$ dB/km   |
|                        | Chromatic Dispersion coefficient in 1530-1565nm band:<br>$\lambda_{\min}$ and $\lambda_{\max}$<br>Minimum value of Dmin<br>Maximum value of Dmax<br>Dmax – Dmin<br>Sign | 1530nm and 1565nm<br>1.0 ps/nm.km<br>10.0 ps/nm.km<br>$\leq 5.0$ ps/nm.km<br>Positive |
|                        | Chromatic Dispersion coefficient in 1565-1625 band:<br>$\lambda_{\min}$ and $\lambda_{\max}$<br>Minimum value of Dmin<br>Maximum value of Dmax<br>Sign                  | 1565nm and 1625nm<br>4.0 ps/nm.km<br>14.0 ps/nm.km<br>Positive                        |
|                        | Dispersion Slope  | $< 0.07$ ps/(nm <sup>2</sup> .km)   |
|                        | Polarisation Mode Dispersion @ 1550nm Individual Fibre  |   |
|                        |   |   |

|                               |  |   |
|-------------------------------|--|---|
|                               | Cabled Fibre PMD for 90% of fibre in a cable<br>PMD Link Design Value  | $\leq 0.2$ ps/ $\sqrt{\text{km}}$<br>$\leq 0.3$ ps/ $\sqrt{\text{km}}$<br>$\leq 0.1$ ps/ $\sqrt{\text{km}}$ |
|                               | Cut-off Wavelength ( $\lambda_{cc}$ )  | $\leq 1550$ nm  |
|                               | Mode Field Diameter @ 1550nm   | $9.0 \pm 0.7$ $\mu\text{m}$   |
|                               | Macro Bending Loss @ 1550nm<br>(1 turn of fibre, $\Phi 32\text{mm}$ )<br>(100 turns of fibre, $\Phi 60\text{mm}$ ) | $< 0.5\text{dB}$<br>$< 0.05\text{dB}$   |
| Dimensional Specifications    | Cladding Diameter  | $125 \pm 1$ $\mu\text{m}$   |
|                               | Core/Clad Concentricity Error  | $\leq 0.8$ $\mu\text{m}$  |
|                               | Cladding Non-Circularity   | $\leq 1.0\%$  |
|                               | Coating Diameter   | $235\text{--}225$ $\mu\text{m}$   |
|                               | Coating-Cladding Concentricity Error   | $10$ $\mu\text{m}$  |
|                               | Fibre Curl   | $\geq 4\text{m}$ radius of curvature  |
| Mechanical Specifications     | Proof Stress   | 1%  |
|                               | Strippability force to remove secondary coating of fibre   | $1.3 \leq F \leq 8.9$   |
|                               | Dynamic Tensile Strength<br>Unaged<br>Aged (Aged at $85^\circ\text{C}$ , 95% RH for 30 days)                       | $> 550$ Kpsi (3.8 GPa)<br>$> 440$ Kpsi (3.0 GPa)  |
|                               | Dynamic Fatigue Parameter  | $\geq 20$   |
|                               | Static Fatigue Parameter   | $\geq 20$   |
|                               |  |   |
| Environmental Characteristics | Temperature Dependence of Attenuation<br>(Induced attenuation at $-60^\circ\text{C}$ to $+85^\circ\text{C}$ )      | $\leq 0.05\text{dB/km}$ at 1550nm   |
|                               | Temperature Humidity Cycle (Induced attenuation at $-10^\circ\text{C}$ to $+85^\circ\text{C}$ , 95% RH)            | $\leq 0.05\text{dB/km}$ at 1550nm   |
|                               | Water Immersion (Induced attenuation at $23 \pm 2^\circ\text{C}$ )   | $\leq 0.05\text{dB/km}$ at 1550nm   |
|                               | Heat Aging (Induced attenuation at $+85 \pm 2^\circ\text{C}$ )   | $\leq 0.05\text{dB/km}$ at 1550nm   |

#### Dimension and Properties:

|          |                           |  |
|----------|---------------------------|--|
| Physical | Fibre Count (G.655)       | 48   |
|          | No of loose tube/filter   | 4/2  |
|          | Fibre number per tube     | 12   |
|          | Glass Composition<br>Core | Germania ( $\text{GeO}_2$ ) doped<br>Silica ( $\text{SiO}_2$ ) |
|          | Cladding                  | Silica ( $\text{SiO}_2$ )                                      |
|          | Primary Coating           | 2 layers of UC curable resin                                   |

#### Colour Code Scheme:

|              |      |        |       |       |       |       |     |       |        |        |      |      |
|--------------|------|--------|-------|-------|-------|-------|-----|-------|--------|--------|------|------|
| Fibre colour | Blue | Orange | Green | Brown | Slate | White | Red | Black | Yellow | Violet | Rose | Aqua |
| Tube Colour  | Blue | Orange | Green | Brown | /     | /     | /   | /     | /      | /      | /    | /    |

### 4.3. Test Requirements

Approved by various professional optical and communication product institution, MULTICOM also conducts various in-house testing. MULTICOM possess the technology to keep its fibre attenuation loss within Industry Standards.

The cable is in accordance with applicable standard of cable and requirement of customer. The following test items are carried out according to corresponding reference.

### 4.4. Routine tests of Optical fibre

|                                    |                |
|------------------------------------|----------------|
| Mode field diameter                | IEC 60793-1-45 |
| Mode field Core/clad concentricity | IEC 60793-1-20 |
| Cladding diameter                  | IEC 60793-1-20 |
| Cladding non-circularity           | IEC 60793-1-20 |
| Attenuation coefficient            | IEC 60793-1-40 |
| Chromatic dispersion               | IEC 60793-1-42 |
| Cable cut-off wavelength           | IEC 60793-1-44 |

Test report for each shipment shall be submitted to the customer in the form of data sheet. Test report shall consist of product name, product code, ID number and the following measured values.

- i. Length
- ii. Attenuation at 1383 nm, 1550 nm, 1565 nm, and 1625 nm
- iii. Cladding Diameter
- iv. Core concentricity error
- v. Cladding non circularity
- vi. Coating Diameter



- vii. Chromatic Dispersion at 1530-1565 nm
- viii. Chromatic Dispersion at 1565-1625 nm
- ix. Zero dispersion slope
- x. Cut-off wavelength
- xi. Mode field diameter
- xii. Fibre Curl
- xiii. PMD at 1550 nm

## 4.5. Test List

### 4.5.1. Tension Loading Test

|                 |  |
|-----------------|--|
| Tension Loading | IEC 60794-1-2 E1   |
| Sample length   | No less than 50 meters   |
| Load            | Max. tension load  |
| Duration time   | 1 minute   |
| Test results    | Fibre strain: $\leq 0.60\%$<br>Additional attenuation: $\leq 0.1\text{dB}$<br>No damage to outer jacket and inner elements |

### 4.5.2. Crush/Compression Test

|               |   |
|---------------|---|
| Test Standard | IEC 60794-1-2 E3  |
| Load          | Crush load  |
| Duration time | 1 minute  |
| Test number   | 3   |
| Test results  | Additional attenuation: $\leq 0.05\text{dB}$ after test<br>No damage to outer jacket and inner elements |

### 4.5.3. Impact Resistance Test

|               |   |
|---------------|---|
| Test Standard | IEC 60794-1-2 E4  |
| Impact energy | 10J   |
| Radius        | 300mm   |
| Impact points | 3   |
| Impact number | 1   |
| Test result`  | Additional attenuation: $\leq 0.05\text{dB}$ after test<br>No damage to outer jacket and inner elements |

#### 4.5.4. Repeated Bending Test

|                |  |
|----------------|--|
| Test Standard  | IEC 60794-1-2 E6                             |
| Bending radius | 15 X diameter of cable                       |
| Cycles         | 25 cycles                                    |
| Test result    | No damage to outer jacket and inner elements |

#### 4.5.5. Torsion/Twist Test

|               |  |
|---------------|--|
| Test Standard | IEC 60794-1-2 E7                             |
| Sample length | 2m   |
| Angles        | ±180 degree                                  |
| cycles        | 5  |
| Test result   | No damage to outer jacket and inner elements |

#### 4.5.6. Bend Test

|                  |  |
|------------------|--|
| Test Standard    | IEC 60794-1-2 E11  |
| Mandrel diameter | 20 X diameter of cable   |
| Turn number      | 4  |
| Number of cycles | 3  |
| Test result      | Additional attenuation: ≤0.05dB after test<br>No damage to outer jacket and inner elements |

#### 4.5.7. Temperature cycling Test

|                    |   |
|--------------------|---|
| Test Standard      | IEC 60794-1-2 F1  |
| Temperature step   | +20°C → -60°C → +70°C → +20°C   |
| Time per each step | 12 hrs  |
| Cycles             | 2   |
| Test result        | Attenuation variation for reference value (the before test at +20±3°C) ≤ 0.15 dB/km and is reversible during last cycle |

#### 4.5.8. Water penetration Test

|                        |  |
|------------------------|--|
| Test Standard          | IEC 60794-1-2 F5                                 |
| Height of water column | 1m   |
| Sample length          | 3m   |
| Test time              | 24 hrs   |
| Test result            | No water leakage from the opposite of the sample |

#### **4.6. Installation of Underground Fibre Optic Cable**

The contractor shall submit his proposals for installation and test regimes to the Engineer for approval prior to fieldwork commencing.

