General Description of the Project and Extent of Works (GTS-1)

KENYA - UGANDA INTERCONNECTION

400 kV DOUBLE CIRCUIT – LINE
(OPERAED INITIALLY AS A 220 kV OHTL)
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1.1 Introduction

The works covered by these technical specifications form part of the Kenya-Uganda Power Interconnection Project. This part of the project consists of design, manufacture, test, supply, erection and commissioning of the Kenya’s part of the proposed 400 kV interconnection transmission line from the existing Lessos substation in Kenya to the existing Tororo substation in Uganda.

1.2 Transmission Line Function

The Kenya-Uganda interconnection will be built as a 400 kV double circuit overhead transmission line. It will be initially operated at 220kV.

The purpose of the interconnection transmission line is for exporting a minimum of 20 MW from Uganda to Kenya at the commissioning date and up to 200 MW in 2030.

1.2.1 Transmission Line Located in Kenya

The interconnection transmission line Kenya-Uganda starts in Kenya from existing Lessos 220/132 kV substation and ends at the existing Tororo substation situated in Uganda near the Kenyan Border.

1.3 Statement of Works for Transmission Line

1.3.1 General

The purpose of this section is to specify basic conditions for the design, manufacture, test, and delivery to site of erection including port clearances and insurance from warehouse to site, civil construction, erection, commissioning and guarantee of materials and the equipment including the substation civil works.

All material not expressly called for in these specifications, but necessary for the complete and proper installation and operation of the equipment and accessories shall be supplied by the Contractor at no additional cost to the Employer, even if not explicitly called for herein.

The work includes design, manufacture, test, delivery to site, civil works, erection, commissioning and guarantee and setting to work of the following but are not necessarily limited to the following:-

- Survey
- Line design
- Right-of-way clearance and access tracks
- Foundation works
- Grounding
- Erection of towers
- Stringing works
- Testing, final inspection and commissioning.

It is not the intention of these specifications to specify any design detail. It is left to the experience and practice of the Contractor, who shall furnish equipment, which shall meet, in all respects; the basic requirements as specified herein with regard to performance, durability and satisfactory operation.

Certain materials, features and design requirements are specified herein. Any deviations from these specific requirements must be listed on the “Schedule of Guaranteed Characteristics” and must be approved by the Employer in writing.

The work shall include furnishing of all drawings and other information required herein including operation and maintenance manuals and design calculations. General, detailed and shop drawings and design calculations
are required, complete with parts lists, of all equipment and “As - Built” drawings of all plants and equipment installed.

The Contractor should have his own erection materials and testing/commissioning instruments, i.e. the Employer will not provide any material or equipment for the work.

1.3.2 Demarcation Points of the Contract

The conductors and OPGW shall be terminated to the relevant gantries by the Contractor. Switchyard gantries at Lessos substation and the 1st tower in Uganda after the Kenya-Uganda border are the demarcation points for the features provided under this Contract.

Demarcation point at the Lessos substation shall be as follows (see drawing No. 0522011-TLUK-011, Contract Demarcation Points):

- The plates where line conductors and OPGW are to be terminated at the gantry structure and required gantries shall not be included in this Contract.
- The dead-end insulator sets and OPGW sets in transmission line side at the gantry structure shall be included in this Contract.
- T-branch sleeve and jumper conductor, to connect line conductor and line trap and/or CVT, shall not be included in this Contract.
- The connectors of line trap and/or CVT for the jumper conductor shall not be included in this Contract.
- The branch sleeve and the conductor for connection between jumper conductor and lightning arrester shall not be included in this Contract.
- The termination of OPGW at the gantry structure, including delivery of termination boxes and the required installation/termination works, shall be included in this Contract.

For demarcation point at the Kenya-Uganda border, refer to Scope of Supply – TS-1, clause 1.3 for details.

1.4 Drawings

The following drawings form an integral part of this Specification:

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Drawings for the implementation of the line at 220kV for which there is no equivalent in the table above for the 400kV line shall be applicable as well for the implementation of the line at 400kV.
Scope of Supply (TS-1)

KENYA - UGANDA INTERCONNECTION

400 kV DOUBLE CIRCUIT – LINE
(OPERATED INITIALLY AS A 220 kV OHTL)
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1 Scope of Supply

1.1 General

The scope of supply listed in this Section (TS-1) of the Bidding Document shall include all equipment and material required to ensure satisfactory operation of the interconnection transmission line. All materials, parts and devices that are essential or necessary for the proper functioning of the complete installation shall be supplied, even if not explicitly called for.

The detailed requirements specified elsewhere in Section VI – Employer’s Requirements are equally applicable to all equipment specified in this Section – TS-1 “Scope of Supply”, particularly these found in the General Technical Requirements (Section GTS-3) and in the Schedule of Rates and Prices.

Before starting the design work, the Contractor shall visit the interconnection transmission line sites named under this contract to obtain all necessary information, drawings and documents for interfacing and modification works. The cost of site visit shall be at the Contractor’s own expense.

1.2 Extent of Work

The contract Works shall comprise of the design, manufacture, inspection, factory testing, packing, transport, insurance, delivery to and off-loading at site, storage, installation and erection, start-up field tests and related work, commissioning, training of KETRACO personnel, warranty and maintenance of the Lessos - Uganda border 400 kV double circuit transmission line, including all temporary works. Supplementary requirements for the various line components are contained in the appurtenant sections of the Specifications.

The major works to be carried out by the Contractor are:

- A new 400 kV double circuit transmission line shall be constructed by the Contractor. The function of this transmission line as part of Uganda-Kenya Power Interconnection Project will be to transmit power from the Tororo substation in Uganda to Lessos substation and deliver power to the existing Kenyan grid.

- The major works to be carried out by the Contractor are 127 km long, 400 kV, three-phase, double circuit overhead transmission line from the existing Lessos substation to the Ugandan border. The portion of the line in Uganda, up to Tororo substation will be built under a separate contract.

The works shall be complete with survey, route clearance, line conductors, earth conductors, insulators and fittings, towers and foundations, earthing and connections, and spare parts and special tools. Estimated quantities stated under the Schedules of Prices are for bid purposes only; final payment shall be made on the basis of quantities as finally erected and confirmed by measurement.

It is intended that the two circuits will be initially operated at 220kV on a temporary basis. Consequently a temporary connection to the 220kV switchyard at Lessos substation is required.

In order to minimize power interruption during interconnection works, the Contractor is required to develop construction methodology, shutdown sequences, shut down schedules and obtain approval from the Employer. The Contractor is required to study the transmission system and familiarize himself thoroughly with the operation system of the Employer for above-mentioned works. The Employer will assist the Contractor in obtaining necessary information and permission.

It is not the Employer’s intent to specify all technical requirements, nor 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 industrial standards.

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

The whole of the Works shall be designed to ensure continuity of service under all working conditions and to facilitate inspection, cleaning and repairs. All reasonable precautions shall be taken in the design of equipment and of the Works, to ensure the safety of personnel concerned with the operation and maintenance of the Works, and of the public.

All workmanship shall be of the highest class throughout and the design dimensions and materials of all parts shall be such that the stresses, which they are subjected to, shall not render them liable to distortion or damage under the most severe conditions encountered in service.

The detailed design shall be such as to facilitate inspection, cleaning and repairs and simplicity of operation and maintenance. All apparatus shall be designed to ensure satisfactory operation under the atmospheric conditions prevailing in the areas where the line is to be built and under such variations of load and voltage as may occur under the working conditions of the system. The design of all line supports, conductors, insulators and fittings shall be such as to minimize the risk of damage in service of any part of the lines.

Corresponding parts of equipment liable to renewal shall be fully interchangeable and the Contractor will be required to demonstrate this feature to the Employer's satisfaction.

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 Bid. The Contractor shall add a statement that no other exceptions are taken to this Specification.

1.3 Contract Demarcation Points

Terminal point at Lessos substation

The downlead connections of conductors and earthwires, from the 400kV terminal towers to the Lessos substation gantry structures including any jumpers or droppers required to connect to the substation equipment are included in this Specification.

OPGW earthwire downleads shall be terminated in a Terminal Joint Box to be mounted on the substation gantry. Connections from the junction boxes towards the substation are not included.