## **5. INSTALLATION OF 132KV UNDERGROUND CABLE SYSTEMS**

### **5.1. Scope of Works**

This specification details approved methods and practices for the installation of 132kV power cable systems where the complete cable route is part of the transmission line.

The supply and services to be performed by the Contractor shall comprise the design, manufacture, testing, packing, transport, insurance, unloading, storage on Site, construction works and erection, corrosion protection, site testing, submission of documentation, commissioning, training of KETRACO's personnel and warranty of the works.

The Contractor is bound to provide complete works, even if the equipment or services to be provided are not specifically mentioned in the specification.

### **5.2. Site Coordination and Integration**

The Contractor shall be responsible for the selection of the route, method of installation and testing of the cables installed. The route(s) shall be co-ordinated with the other aspects of design to optimise the performance of the installation and minimise access limitations to facilitate maintenance and repair.

Where necessary, the Contractor shall carry out, at his own expense, moisture content, water table level, and soil thermal resistivity tests within the proposed site and such other tests as he may consider necessary, sufficiently in advance of the manufacture of any cable, to satisfy himself that the conditions on site and his proposed arrangement of cables and method of installation are such that the required current carrying capacity can be maintained.

All routes shall be defined precisely, and shown in drawings at an approved scale. The dates of installation of cable joints, cable drum serial numbers, name of jointers, shall be included in the "AS-BUILT" drawings. Cable section lengths shall also be given. All drawings shall be subject to KETRACO's approval.

During installation, when crossing other heat sources, or laying at depths deeper than 1.1m at the crossings or such similar conditions, the Contractor shall maintain the specified rating, either by application of the special stabilised backfill or by increasing the phase spacing. For every situation the arrangement with relevant calculations shall be submitted to KETRACO for approval, prior to installation.

Specific thermal resistance of 2.0Km/W shall be maintained even for completely dry backfilling material. This has to be confirmed before placing the backfill materials in the trench. The ground temperature at depth of laying as well as the thermal resistance of the backfilling material shall be controlled during the cable installation and shall form part of the installation procedure. The works or supply necessary to meet this requirement is deemed included in the Contract Price.

Where conditions require it, the use of a special backfill or other approved means to achieve cable rating shall be allowed. The costs of these measures are deemed to be included in the contract price.

## **5.3. Civil Works Criteria**

### **5.3.1. General**

The Contractor shall coordinate the cable civil works requirements with civil works required for the installation of other equipment, buildings and services to ensure technical and programme compatibility. The requirements of each of the installation methods listed above shall be considered and the installation design optimised from technical, availability and cost considerations.

In general, the following principles shall be followed

- The power and pilot cable of each circuit shall be laid in separate trenches, troughs or ducts. Two circuits in one trench shall be avoided as far as possible unless the circuit functions are inter-dependent in which case, subject to the approval of KETRACO, two segregated circuits may be installed in one (concrete) cable trench. The minimum separation between independent circuits shall be 1.5m.
- To prevent fire spreading across circuits, appropriate separating walls or barriers must be provided between circuits.
- Where cables leave / enter a different installation system (e.g. cable trough into cable basement or direct buried into a cable basement) the transition shall be made via sealed ducts and the impact of the ducts on cable rating shall be taken into account.

Concrete pits and tunnels/trenches at road crossing and area subject to traffic shall be designed for the maximum wheel load of 6T. (Maximum axle load of 12.5T). Actual road axle limit shall however be applied in case of a road with a higher axle load limit. All foundations and concrete surfaces at and below ground level are to be isolated from contact with soil.

The contractor shall make good any damage to the roads and other public utilities as a result of their works.

In case of cable running along a class B road, the cable location shall be within 2 metres of the edge of the road reserve marker posts.

In road reserves and similar areas generally likely to be used by other utilities infrastructure, the cable must not be directly buried. In case of space constraints in such areas, other formations other than the flat formation may be adopted.

### **5.3.2. Cable Laying Condition**

This specification prefers flat formation for cable laying. In road reserves, alternative formations may be adopted to accommodate the line within the two-meter corridor from the edge of the reserve. Physical separation between the circuits must be provided to avoid the

spread of fire to other circuits Nevertheless, the contractor must account for the various cable arrangements in the computation of power transfer capacity of the cable.

#### **5.3.2.1. For direct buried cables**

The cables shall normally be laid with the group or phase spacing 250mm in a flat formation but this may be increased where necessary to improve the thermal performance. The material surrounding the cable in its trench must not damage the cable surface and must be suitable for restraining the cable against any thermal expansion or traffic induced movements and, also must be suitable for thermal dissipation from the cable to its surrounding. Bedding material must be sufficiently dense to ensure that the value of thermal resistivity of cable environment should not exceed 2.0K.m/W even if dried out due to cable loading. The compaction of backfill to obtain a low thermal resistivity is usually carried out with vibrating plates and punners. The cables shall be laid on approximately 200mm of sand fill, which will be placed to form a bed for a cable. Upon completed laying of a cable it shall be covered with additional sand layer 200mm thick above the top of the uppermost cable.

The reinforced concrete slabs are to be used as mechanical protection over the cables. They shall be carefully centred over the cables, and each cover being closely interlocked with the adjacent covers along the entire length of cable.

The width of protective covers shall be enough to overlap cable circuits on both sides with 100mm at least. Cable slabs shall be covered with a 50mm layer of dune sand followed by 250mm of back fill over which LSOH warning tapes shall be laid. Semi-permeable membrane shall be provided where water table is found above the cable laying depth.

#### **5.3.2.2. For cables installed in surface troughs**

The cables shall be laid with the phase spacing 250mm. in a flat formation.

In the cable troughs, the material surrounding the cable must not damage the cable surface and must be suitable for restraining the cable against any thermal expansion or traffic induced movements and, also must be suitable for thermal dissipation from the cable to its surrounding. Bedding material must be sufficiently dense to ensure that the value of thermal resistivity of cable environment should not exceed 2.0Km/W even if dried out due to cable loading.

The reinforced concrete trough covers are to be used as mechanical protection over the cables. They shall be fully supported and located by the walls of the trough such that covers may not apply pressure to the filling material or cable due to the movement of traffic across them.

#### **5.3.2.3. For cables installed in air**

The cables shall be laid with the group or phase spacing 250mm. in a flat or vertical formation.

When cables are required to be installed in concrete troughs or cable tunnels all cables shall be supported on cable trays, racks, or in hangers supplied and installed under this contract as required by the cable system design. Cables laid on horizontal and vertical support arms shall be clamped and snaked in accordance with the cable manufacturer's recommendations. The supports shall be at regular intervals and adequate to withstand normal and short circuit forces confirmed by necessary calculations. Sufficient clearance between cable circuits shall be

provided to facilitate easy maintenance works, later. If a walkway is required to run along the cable installation a space of at least 750mm shall be allocated for this.

Cable troughs shall not be filled with sand. And sufficient natural ventilation shall be provided to meet the cooling requirements of the installation. Current carrying calculations for proposed cables in concrete troughs/trenches shall be provided for review and approval by KETRACO. Some trench covers may be of the heavy-duty type as required by local loading conditions. All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall be avoided as far as possible.

### **5.3.3. Installation Conditions**

#### **5.3.3.1. Direct buried cables**

Maximum thermal resistivity of ground                      2.0Km/W

In the calculation of current rating, the soil has been assumed to have constant thermal resistivity of 2.0Km/W regardless of the heat input from the cables. The Contractor shall maintain this figure even in case of the moisture migration and completely dry soil.

The main factors determining thermal resistivity are: composition density, moisture content and degree of saturation, burial depth of cables and soil and cable surface temperature.

The Contractor shall check these factors prior to finalising the design of the cable installation, taking into account the overall design of the transmission line and other heat sources which may affect thermal performance or route selection.

#### **5.3.3.2. For cables installed in surface troughs**

Maximum thermal resistivity of ground                      2.0Km/W

In the calculation of current rating, the soil has been assumed to have constant thermal resistivity of 2.0Km/W regardless of the heat input from the cables. The Contractor shall maintain this figure even in case of the moisture migration and completely dry soil. The contractor shall demonstrate by calculation that the thermal performance of the installation meets the requirements of the circuit, taking into account all credible operating conditions.

#### **5.3.3.3. For cables installed in air**

The thermal conditions are assumed as follows:

Maximum temperature of ambient air:                      35°C.

The contractor shall demonstrate by calculation that the thermal performance of the installation meets the requirements of the circuit, taking into account all credible operating conditions. Forced ventilation shall not be used to achieve the thermal performance required but means to enhance natural ventilation process may be incorporated.