The line will be connected to the 220kV substation in the first instance. Provisions will be made during construction and design to facilitate any future diversion that may be required to connect the line to the future 400/220kV switchyard at Lessos substation.

A temporary connection shall be done since the 400/220kV Lessos substation will not exist by the time the transmission line is commissioned. The temporary connection shall start and end at the nearest angle point to the substation terminal gantry. The 400kV line shall then be energized on 220kV.

Terminal point at the Kenya-Uganda Border

The connections of conductors and earthwires, from the last 400kV tower in Kenyan territory to first tower in Uganda (the later will be supplied and erected under a separate contract) including any jumpers or droppers required to connect to the tower structure are included in this Specification.
OPGW earthwire downleads shall be terminated in a Joint Box to be mounted on the first tower in Uganda. Connections of all individual fibers within the junction box to the OPGW cable of the Uganda portion of the line are included.

The coordinates of the two towers at the border are (projection UTM 36N, datum Arc-1960):

- 632364.697mE 67946.000mN for the last tower in Kenya before the Uganda border
- 632233.975mE 68007.595mN for the first tower in Uganda after the Uganda border

The programme for work and work at each of the terminal points are required to be co-ordinated with others at no additional cost to KETRACO.

1.4 **Transmission Line Route**

Details of the general routing of the overhead line are provided as the precise location of all angle points and given on drawing No. 0522011-TLUK-037 with the Bid Document.

The line route described in this list of Angle Points is 30m off the centreline of the existing Lessos-Tororo, 132kV, double-circuit transmission line and it includes detours at Ikoli, Musaga, Sibembe, Kibachenje and Siera Schools reflecting constraints in the 60m wide wayleave corridor.

The altitude is relatively high along the line route. Elevation at each end is:

- Lessos substation: 2146m asl
- Kenya-Uganda border: 1115m asl

The average elevation for the entire line route is 1578m asl.

The line route provided is a conceptual one from which an estimate of the bill of quantities has been established. The Contractor is expected to carry out a detailed survey of the route and propose any modifications deemed necessary.

2 **Environmental Management**

The Contractor shall carry out all his works by adhering strictly to the Design, Construction and Maintenance Principles of the Environmental Management Plan, such as follows, but not being limited to:

2.1 **Alignment Survey and Design Stage**

- Avoid routing transmission line through protected areas, other environmentally sensitive areas or through mature forest stands;
- Avoid cultural and heritage sites;
- Site transmission line towers on high points of land such that conductors can be strung over valleys thereby eliminating the need to remove trees;
- Locate transmission line along base of mountain slopes, rather than down centre of valleys where heavy birds could come into contact with conductors;
- Locate transmission line to avoid running through villages; run lines behind villages;
- Consult villagers regarding location of valued village resources and locate transmission line to avoid these features;
g. Situate transmission line not far away from roads, but behind roadside forested areas so as to minimize visual intrusion;

h. Minimize the need to construct of new access tracks wherever possible;

i. Employment of existing access roads and tracks wherever available;

j. Ensure minimum clearance distances between conductors and ground, waterways, road crossings, buildings, communication systems etc. are incorporated into design.

2.2 Construction Stage

a. Limit right-of-way to 60 meter width;

b. Clear only narrow path to facilitate pulling the nylon rope between towers to string the conductors;

c. Strictly define right-of-way clearing activities in the contract specifications and environmental special provisions;

d. String conductors under tension to minimize potential damage to remaining ground vegetation;

e. Use existing access roads and tracks wherever available;

f. Decommission additional temporary access tracks at end of construction;

g. Where access is required across agriculture lands use temporary access paths during dry season involving placement of geotextile over which aggregates shall be placed;

h. Design and construct transmission line towers with staggered legs so as to eliminate the need to cut a level pad into slopes on which to construct the towers;

i. Minimize the need for access tracks whenever possible;

j. Construction to proceed in the dry season if possible to minimize soil erosion and mass wasting – where construction is required in the rainy season, potentially unstable slopes to be avoided;

k. Scaffoldings to be placed over roadways at locations conductors are being strung to ensure traffic flow is maintained and public safety is provided.