### **5.3.4. Termination Supporting Structure**

Supporting structures for all cable terminations shall be provided as part of this Contract. They shall be of an approved design and construction.

All steelwork shall be galvanised.

Foundation bolts and plates or steel stubs shall be provided and shall be firmly keyed and grouted into foundation blocks. Complete details of the structures with dimensions and loading shall be provided to enable the foundation design to be checked. Responsibility for final grounding and levelling of the structures and co-operation with the other Contractors shall form part of this Contract.

### **5.3.5. Supporting Steelwork and Cleats**

All cable supporting steelwork for the cables in the concrete trenches or basement shall be provided under this Contract. Supports and other materials supplied and installed by the Contractor shall carry and hold the cables in a neat and orderly manner so as to prevent undue sagging of any of the cables. They shall withstand mechanical stresses during short circuits, switching and maintenance personnel climbing such structures. The design shall ensure that there are no circulating currents.

The Contractor shall pay special attention to the supporting and fixing any cable crossing other cables, pipes, and ducts or building expansion joints, when preparing these proposals.

Cable supports, cleats and clamps shall be made of material compatible with the cable outer sheath and shall be of the stand-off type shaped to suit the size of cable and not to cause undue distortion of the outer cable sheath. Cleats used for single core AC cables shall be of non-magnetic materials and be arranged in such a manner as to avoid setting up of magnetic circuits through steelworks, which may affect the intended capacity of the cable. Trefoil cleats shall be used as required by the cable system design.

The design of claw type cleats shall be such that they grip the cable sheath firmly but cannot be tightened to such an extent that the sheath is marked or damaged. A range of sizes shall be available to suit all cable sizes required under the Contract.

When the cable routes inside the basement have been agreed the Contractor should prepare and submit for approval drawings showing his proposals for the supporting and fixing of the cables. The erection of the supports and cleats shall not proceed until the proposals have been approved.

Cables shall be cleated over the whole of the appropriate section of their length before jointing at either end commences. Cables shall not be subject to undue strain or bending during the process of laying on supports. The maximum spacing of supports for all cables shall be confirmed by calculation of the mechanical stresses.

Where cables rise from the ground level to sealing ends adequate protection shall be provided against possible mechanical damage to the cables and against solar radiation if applicable. All cables supports, trays or racks shall be galvanized and shall be constructed or installed to



exclude any possibility of electrolytic action between the supports and cable sheath, and shall be adequately earthed.

### **5.3.6. Installation Requirements**

#### **5.3.6.1. General**

The arrangement of cables and all methods of laying and installation, including any special methods, which may be necessary, shall be subject to approval of KETRACO and the third party agencies whose property will be traversed.

The cables may be laid directly in the ground, installed in cable trenches, shafts, pipes, ducts, in concrete troughs or on racks in air in accordance with the route requirements and approved installation practices.

Adjacent to terminations and joints the cables shall be laid in a loop or snaked in the ground in order to provide approximately 3 metres spare length on each side to facilitate re-termination and re-jointing at a later date, if necessary.

The Contractor shall ascertain from the cable manufacturer, the limitations of the Low Smoke Zero Halogen (LSOH) over-sheath with respect to exposure to sunlight and the maximum temperature for cable laying governed by the tensile strength of the over-sheath at high ambient temperatures. Any damage to cable sheathing during installation must be reported to KETRACO in writing and approval of the method of repair must be obtained. The position of the damage must be accurately recorded prior to commencement of repair. Only repairs to damage to outer LSOH sheath of the cable shall be considered.

The depth of laying for direct buried cables from the surface of the ground to the top of the cable shall not be less than 1.1 m. It shall be measured from the ground level to the upper surface of the top most cable. This depth may be increased in selected parts of the route or locally to avoid other service installations.

Unless it has been agreed that the construction of cables is such as to permit laying at sub-zero temperatures, cable laying shall take place only when the ambient temperature is above 0°C and has been at this temperature for at least 24 hours, and approved special precautions have been taken to keep the cable above this temperature to avoid risk of damage during handling.

All cables shall be installed with a bending radius not less than that recommended by the cable manufacturer. All combustible outer coverings of cables installed within buildings shall be protected against the spread of fire in an approved manner. Cables passing through floors shall be installed in the manner specified and where required shall be sealed using fire resisting material to minimise the risk of spreading fire.

All cable specified in the Schedules under this Contract shall be installed in an approved manner. Pilot cables shall be installed in the same trench as power cables.

#### **5.3.6.2. Provision of Labour and Skilled Supervision**

The Contractor shall be responsible for providing all labour and skilled supervisors for handling equipment, and laying cable in accordance with this Specification.

The Contractor shall also provide the necessary trained staff and tools for terminating and jointing all cables supplied and laid under this Contract.

#### **5.3.6.3. Responsibility**

The Contractor shall be responsible for all Site Works associated with the Contract Works, installation and termination of all cables in accordance with this Specification.

#### **5.3.7. Method of Cable Laying**

The procedure of cable laying shall be subject to KETRACO's approval.

Unless instructed to the contrary by KETRACO, the Contractor shall lay cables direct in the ground in the following manner:

The material surrounding the cables, between trench floor, walls and cable tiles, shall be at least, 150mm of approved material, free of stones or any other material likely to damage or penetrate the cable outer sheath. It may be necessary to use an approved semi-permeable membrane to avoid migration of the fill under wet conditions.

The backfill in the remainder of the trench shall be adequate to meet the required thermal resistivity value as specified. A high degree of compaction is required, sufficient to restore and maintain thermal resistivity levels equal or better than undisturbed ground. At the direction of KETRACO, the Contractor shall remove any material, which is considered harmful, and replace it with an approved backfilling material. If the thermal resistivity of this material can rise above 2.0Km/W, the Contractor shall provide calculations to ensure that effective external thermal resistivity shall remain below the specified value under all operating conditions.

The results of all tests shall be logged and shown on as-laid records of the route.

After any cable has been laid and until the whole length of the cables to be laid in the trenches have been covered with protective covers, no sharp metal tools such as spades or fencing stakes shall be used in the trench or placed in such a position that they may fall into the trench. The protective covers shall consist of interlocked slabs of the hydraulically pressed concrete or other approved material of approved dimension and of ample width to protect the cables.

If more than one cover is require to cover a group of cables, the width for the covers shall be such that the longitudinal joint between adjacent covers shall be placed above the space between the groups of cables and not immediately above a cable. The position of cables or groups of cables in a trench shall be staked out once the cable has been laid so that covers may be placed in the correct position when the top layer of riddled soil or dune sand has been applied. The width of the cover or covers shall be such that there is a minimum 100mm overlap on each outside edge of the cable or group of cables.

A provisional sheath test shall be carried out for every section before backfilling over the cable tile.

Where, in the opinion of KETRACO, the soil on Site is unsuitable for riddling or back-filling, the Contractor shall arrange for the importation of suitable material (at Contractor's own expense), which shall be subject to approval of KETRACO.

The Contractor shall take all reasonable steps to ascertain where the cables and associated corrodible materials may be subjected to chemical or electrolytic action and shall submit his recommendations for special precautions to the Company for his approval.

Where auxiliary cables are laid under the same covers as power cables, there shall be at least 75mm of riddled earth between the two types of cables.

The position of the cables and joints shall be recorded on the route plans. The route shall be identified by means of a grid with at least two reference points for each length of straight cable run.

The distance between the centres of power cables and power cable circuits shall be in accordance with the cable manufacturer's specification and recommendation and the installation Contractor, if different from the cable manufacturer, shall be responsible for obtaining the correct spacing parameters from the cable manufacturer and details of installation limitations from KETRACO to ensure the cables operate at the pre-determined operation temperatures when installed.

The installation Contractor shall be responsible for obtaining values of the minimum bending radii for all cables covered by the Contract Works from the cable manufacturer prior to the commencement of installation.

Rollers used during the installation of the cables shall have no sharp projecting metal parts liable to damage the cable. All cables on vertical runs or horizontal runs in the vertical plane shall be cleated.

The Contractor shall provide all necessary pulling tools and equipment such as jacks, shafts, rollers, self-driven rollers, pulling cords, etc. including any required power for this equipment. The procedure for unwinding and pulling the cables shall be approved by KETRACO. Pulling by use of stockings is not allowed.

The Contractor shall strictly conform to the prescriptions given by KETRACO for all handling of cables and their accessories. The Contractor shall have as many men as necessary for all pulling and supervising operations to be carried out according to the best procedure. The number of men shall be stated in the cable laying procedure and approved by KETRACO.

The Contractor shall be solely responsible for any damage due to the carelessness of his staff or workmen. Any cable length so damaged shall be rejected as destroyed.

Mechanical pull with a winch solely from one end will be allowed only in special cases due to increased fragility of the cables. The self-driven cable rollers shall be used for installation of power cables.

Extra snaking 3m length at termination and joints location shall be provided.