3 Requirements of Transmission Line

3.1 Conductors

3.1.1 General

The line conductors shall be All Aluminum Alloy conductor (AAAC) and shall comply with the requirements specified in this Specification, IEC 1597, ASTM B 399, NFC 34 120, BS 215 Part 1 and/or other approved standards.

3.1.2 Requirements

All wires making up the conductor shall be uniform and smooth and shall have no defects such as points, sharp edges, abrasions, or other imperfections that would tend to increase radio interference and corona loss. The conductor shall also be free of metal particles and dirt. The makeup and lay of the conductor strands shall be such that all conductors are free from the tendency to untwist or spring apart when cut.
Aluminium shall be of the highest purity commercially obtainable. Purity shall not be less than 99.5 per cent. The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made.

In all constructions the successive layers shall have opposite directions of lay, the outermost layer being right handed (z-stranding). The wires in each layer shall be evenly and closely stranded.

The conductor shall be FLINT (AAAC-37 wires). The conductor from British standard that would be close to the FLINT is the UPAS.

3.1.3 Conductor Drums (Reels)

The conductors shall be supplied on drums of approved construction; drums shall be securely battened to protect the conductor. Drum battens shall not be removed until the drum is properly mounted at the drum station on the line and battens shall be immediately refitted to the drum if any surplus conductor is left thereon.

The length and size of the conductor shall be marked on each drum together with the conductor manufacturing batch number.

3.1.4 Technical Characteristics and Guaranteed Values

The characteristics and guaranteed values shall be as stated in Annex 9 – Schedule of Guaranteed Characteristics.

3.1.5 Tests and Inspections

The inspection and testing shall be carried out on individual wires and stranded conductors in conformity with IEC 60209 and 61089.

The test specimens shall be taken from 2% of the reels for conductors. However, if reels are to be supplied in batches then at least 5 reels shall be tested from each batch. The test specimens of component wire before stranding shall be taken from 10% of individual lengths and shall be of a sufficient length so that required tests can be carried out.

3.1.6 Bid Drawings, Technical Particulars and Guarantees

3.1.6.1 Bid Drawings and Documents

The following documents shall be provided:

a. Quality assurance plans for inspections and type and sample tests to be performed.

3.1.6.2 Technical Particulars and Guarantees

All data stated and required in Schedules of Guaranteed Technical Particulars concerning the conductor shall be fulfilled rigorously.

3.1.7 Measurement for Payment

Payment for conductor shall be based on the length of the Transmission Line route, measured in horizontal plane, at the unit prices stated in the Schedule of Prices.

3.2 Ground Wires

3.2.1 Types of Ground Wires

The interconnection overhead transmission line shall be equipped with one steel ground wire (11 mm diameter, grade 1300) and one optical ground wire (OPGW 96).
The ground wires shall have the characteristics stated in Annex 9 and they shall comply with standards mentioned below or other approved international standards. The tests on the ground wire including individual wires shall be made according to BS 183.

All ground wire suspension and tension sets shall be attached to crossarms by means of shackles, links, straps or swivels depending on the fixing point of the tower.

The ground wires shall be bonded to the tower. The earth bond is not allowed to be tension loaded in any weather or load condition.

The material of earth bond shall be aluminium, stainless steel or galvanised steel and its conductance shall be at least equivalent to ground wires’ conductance.

3.2.2 Overhead Ground Wire

3.2.2.1 General

This Specification defines the requirements for the design, manufacture, supply, installation and commissioning of overhead galvanized steel ground wire (11 mm diameter, grade 1300). The Contractor shall include design, manufacture, supply, installation including all the necessary fittings and installation materials to complete the system.

3.2.2.2 Standards

IEC 60888  Zinc-Coated Steel Wires for Stranded Earth Wires
IEC 61089  Round wire Concentric Lay Overhead Electrical Stranded Earth Wires
IEC 61394  Overhead Lines – Characteristics of Greased Aluminium, Aluminium Alloy and Steel bare Conductors

3.2.2.3 Technical Characteristics and Guaranteed Values

The characteristics and guaranteed values shall be as stated in Annex 9.