The Contractor shall allow for installation of permanent thermocouples for sheath temperature test in his contract price. At least one set of permanent thermocouples shall be installed at every 3000m. The locations, number and arrangement of testing (the number of thermocouples at each location shall be at least seven) shall be submitted to KETRACO for review and approval, prior to installation

#### **5.3.7.1. Excavation of Trenches**

The exact location of each trench shall be approved on Site. Trenches shall be kept as tight as possible and each trench shall be excavated to the approved formation and dimensions and shall have vertical sides which shall be timbered or otherwise secured where necessary so as to avoid subsidence and damage to all walls, roads, sewers, drains, pipes, cables and other structures. Timber and other material for this purpose shall be supplied by the Contractor.

The depth of all excavations for trenches shall be measured from the surface of the ground and the width of the trench shall be measured between the vertical sides of the trench or between the inside faces of the sheeting (if any). The bottom of each trench shall be firm and of smooth contour. The Contractor shall take reasonable precautions to prevent damage or ground surface from a slip or breaking away of the sides of the trench.

Where trenches pass from a footway to a roadway or at other positions where a change of level is necessary, the bottom of the trench shall rise or fall gradually. The rate of rise or fall shall be approved by KETRACO.

It is the Contractor's responsibility to ensure that he is acquainted with the nature of the ground conditions prevailing along the cable route and the installation rates of the cables to be quoted in the Schedules shall include for any and all types of excavation and backfill on the "as found" basis.

The Contractor shall deal with and dispose of water to prevent any risk of cables and other materials to be laid in the trenches being adversely affected. He shall provide all pumps and appliances require and shall carry out necessary pumping and baling.

When the excavation for trenches has been accurately executed, the relevant notice shall be given by the Contractor to KETRACO. Laying of cables shall not be started until the Contractor has obtained KETRACO's approval to proceed with the work.

For trenches in areas accessible to the public, the contractor must prevent unauthorised access for safety. Additionally, for trenches along roads, no open trenches shall be left overnight. No material stacks shall be left overnight. The contractor take all measures to ensure the safety of pedestrians and other road users.

The Contractor shall satisfy himself that there are no other utilities' underground services within the along the cable route. In case of uncertainty the Contractor shall perform all hand excavations as required to locate existing of services within the limits of the cable route. The existing utilities and services referred to herein shall include, but shall not be limited to all sewers, water mains and lines, gas mains, electric (both power and lighting), telephone and such others as may be encountered under this Contract.

There shall not be any soil classification for excavating either in soft or in hard material. The Contractor is responsible for obtaining information he considers necessary regarding the possibility of encountering soil with varying degree of hardness, and allow for it in his tender.

The excavation of hard material, if any, shall be carried out by pneumatic tools. Blasting shall not be allowed under any circumstances.

All trenches shall be excavated with vertical sides to the width, lines, grades and depths as shown on the drawings or as specified in writing by KETRACO. All excavations shall be adequately supported and kept free from water from any source at the Contractor's expense and to the satisfaction of KETRACO.

Any over-excavation shall be backfilled with suitable fill material and completed in accordance with the specifications. Where directed by the Company such over excavations shall be backfilled with mass concrete at the Contractor's expense. The unsuitable or surplus excavated material shall be removed to an approval tip to be provided by the Contractor and at his expense.

The Contractor shall take all necessary security measures, such as signs, lights, supports etc. and generally comply with the recommendations and requirements of the Authorities in order to avoid accidents, landslides and other damages.

#### **5.3.7.2. Excavated Material**

The material excavated from each trench shall be placed so as to prevent nuisance or damage to adjacent hedges, trees, ditches, drains, gateways and other property, objects or things. Excavated material shall be stacked so as to avoid undue interference with traffic (animal, pedestrian, vehicle etc) . Where, owing to traffic or other considerations, this is not permissible; the excavated material shall be removed from the Site and returned for refilling the trench on completion of laying. Surplus materials shall be disposed of by and at the cost of the Contractor in accordance with the Conditions of Contract. Surplus material shall never be left on site for more than one week.

Excavated material shall be stacked at a minimum distance of 300mm from the edge of the trench to provide a walkway and eliminate risk of stones falling in the trench.

#### **5.3.7.3. Cables Drawn into Ducts and Pipes**

Cable ducts are required at all road crossing, regardless are they minor or major.

The Contractor shall provide the ducts and pipes. Pipes and ducts in building foundations shall be provided under a separate Contract. The Contractor shall remove any loose material from the ducts, and prove them by drawing through a mandrel of slightly less diameter than the duct, immediately before pulling in the cables. A suitable draw line shall be used to facilitate cable pulling. If the pipe or ducts form a tortuous path with friction a suitable lubrication may be used to ease the stress on the cables when pulled. Any lubricant used shall have no detrimental effect on the cables.

The Contractor shall reapply graphite coating if it is scraped off while pulling or after the application of a lubricant. Where specified by KETRACO, two split pipes shall be fitted around the cable. The splits shall be positioned on opposite sides of the cable after its installation.

All ducts or pipes, whether in use for cables or not, shall be sealed against entry of water, oil and vermin with a suitable semi-plastic compound supplied and installed by the Contractor after the approval of KETRACO. Cable ducts on the existing road shall be extended 500mm beyond verge.

All ducts, floor bushings etc. shall be completely filled and sealed at either end. The filling material shall be bentonite mixture with addition of a small quantity of cement to stabilise the gel and sand to improve load bearing. The material shall be pumped into suitably prepared ducts with a cement pump and must be able of being removed by the application of high-pressure water jets. The content of bentonite mix shall be subject to KETRACO's approval. It is preferable that cable ducts are not longer than 12m, but the maximum allowed length is 30m.

When the cable route is such that changes in direction of pipes do not facilitate a continuous pipe or where a pipe is too long to allow a continuous cable run, facilities shall be made for cable draw pits in which the cables shall be supported and routed in accordance with these Specifications.

#### **5.3.7.4. Cables Installed in Concrete Troughs and Tunnels**

When cables are required to be installed in concrete troughs or cable tunnels all cables shall be supported on cable trays, racks, or in hangers supplied and installed under this contract as required by the cable system design. Cables laid on horizontal and vertical support arms shall be clamped and snaked in accordance with the cable manufacturer's recommendations. The supports shall be at regular intervals and adequate to withstand normal and short circuit forces confirmed by necessary calculations. Sufficient clearance between cable circuits shall be provided to facilitate easy maintenance works, later. If a walkway is required to run along the cable installation a space of at least 750mm shall be allocated for this.

Cable troughs shall not be filled with sand. Current carrying calculations for proposed cables in concrete troughs/trenches shall be provided for review and approval by KETRACO. Some trench covers may be of the heavy-duty type as required by local loading conditions.

All cables shall be run in a neat and orderly manner and the crossing of cables within the trench shall be avoided as far as possible.

#### **5.3.7.5. Concrete Structures**

Concrete structures for joint-pits etc. shall be provided under this Contract and the Grade of concrete shall be SRC 25. All foundations and concrete surfaces at and below ground level are to be isolated from contact with soil.

Cover slabs for joint-bays and draws-pits and the joint-bays and draw-pits themselves shall be designed for a 36 tonne truck to pass over it and axle load of 12.5 tonnes. The point load under such a condition shall be indicated accordingly.

#### **5.3.7.6. Guards**

Where cables are exposed to mechanical damage, sheet steel guards shall be provided to protect them. Detailed drawings of all cable guards shall be approved by KETRACO before fabrication has commenced.

#### **5.3.7.7. Sealing of Holes in Floors and Walls**

Where holes and slots have been made through floors and walls for the installation of cables and cable trays, the Contractor shall arrange to seal these holes and slots when the total number of cables to pass through any slot or hole has been installed.

The seal shall prevent access of vermin and shall not permit the passage of air or gas through the hole when sealed. The material used for sealing shall not be magnetic or detrimental to either cable sheaths or conductors, and shall be fire resistant.

#### **5.3.7.8. Cable Markers and Records**

Cable markers and other approved means shall be provided to mark the position of each joint and shall also be used in approved positions to show the positions of all cables, pipes and ducts, particularly where they cross a road, or are laid along a road or where there is an abrupt deviation on the route, and such cable markers shall be erected as reinstatement is being carried out. At road crossings permanent markers shall be provided on both sides of the crossings in the event of damage to or removal of one of the markers.

The Contractor shall supply as soon as possible after installation two copies of the route plan showing the certified depth and position of all buried cables including these laid to the specified instructions of KETRACO. An up-to date copy must be available at Site at all times.

#### **5.3.7.9. Tests during Cable Laying**

Provisional sheath test shall be carried out for every section before backfilling over cable tile.

#### **5.3.7.10. Cable Routes**

The cable routes are part of the transmission line route and shall be selected to co-ordinate with the overall transmission line design. The proposed routes shall be shown on site layout drawings and submitted for approval before work is commenced

#### **5.3.7.11. Route Plan**

The Contractor shall also record on approved cross-section plans particulars of the depth of the trench, the arrangement of the cables, the positions of all obstructions beneath or above which the cables are laid and such other particulars as may be required. These plans shall be made as reproducible drawings of approved dimensions and shall be the property of KETRACO. They shall be submitted to KETRACO within one month of completion of each section of the Contract Works together with such prints as may be required.

#### **5.3.7.12. Cable Termination**

The Contractor is to terminate and connect up the cables in accordance with details provided by him and approved by KETRACO. Necessary sunshields shall be provided and installed for cables exposed to direct solar radiation.

The Contractor is to be responsible for the correct phase rotation and connections in accordance with information supplied by KETRACO. Particular care is to be taken in the case of those cables, where subsequent correction may be difficult. Phase tests will be carried out by the Contractor to the satisfaction of KETRACO. All equipment required to carry out these tests shall be provided under this Contract.

Where insulated glands are provided, the Contractor is to ensure that the insulation is maintained after jointing the cable, and shall demonstrate this to the satisfaction of KETRACO.

Cables shall be terminated under controlled environmental conditions preventing ingress of moisture and dust. The point of termination shall be covered with a weatherproof and dust proof cover with a slanting roof mounted on a fixed frame to give adequate working space both above and below sealing end base plate.

Adequate floor space shall be provided, at more than one level, to enable the cable to be clamped and plumbed, if applicable, below the sealing end base plate. The construction of the frame and cover shall be approved by KETRACO before all termination work commences. The humidity of the atmosphere shall be kept below the acceptable value stated in approved installation procedure.

The installation procedure must be continuous. Complete preparation of cleaning, plumbing of metallic sheaths and earth bonding may be carried out before termination work commences and the Contractor shall provide instruction manuals and drawings on Site so that KETRACO may follow the termination procedure in detail.

The Contractor shall ensure that only one team of jointers is assigned to one “Three phase termination” until it is completed to ensure that the termination is continuous without changing personnel.

Terminations shall be carried out in situ, and in no case shall be completed at ground level and lifted into final position.

Cable identification. Each end of a cable run shall be provided with labels for identification. The labels shall be lifted in a suitable position under the cable termination.

The material of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials, and to ensure permanent legibility.

### **5.3.8. As Built Drawings**

During the progress of the Work, the Contractor shall record, in approved schedule form and on a set of site plans at a sufficiently large scale (1:500) such particulars, which will allow an accurate reference to be made in case of any fault, or subsequent modification to the cable system. Cross sections are required whenever elevation changes. The schedule and the plans shall be prepared during the course of installation and shall be available for the Company’s inspection. On completion of the job, the schedule and plans shall be issued as “as-built” drawings.

It shall be noted that details regarding submission of Operation & Maintenance Manuals are covered in General Technical Requirements. Though the above document submissions for HV



Cables and accessories will be in accordance with the General Technical Requirements, these will be subject to review and approval by KETRACO.

### **5.3.9. Method Statement**

Before commencement of any site works the Contractor shall develop and submit for approval the Method Statement document comprising at least the following procedures and documents:

- a. Project and Site Organisation
- b. Programme of Works
- c. HSE Policy Document
- d. Local Transportation
- e. Installation Procedures for Each Piece of the Equipment
- f. Site Quality Plan, which, in brief, shall cover the following aspects:
  - All phases of the site works shall be clearly distinguished in their sequential order (e.g. route approval and detailed survey, soil investigation and excavation of the trial pits, trench excavation, cable pulling, jointing, sealing end erection, back-filling and compaction, test on completion, etc.)
  - Quality requirement and responsibilities for each phase shall be described in detail.
  - Conditions to commence the works on each phase shall be set out in the Commencement of Work Form (COW). Each COW Form shall be accompanied by the Applicable Document List (ADL) to confirm that all necessary documents are in order. COW shall be submitted for approval and works should not start before COW is signed by supervising body.
  - The Hold Points (HP) shall be identified, and the Contractor shall invite for inspection for each HP by Control Notification Form (CNF). CNF shall indicate date and time, location and item to be inspected and shall be send by fax at least 24 hours in advance. The respective inspection form signed by the Contractor and supervising body shall document each HP inspection.
- g. Final inspection of each phase shall be recorded in the separate form, which shall be then included in the Monthly Work Progress Statement as supporting document for the progress reported.
- h. List of proposed subcontractors for approval.

- i. List of the proposed materials for approval (e.g. concrete mixture, PVC ducts, and other small materials not defined in the tendering stage)

At every step during the progress of site works necessary approvals shall be obtained from KETRACO.



## **6. UNMANNED AERIAL VEHICLE (UAV)**

### **SPECIFICATIONS**

The UAV to be supplied shall be a multi-rotor device, fully customised for the proper inspection of High Voltage Transmission Lines (HVTL)

The UAV based fully automated route survey and HVTL inspection system shall be implemented as a human independent, on-board, embedded system. The system shall be able to handle local environmental challenges. In addition to this, the challenges that come with inspection should be incorporated in the system to enable the UAV competently inspect the line. The system should also have a user friendly human-machine interface.

The UAV system shall comprise the following major components;

- The UAV (drone).
- The camera system, which shall comprise two types of cameras; a 4K Color Camera and a Thermal Camera.
- Survey sensory and data collection equipment.

The system software should be able to handle the following major aspects of the UAV:

- Flight – This should enable for reliable flight control of the UAV in various climatic conditions to enable the proper completion of missions, while maintaining awareness and getting the best imaging.
- Mission – The UAV software should handle mission planning, mission operations and real time monitoring of mission by the ground crew.
- Awareness – The system should be able to monitor the UAV's situation and take over control in the event of unexpected critical conditions. This should put into consideration safe-fly zones and transient over voltages.
- Imaging – The system should have proper component recognition of various transmission line and substation components and tracking to assist undertake missions.

The UAV should be able to operate in three different modes:

- Manual mode; where the UAV is controlled by users from the ground.
- GPS Fixed location; where the UAV is flown in manual mode and attempts to maintain a particular GPS location and altitude.
- GPS Navigation; where the UAV autonomously flies following a specific GPS path defined by the user.

The UAV Ground Control Station (GCS) shall comprise two (2) iPad Pros (4<sup>th</sup> Generation) or equivalent, for control of the UAV. The system should also have a joystick control. These shall form part of the GCS system.

The UAV should be equipped with an obstacle detection and avoidance system.

A LIDAR system is to be incorporated with the UAV.

## **6.1. Camera Specifications**

The vision system shall comprise a 4K Color Camera and a Thermal Infrared Camera. The cameras shall generate blur free images. These images and videos shall be transmitted to the Ground Control Center from the UAV.

An algorithm shall be implemented that shall process these images so as to enable qualitative and quantitative inspection of the substation equipment and HVTL. A combination of the color and Thermal Infrared images shall be used during the analysis.

The Thermal range, Thermal sensitivity and Resolution should be appropriate for the analysis of high voltage transmission systems.

The cameras shall also be suitable for transmission line route survey.

## **6.2. Route Survey System**

The UAV shall also incorporate a route survey system that is capable of carrying out HVTL route monitoring. The system shall be able to rapidly provide high quality 3D data. The system shall also be able to operate autonomously without being manned.

The system should be able to carry out mobile mapping.

## **6.3. Training**

The supplier shall provide for training to the Employer's staff to enable the Employer to be able to fully operate and maintain the UAV. The number of staff to be trained shall be at least four (4).

The specific training for the UAV shall include but not be limited to;

- Flying, controlling and maneuvering the UAV
- Use, operation and maintenance of the various sensory devices
- Use, operation and maintenance of the cameras
- Use operation and maintenance of the UAV

The training can be held locally or in the supplier's location of choice. The training location shall be selected so as to ensure a maximum number of the Employer's staff gets access to the training.

## **6.4. Licensing**

In the event that the UAV system and any auxiliary systems such as the camera and sensors require licenses and licensed software to operate, the supplier shall provide for the various licenses to enable proper operation for a period of at least three (3) years, after the supply of the UAV to the Employer.

The supplier shall also ensure that the UAV meets all Kenya Civil Aviation Authority requirements, in addition to any other local directives on UAVs.

## **6.5. Spares**

The supplier shall recommend a spares holding for a two (2) year period following the hand over of the UAV to the client. The supplier shall also provide a cost breakdown for the spares. The Employer is not obliged to obtain the spares from the supplier.

The maintenance philosophy which will be adopted will generally be for fault-finding to card level and module replacement, with the faulty modules being either scrapped, if damaged beyond repair, or returned to the Supplier for repair, as appropriate. The Supplier shall operate a module repair and replacement scheme, details of which shall be provided, including turnaround times.

The supplier shall base the list of recommended spare parts on the above maintenance philosophy. In addition to this, the supplier shall also provide a list of the necessary spare parts required for routine maintenance.

This list shall be submitted as an optional price and shall include a cost breakdown. Prices for the supply of spares shall include all associated charges and shall remain valid for orders placed within the term of the Defects Liability Period. KETRACO shall be at liberty to order quantities of spare parts at variance with those listed by the Supplier. The prices shall remain valid for any such variation of quantities, unless stated otherwise.