3.2.2.4 Tests and Reports

All materials shall comply with test criteria, and the Employer acceptance of the ground wires and accessories shall not relieve the Contractor of his responsibility for meeting all requirements of this Specification.

The inspection and testing shall be carried out on individual wires and stranded ground wires in conformity with IEC 60209 and 61089. The Contractor shall submit proposed procedures for GSW tests to the Employer for approval.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the date of the tests to be witnessed forty five (45) days in advance.

Sample tests shall be witnessed by the Employer or his authorized representative unless waived in writing. No ground wires shall be shipped until released for shipment by the Employer. The Contractor shall furnish four certified copies of full reports of tests required under this Specification prior to shipment of the GSW.

The Contractor shall bear the cost of furnishing these records and reports.
3.2.3 Overhead Ground Wire with Optical Fibers (OPGW)

3.2.3.1 General

This Specification defines the requirements for the design, manufacture, supply, installation and commissioning of composite fibre optic overhead ground wire (OPGW). The Contractor shall include design, manufacture, supply, installation including all the necessary fittings and optical joint enclosures, optical terminal boxes, hood closures for OPGW, splicing, and installation materials to complete the system.

3.2.3.2 Standards

The materials covered under this Specification shall conform to the following standards except as noted:

- **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
- **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**  Definition and test methods for the relevant parameters of single-mode fibres
- **ITU-T G.655**  Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable

3.2.3.3 OPGW Characteristics

OPGW shall have the following main characteristics:

a. The optical fibres shall be of Non-Zero Dispersion-Shifted Single-Mode type and shall conform to IEC 61089, IEC 60793, IEC 60794 and ITU-T recommendation G.655 with transmission of information at all ITU-T recommended rates for PDH and SDH systems;

b. The fibres shall be suitable for operation at wavelengths of both 1550 nm and 1625 nm, with transmission of information at minimum data rates of 620 Mbit/s;

a. Minimum of 96 fibre cores,

b. Metal free optical fibre cable with loose tube construction,

c. Maximum optical attenuation shall be 0.25 dB/km for 1550 nm.

Each individual fibre shall be colour coded for identification purposes, with details of the colour-coding scheme adopted being provided in the Bid.
The fibre cables shall be able to withstand temperature cycling in the range 0°C to +60°C without changing the optical values during laying, installation, stocking and transportation.

The Bidder shall provide a drawing showing a cross-section of the OPGW cable indicating the dimensions of each element it contains. The drawing shall provide a clear illustration of the design and make-up of the cable. Technical descriptions detailing the fibre optic cable performance shall be provided in the Bid.

All necessary civil works and installation materials required to complete the fibre optic cable installation shall be included in the Contract.

Fibre optic cables shall have a design life of at least 40 years.

The Bidder shall show evidence that the manufacturer of OPGW has at least 3 years’ experience in supplying OPGW for a minimum of 1000 km, with similar basic construction to the type being offered.

The wires shall be of uniform circular section, smooth and free from surface imperfections. The diameter of the wires shall not vary more than 2 per cent from the standard figures stated in the Technical Characteristics Schedule. Aluminum clad steel wires shall be pre-formed so that they remain inert when the conductor is cut. The lay of the outer layer shall be right-hand. There shall be no joints in individual wires in a reel length unless specifically approved. The aluminum alloy tube surrounding the optical fibre cable may be cold formed with a longitudinal seam or be formed from segmental aluminum alloy wire strands.

The OPGW shall be capable of carrying a lightning stroke current and the associated power frequency fault current, which may from time to time occur, with negligible temporary effect on the attenuation of the optical cable and no permanent damage to the optical characteristics. The OPGW shall be capable of withstanding the short-circuit current test specified in the Technical Schedule.

3.2.3.4 Technical Characteristics and Guaranteed Values

The characteristics and guaranteed values shall be as stated in Annex 9.

3.2.3.5 Construction

The ninety six (96) fibres shall be single mode and stranded together in four units of 24, or eight units of 12. They shall be tight buffered for protection and colour coded for identification.

The spacer shall comprise of an aluminum rod containing four helical slots. One optical fibre unit of 24 fibres shall be placed in each of the four slots. An aluminum tube shall be formed tightly around the spacer. It shall be seamless and pressure tight.