The cost of spare parts shall not be used to calculate the cost of any variations to the Contract.

The spare parts recommended shall be identical functionally, electrically and mechanically, to the corresponding parts in the equipment supplied under the Contract and shall be suitably packed and clearly marked, ready for reception at KETRACO's stores. Any special handling instructions shall be clearly marked on the packages.

The recommended spares holding shall be quoted on a unit basis, as an option, for selection by KETRACO at any time up until the end of the Defects Liability Period.

The availability of spare parts to KETRACO, at a reasonable cost, shall be guaranteed by the Supplier as follows:

- The Supplier shall maintain an adequate stock of spare parts for a minimum period of ten years (or until the end of the equipment's specified life) after the product has been removed from quantity production, declared obsolete or officially removed from sale.
- Where a component, which is not under the Supplier's control, has become unavailable, it is the responsibility of the Supplier to offer a compatible alternative at reasonable cost.
- Design improvements or changes made to a product during its production run shall be carefully assessed such that component interchangeability shall not be affected.
- This requirement shall apply to equipment.

The supplier shall have local presence.

## **7. DETECTION/SURVEILLANCE SYSTEMS**

### **TECHNICAL SPECIFICATIONS**

#### **7.1. SUMMARY**

The contractor shall install a precision locating fiber optic sensor to detect third party interference (TPI) of the underground cable system. The system should also have a cut-immune deployment configuration whereby the system is still able to detect and locate in the event of a sensor cable cut. The system shall also include video-based smart vandalism detection.

The system should provide early detection of vandalism of the underground cable system and alert the employer via SCADA and the mobile phone. The system should however not produce nuisance alarms from non-vandalism activities near the cable. The system should combine video cameras, image sensors, vibration sensors, impact sensors and at least one other sensor.

The system should detect TPI such as hand and machine digging and presence of heavy vehicles. The system shall detect TPI events that threaten the integrity of the telecommunications cable such as fiber tapping or nearby manual digging, machine digging, or presence of heavy equipment. The system should also be able to accurately locate events even when there are multiple simultaneous events, even when there is environmental noise that is not localized to that area.

#### **7.2. STANDARDS**

The system shall comply with the following regulations:

- Federal Communications Commission: FCC CFR Part 15, Subpart B requirements for Class A devices
- Conformité Européenne (CE)

#### **7.3. MECHANICAL REQUIREMENTS**

##### **7.3.1. SENSOR CABLE**

The sensor cable shall have the option to be encased in an armor jacket, for use in areas that have a high potential of physical damage to the cable.

The sensor cable shall have a minimum bend radius no greater than 15 cm

When used in fence-mounted perimeter intrusion detection applications, the sensor cable shall be affixed to the facility's fence through the use of UV- resistant plastic or metal cable ties.

When used in fence-mounted perimeter intrusion detection applications, the sensor cable shall not require a cable conduit to be installed along the fence perimeter to protect the cable.



The sensor cable shall be able to include additional, unused fibers for use by other equipment (such as for data or video communications).

The sensor cable shall not require conductive elements.

The sensor cable shall be intrinsically safe within explosive atmospheres.

The sensor cable shall be completely immune to all forms of electromagnetic energy from radio communications, radar, electrical power transmission equipment and lightning.

The system shall be capable of being used with standard commercially-available fiber optic cable that meets the necessary attenuation and single-event loss requirements

### **7.3.2. SENSOR UNIT EQUIPMENT**

The system shall not require any active devices or processor modules to be installed outdoors.

All active components shall be rack-mountable in an indoor equipment room environment

The indoor system components shall be designed for a standard 19-inch wide rack.

The system shall provide the option for a slide-out monitor and keyboard that enables local console access to the system.

### **7.3.3. ENVIRONMENTAL REQUIREMENTS**

The sensor cables shall be able to operate in temperatures from  $-40^{\circ}\text{C}$  to  $70^{\circ}\text{C}$  and a relative humidity of 0 to 100% (condensing) without performance degradation.

The sensor unit components shall be designed for indoor use and meet the following requirements:

- Temperature:
  - Operating: 0 to  $50^{\circ}\text{C}$
  - Storage:  $-20$  to  $70^{\circ}\text{C}$
- Humidity:
  - Operating: 20% to 80% (relative, non-condensing)
  - Shipping and storage: 5% to 85% (relative, non-condensing)

## **7.4. RELIABILITY AND REDUNDANCY REQUIREMENTS**

### **7.4.1. Sensor cables:**

The sensor cables shall have a nominal service life of 20 years, excluding damage caused by non-environmental forces.

### **7.4.2. Sensor unit:**

The sensor unit modules shall have a predicted mean time between failures (MTBF) of greater than 87,000 hours.

System mass storage will be implemented with a minimum of two field-replaceable solid-state drives in a RAID1 configuration that are installed inside the sensor unit.

The sensor unit shall incorporate two redundant field-replaceable power supplies.

The sensor unit shall incorporate dual Gigabit Ethernet interfaces.

The sensor unit shall be capable of performing continuous self-diagnostic tests of the internal circuitry, software operation, and cable continuity and be capable of reporting any faults detected.

The sensor unit software shall be field-upgradeable.

## **7.5. ELECTRICAL REQUIREMENTS**

Each sensor unit shall meet the following electrical requirements:

- Input power: 100 to 240 VAC, 50/60 Hz
- Power consumption: Less than 200W
- Backup power: The sensor unit shall be capable of being powered from a third-party Uninterruptable Power Supply (UPS) or standby generator.

The system shall not require any outdoor power or grounding connections.

### **7.5.1. DETECTION CAPABILITY**

#### **7.5.1.1. UNDERGROUND POWER CABLE**

The sensor shall consist of fiber optic cable that is buried along the full length of underground power cable right-of-way to be protected.

The system shall provide two independent sensing channels.

The system shall be able to detect and locate TPI events over a cable distance of up to 100 km when the two sensing channels are used independently.

The system shall be able to detect and locate TPI events over a cable distance of up to 50 km when the system is deployed in the linear cut-immune configuration.

The sensor unit shall have the following detection capabilities:

- Process the signal from the sensor cable to detect TPI events
- Locate the position of a detected TPI event within 4.0 m or less at least 95% of the time.
- Detect multiple TPI events, when each TPI event is separated by a sensor cable distance greater than 30 m when deployed in the cut-immune configuration or 15 m when deployed in the non-cut immune configuration.
- Support up to 1440 virtual detection zones.
- Utilize adaptive algorithms in the detection process to optimally discriminate between actual TPI events and environmental activity.

Intrusion detection performance:

- The typical detection range for different TPI events shall be as given in the table below. It shall be recognized that actual performance will depend on specific site conditions and can increase or decrease considerably from these typical values.

| <b>TPI EVENT</b>                       | <b>TYPICAL DISTANCE FROM CABLE FOR DETECTION – FIRST 40 KM OF EACH SENSOR CHANNEL*</b> |
|--|--|
| Direct manipulation of the power cable | 0 m  |
| Light vehicle moving                   | 3 to 5 m   |
| Heavy vehicle moving                   | 10 to 20 m   |
| Heavy vehicle engine running           | 5 to 10 m  |
| Manual digging (pickaxe)               | 10 to 20 m   |
| Machine digging (backhoe)              | 10 to 30 m   |

\* At the maximum sensor length of 50 km the typical lateral detection distances are halved. These distances will be modified to fit the actual environment in which the cable is to be installed

- False alarm rate: The maximum rate for alarms generated by the internal electronic processes of the processors (cables excluded) shall be less than one per zone per year, averaged over the total number of zones in the system.
- Nuisance (environmental) alarms:
- The system when calibrated according to manufacturer's guidelines shall not suffer nuisance alarms from any of the following sources:

- Temperature changes
- Sunrise/sunset
- Acoustic or magnetic effects
- Fog
- The system shall utilize advanced processing and an environmental compensation algorithm to minimize the probability of nuisance alarms from the following sources:
- Wind
- Rain and hail
- Sandstorms
- Motion of nearby objects or vegetation
- Motion of surface or ground water
- Seismic vibration caused by nearby vehicular traffic
- The system shall provide a means to detect and reject alarms from vehicle traffic moving parallel to the sensor cable.

Time to detection:

- Detected TPI events shall be reported no later than one second after the detection conditions have been met.

### **7.5.2. UNDERGROUND FIBER OPTIC CABLE**

The sensor shall consist of fiber optic cable that is buried along the full length of underground fiberoptic cable right-of-way to be protected.

The system shall provide two independent sensing channels.

The system shall be able to detect and locate TPI events over a cable distance of up to 100 km when the two sensing channels are used independently.

The system shall be able to detect and locate TPI events over a cable distance of up to 50 km when the system is deployed in the linear cut-immune configuration.

The sensor unit shall have the following detection capabilities:

- Process the signal from the sensor cable to detect TPI events
- Locate the position of a detected TPI event within 4.0 m or less at least 95% of the time.

- Detect multiple TPI events, when each TPI event is separated by a sensor cable distance greater than 30 m when deployed in the cut-immune configuration or 15 m when deployed in the non-cut immune configuration.
- Support up to 1440 virtual detection zones.
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Intrusion detection performance:

- The typical detection range for different TPI events shall be as given in the table below. It shall be recognized that actual performance will depend on specific site conditions and can increase or decrease considerably from these typical values.

| <b>TPI EVENT</b>                             | <b>TYPICAL DISTANCE FROM CABLE FOR DETECTION – FIRST 40 KM OF EACH SENSOR CHANNEL*</b> |
|--|--|
| Direct manipulation of the fiber optic cable | 0 m  |
| Light vehicle moving                         | 3 to 5 m   |
| Heavy vehicle moving                         | 10 to 20 m   |
| Heavy vehicle engine running                 | 5 to 10 m  |
| Manual digging (pickaxe)                     | 10 to 20 m   |
| Machine digging (backhoe)                    | 10 to 30 m   |

\* At the maximum sensor length of 50 km the typical lateral detection distances are halved

- False alarm rate: The maximum rate for alarms generated by the internal electronic processes of the processors (cables excluded) shall be less than one per zone per year, averaged over the total number of zones in the system.
- Nuisance (environmental) alarms:
  - The system when calibrated according to manufacturer's guidelines shall not suffer nuisance alarms from any of the following sources:
    - Temperature changes
    - Sunrise/sunset
    - Acoustic or magnetic effects
    - Fog
  - The system shall utilize advanced processing and an environmental compensation algorithm to minimize the probability of nuisance alarms from the following sources:
    - Wind

- Rain and hail
- Sandstorms
- Motion of nearby objects or vegetation
- Motion of surface or ground water
- Seismic vibration caused by nearby vehicular traffic
- The system shall provide a means to detect and reject alarms from vehicle traffic moving parallel to the sensor cable.

Time to detection:

- Detected TPI events shall be reported no later than one second after the detection conditions have been met.

## **7.6. CABLE CUT RESPONSE**

The system shall support a closed-loop cut-immune configuration that enables the system's detection and locating capabilities to remain fully operational in the event of a sensor cable cut.

The system shall be capable of detecting and locating a sensor cable cut.

The cut location shall be determined and reported with an absolute accuracy of equal to or less than 30 m

In the event of a sensor cable cut, the system shall retain detection and locating capabilities in the portion(s) of the sensor cable that remain connected to the system sensor unit.

## **7.7. INSTALLATION AND CONFIGURATION CAPABILITIES**

The system shall have the following characteristics, as a minimum:

- The sensor cable shall be capable of being attached directly to a fence without needing to be in a conduit.
- The sensor cable shall be capable of being attached to the fence with standard UV-resistant cable ties (plastic or metal).

The system shall support the following configuration and calibration features:

- A Windows®-based graphical user interface (GUI)

- Configuration and calibration settings shall be capable of being stored in a computer file for record keeping purposes and available for reuse when configuring additional or replacement processors.

It shall be possible to access the configuration GUI remotely using Windows® Remote Desktop Connection.

The central system for monitoring and control of the cctv/detection cable systems shall be installed in the be in the Kenya Air Force control centre.

## **7.8. NETWORKING CAPABILITY**

The system shall provide a TCP/IP-based interface for communicating alarm and status data to and from security management systems.

The system supplier shall make available a complete Software Development Kit (SDK) to facilitate integration with third party systems such as video management systems, security management systems, or physical security information management systems.

The SDK shall consist of complete written documentation, sample code, and a software simulator that eliminates the need to have actual hardware to test the integration.

The sensors and I/O modules should be networked via a common, open architecture communications protocol using standard RS422 serial data interface. The network connections should be via fiber optic cable method.

The contractor should structure the network architecture in a configuration that provides the best address network size and alarm delivery requirements.

The detection sensors shall consist of fiber optic cables whereby the fibers will connect to a signal processing module. Any vibrations in the sensor cables will be lead to changes in reflected energy in the fibers. The signal processing module will analyze this to detect and locate the intrusion.

## **7.9. EVENT MANAGEMENT**

The system shall provide a local PC-based operator interface with graphical alarm annunciation at the sensor unit. The system shall also provide a mobile phone app interface and USSD and sms interphase for the employer.

The system shall provide access to the following information and functionality when in a local or networked configuration:

- A user-configurable image depicting the protected site with a schematic perimeter overlay
- Hardware monitoring and control

- Event detection and alarm generation (including flashing notification message, location marker, and audible alert)
- Basic alarm management
- Event and alarm logging
- Detection zone definition and configuration
- Adjustment of detection parameters

The system shall support the following alarm management functions:

- Maintain complete information on all alarms for 24 hours or until the alarm is cleared.
- Alarms shall be cleared by local or remote operator or automatically in 24 hours after alarm generation.
- Until cleared, the alarm information shall be compiled in a scrollable multi- column table.
- The maintained information shall include:
  - Unique alarm ID number
  - Time label
  - Event duration
  - Event status
  - Event strength
  - Event location
- The operator shall be able to:
  - Select any of the alarms from the list.
  - Enter text notes regarding the cause of the alarm and the mitigation measures.
  - Clear the alarm.
  - Operator notes as well as the alarm clearing event shall be recorded in the event log.
- Alarm location:
  - The system shall report the down-cable distance of the alarm location
  - It shall be possible to report the alarm location in either meters or feet
  - The system shall report the zone number within an alarm occurs



- It shall be possible to configure the system to report the latitude and longitude (GPS coordinate) of the alarm location
- Event logging:
- The system shall maintain and display an event log, including alarms, system notifications, and user actions.
- The logs shall be periodically saved to the hard drive.
- A new set of log files shall be generated every 24 hours at midnight

## **7.10. ACCESS CONTROL**

The system shall require the entry of a valid password at start-up and shutdown.

The system shall divide user access into three security levels:

- Operator level for routine operation
- Supervisor level for advanced system monitoring, configuration, and troubleshooting
- Installer level for advanced configuration and troubleshooting

## **7.11. SYSTEM CONTROLLERS**

A universal controller should manage all the sensors and I/O modules. The contractor should ensure that the control modules offered on this controller include a centralized local or remote multi-site management as well as a high level CCTV interface. Two SDK options should be made available for high level integration of the sensors into custom control applications.

The system controller assigns detection zones by auto discovering networked alarm inputs. This is to check whether the proper configuration has been done. Alarms may be reported by zone number, cable distance and/or GPS coordinates.

### **7.11.1. I/O MODULES**

An auxiliary input module should be provided to allow incorporation of auxiliary devices. A 16 port relay output should provide an interface to CCTV, alarm panels and other relays.

### **7.11.2. SOFTWARE**

The installation service software for this system should be easily configured to the sensors. The software should be easy to set up and calibrate using a laptop.

The device settings should be password protected and the password known only to authorized personnel. Once configuration has been done, the device settings should be locked down and any changes to be made can be done by unlocking the system with a password.

### **7.11.3. ZONE ASSIGNMENT**

Networked alarm inputs are to be associated with detection zones and multiple sensor technologies are to be assigned to a single zone to allow for flexibility.

### **7.11.4. MONITORING AND CONTROL SYSTEM**

The system should be real-time and Windows based. It should be able to monitor, display and control all the sensors as well as facilitate a high level interface to all the CCTV cameras, digital video recorders and monitors.

The system should feature hierarchical operation, multiple site control, multiple user workstations and remote system access via password protected TCP/IP protocol.

It should employ software that can allow for robust alarm handling and reporting capabilities, including definable user levels and access, programmable alarm and action scenarios, programmable CCTV tours, and comprehensive database log files.

The graphical user interface (GUI) of the system should be scalable and offer quick configure site plans. It should incorporate intuitive, high resolution 2D graphics, text acknowledgements and real time active icons indicate device location and status. It should be easy to navigate by use of customizable links to offer a more detailed view of the area being monitored around the underground cable.

As soon as an incident occurs, the operators should be notified and given event handling instructions that will appear on-screen. This is to be pre-programmed by system administrators.

To secure the networking workstations, ensure integrity of the database and maintain control of all the security equipment connected to the network, one or more of the workstations should be a backup master PC. This will be done through a migrating server format, so that when the master PC is disabled, another workstation can become a master PC immediately.

Devices controlled by the system should be linked together and set to trigger a series of events when one or more actions or alarms occurs. This will reduce the risk of human error. The system can be set up in a way that the cameras switch to a pre-programmed location and video is activated to capture an incident, and an alert is sent to security personnel when a certain alarm signal is received.

In the event that the sensor cable is cut, the system should immediately report the incident and its location. The sensor should still be able to detect and locate intrusions up until the point where it is cut. The system should remain fully operational after a single cable cut.

## **7.12. DOCUMENTS TO BE SUBMITTED**

As a minimum, the contractor shall provide:

- Site conditions report
- Configuration and calibration settings for the system after installation and calibration are complete
- All manufacturer supplied software required for the calibration and operation of the system
- Documentation providing system operation and maintenance procedures

## **7.13. QUALIFICATIONS**

The manufacturer of the system should have a minimum of five (5) years experience in the last ten (10) years of the manufacture and successful implementation of similar systems

## **7.14. EXECUTION**

### **7.14.1. Site Assessment**

Before installation begins, the installation contractor shall provide a report to the facility's owner documenting any site conditions that may prevent the system from operating satisfactorily. Examples of such conditions include loose fence fabric, loose gates, or objects such as signs or tree branches hitting the fence.

### **7.14.2. System Installation**

The system shall be installed in accordance with the manufacturer's recommended procedures as defined in the manufacturer's documentation for the system.

## **7.15. System Calibration**

The installation contractor shall calibrate the system in accordance with the manufacturer's recommended procedures as defined in the manufacturer's Product Guide.

The installation contractor shall submit to the owner the calibration and configuration settings for the system.

## **7.16. SPECIFICATIONS**

### **CCTV MATRIX**

**SYNECTICS:** PC232 Interface for X 2600 SERIES

**BBV:** TX1000, TX1500

**ERNITEC:** SYSTEM X (LON 1141, 114CX, 1141SX)

**BOSCH:** TC8000, 8500, 8600, 8700, 8800 ALLEGIANT

**VIDEO BLOX:** All ranges with Revision 3 protocols

**PELCO:** CM 6800/6700/9740

**COE:** TW 16PC, TLU 16PC TELECOMMAND

**MOLYNX:** TTX 309 (DCCON and TTX309 Interfaces) and PCCON  
**TECTON:** DRAX (Multiplexer)  
**DEDICATED MICROS:** BX2 (Multiplexer)  
**MEYERTECH:** ZONEVU-SDK (ZSC-250SDV) Interface  
**VICON:** All ranges from 2002  
**AMERICAN DYNAMICS:** AD1024 MEGAPOWER II CPU  
**BAXALL IP CAMERA:** GTN AP1 Protocol  
**LEDERER:** Various models  
**BAXALL:** ZTX80 TELEMETRY  
**MAXPRO:** MAX 1000  
**PANASONIC:** WJ-MPU955A, SX850 MATRIX with RT416 DVR, SX650  
**VIDEO MANAGEMENT SYSTEMS**  
**PELCO:** ENDURA  
**DVR**  
**NICE/FAST:** ALPHA BLUE and SILVER RANGE  
**ERNITEC:** 6000 SERIES DIGIOP  
**DVTEL:** LATITUDE SDK (Visual Basic)  
**PETARDS:** PI VISION SDK  
**PELCO:** DX8x00  
**SYAC:** DIGIEYE  
**AMERICAN DYNAMICS:** INTELLEX  
**VIGILANT:** ENTERPRISE ELITE  
**VISIMETRICS:** FASTAR and OCTAR  
**COVI TECHNOLOGIES:** COGNITIVE VIDEO DVR@4  
**GEUTEBRUCK:** MULTISCOPE II  
**BOSCH:** 700 SERIES

#### CODEC/IP CAMERAS

**COE:** X Class codec G2/3 full interface with Quad Video streaming, Audio and I/O  
**INDIGO VISION:** CONTROL CENTRE INTERFACE\* and Pelco Keyboard functionality  
**AXIS:** IP  
**BAXALL:** IP

#### MONITORING AND CONTROL SYSTEM

##### *System Requirements*

##### **PC Minimum Requirements:**

**Processor:** Pentium® / Celeron®, 2.8 GHz

**Operating System:** Windows® 2000, XP Professional, 7

**Memory:** 512 MB of Ram

**Hard Disk:** 40 GB Hard Drive

**CD-ROM Drive:** 16x or faster

**Video:** 64 MB graphics card (1024 x 728 min.) with video input

**Sound Card and Speaker**

**Ports:** 1 Serial, 1 Printer

**Monitor:** 17 in. or larger SVGA (XGA recommended)

**Ethernet Adapter:** 100 Mb network port

**PCI Slot:** (required)

##### *Hardware Options*

62A16055-A01

### **8-Port RS232 Serial Expansion Card**

Required for systems with two or more serial connections to hardware

*62A16056-A01*

### **4-Port Serial to Ethernet Rocket Hub**

Used for Migrating Server

*62A16058-A01*

### **Video Graphics Card for PC - NTSC Format**

(128 MB display memory)

*62A16059-A01*

### **Multi Input/Output Card**

Allows RS-485 communication with auxiliary security devices:  
(8) relay inputs, (4) relay outputs

*62A16060-A01*

### **Network Card for Multi Input/Output Card**

RS-232/RS-485 network controller for up to 32 MIO cards  
(Required for each network)

## **PROCESSOR**

The processor should provide electronic processing for up to two 200 m (656 ft) sensor cable sets for a total perimeter length of 400 m (1312 ft). It should be packaged in a black metal EMI/RFI housing which is installed in a weather-tight enclosure for outdoor use.

The processor should be able to communicate with all devices using RS422 serial data interface and use a System Controller for command and control.

**Size:** 337 H x 216 W x 102 D mm (13.25 H x 8.5 W x 4 D in)

**Weight:** 2.5 kg (5.5 lbs)

**Operating Temperature:** -40°C to +70°C (-40°F to +159°F)

**Power:** 10.5 to 60 VDC @ 11 Watts

**Current Draw:** 12v @ 925 mA, 24v @ 465 mA , 48v @ 245 mA

**Inputs:** 2 Cable Pairs (A and B), External Tamper Switch Input

**Ports:** RS232 (1), RS422 (2)

**Enclosure Options:** NEMA 4, NEMA 4X

## **INSTALLATION SERVICE TOOL**

The Installation service software should configure the processor with laptop convenience at each module via RS232 connection. To simplify setup and calibration, the sensor should have autodiscovery, as well as guided navigation and forward propagation. The configuration security should allow lockdown of device settings once changes have been approved. While the system is operational, remote adjustment should be enabled via TCP/IP connection.

## **7.17. TESTING**

Complete Factory and site testing shall be conducted in accordance with international standards

## **7.18. TRAINING**

The contractor shall provide for complete training on the calibration, extension, system maintenance procedures and trouble shooting of the system, as given in the manufacturer's product documentation

## **7.19. SPARES**

The contractor shall deliver to the employer spare system components. For each system component, spares consisting of at least one unit or 10% of the number shall comprise the system, whichever is greater, shall be provided.

## **7.20. WARRANTY**

The product shall be under warranty for a minimum of three years from the date of purchase. The supplier shall repair or make equivalent parts available for a minimum of 10 years from the date of purchase, based on when equipped is shipped to site.

## **8. Handheld Data Collector Specifications**

### **8.1. System**

The system for the handheld data collector shall be open software based, preferably Android based. It shall come with multi-lingual operational options, with the standard United Kingdom English as a mandatory option.

The device shall have a minimum six (6) inch display. It shall have a minimum of 4 GB RAM, 64 GB storage memory with an option of upgrading the memory. It shall have integrated speaker and microphone. It shall have front and back cameras with the ability to take High Definition (HD) images.

It shall also include the Google Mobile Services. The device must be suitable for outdoor all, water proof minimum (5 m), weather use with ultra-rugged design with a minimum grade MIL-STD-810G certification. The device shall have Real-time positioning with built-in GNSS receiver. The battery should be suitable for at least two full days continuous usage without recharge

### **8.2. Communication**

For communication purposes, the device shall have the following capabilities on the minimum:

- Integrated Cellular 4G data, text and voice
- Cellular: GSM (850/900/1800/1900), WCDMA (B1/B2/B5/B8), LTE-FDD (B1/B2/B3/B4/B5/B7/B8/B12/B13/B17/B20/B25/B28), LTE-TDD (B38/B39/B40/B41),
- TD-SCDMA (B34/B39)
- Wi-Fi IEEE 802.11 a/b/g/n/ac
- Bluetooth 4.1
- NanoSIM x 2
- USB 3.0 (Type-C)
- NFC

### **8.3. Standard Accessories**

The device shall be supplied with the following accessories

- Hand strap
- A/C charger
- USB cable
- Lanyard

## **8.4. Communication**

The contractor shall provide voice (1000 minutes) and data (30 GB) for each device. For a period of 36 months for the devices. This shall be from the Safaricom network or an equivalent network with similar or better coverage and reliability.

## **8.5. Licensing**

In the event that the device system and any auxiliary systems require licenses and licensed software to operate, the supplier shall provide for the various licenses to enable appropriate operation for a period of at least six (6) years, after the supply date of the devices to the Employer.

## **8.6. Training**

The supplier shall provide for training to the Employer's staff to enable the Employer to be able to fully operate the device. The number of staff to be trained shall be advised by the Employer.

The specific training for the UAV shall include but not be limited to;

- Operation and daily use of the devices
- Basic maintenance of the devices

The training can be held locally or in the supplier's location of choice. The training location shall be selected so as to ensure as many a number of the Employer's staff as the Employer states gets access to the training.

## **8.7. Spares**

- Replacement batteries (for 30% of the total number of units supplied)