The optical fibres shall be protected from water ingress by the application of a waterproof gel during manufacture.

The aluminum clad steel and aluminum alloy wires shall be stranded around the aluminum tube to provide the necessary strength and conductivity together with further mechanical protection to the fibres. The aluminum clad steel wires shall meet the requirements of IEC 61232 and shall have a minimum conductivity of 20% IACS. Aluminium alloy wires shall meet the requirements of IEC 60104.

3.2.3.6 Test and Reports

All materials shall comply with test criteria, and the Employer acceptance of the ground wires and accessories shall not relieve the Contractor of his responsibility for meeting all requirements of this Specification.
The inspection and testing shall be carried out on individual wires, fibres and stranded conductors in conformity with appropriate IEC standards. The Contractor shall submit proposed procedures for OPGW tests to the Employer for approval.

The Contractor shall make all preparation for tests and provide the test apparatus and personnel and shall notify the date of the tests to be witnessed forty five (45) days in advance.

Sample tests shall be witnessed by the Employer or his authorized representative unless waived in writing. No ground wires shall be shipped until released for shipment by the Employer. The Contractor shall furnish four certified copies of full reports of tests required under this Specification prior to shipment of the OPGW.

The Contractor shall bear the cost of furnishing these records and reports.

### 3.2.3.7 Technical Particulars and Guarantees

All data stated and required in Schedules of Guaranteed Technical Particulars concerning OPGW shall be fulfilled rigorously.

### 3.2.3.8 Measurement for Payment

Payment for OPGW shall be based on the length of the Transmission Line route, measured in horizontal plane, at the unit prices stated in the Schedule of Prices.

### 3.3 Insulators

#### 3.3.1 Insulator Types

The insulator strings/sets shall be cap and pin glass type.

##### 3.3.1.1 General Requirements

1. **General**

   The insulators shall be made of good commercial grade toughened glass, and the characteristics of all aspects shall be equal or better than that of porcelain insulator.

   The entire surface of the glass insulators shall be relatively free from imperfection.

   Metal parts, except for split pins, shall be made of a good commercial grade of malleable iron, ductile iron, steel or aluminium. Ferrous parts, other than stainless steel, shall be galvanized in accordance with BS 729 or equivalent standard. Split pins shall be made of authentic stainless steel.

   The minimum factor of safety shall be 2.5 for complete insulator strings/sets and fittings based on the minimum breaking load of insulator unit.

2. **Identification of the Insulator**

   Each insulator unit shall bear symbol identifying the manufacturer and giving the year of manufacture and the tension-proof test load in kN identified by the word "TEST".

   The markings shall be legible and durable.

##### 3.3.1.2 Special Requirements

The insulators shall be standard type and made of high quality toughened glass and shall comply in all aspects with IEC publications 60120, 60305, 60372, 60383 and 60575.
The insulators shall be made of the highest grade, dense, homogeneous toughened glass completely to produce uniform mechanical and electrical strength and long life in service.

The ball and socket shall be hot dipped galvanized, and shall have no defects such as rusts, strains, cracks, etc., and they shall be designed so correctly as to be mutually jointed and facilitate easy assembly and disassembly.

The insulator studs or pins shall be made of forged steel free from cracks and air holes, with zinc sleeve. The material of zinc sleeve shall be pure zinc of high quality. Total fused area of the interface should be more than 80 % of the total area of the interface between zinc sleeve and pin shank.

The zinc coating quality shall be 610 g/m² in minimum value.

Self-locking type stainless split pins shall be prepared for the sockets.

3.3.1.3 Technical Characteristics and Guaranteed Values

The characteristics and guaranteed values shall be as stated in Annex 9.

3.3.1.4 Factory Acceptance Tests

a. Type Tests

The insulator units and/or complete insulator strings/sets shall be tested according to IEC 60383-1. The type tests need not to be repeated for the units in this delivery provided that type tests have previously been performed on similar units. The bidder shall include evidence of successfully performed type tests in his bid. Copies of the type test reports shall be included in the FAT report.

b. Sample Tests

The insulator units shall be sample tested according to IEC 60383-1.

The complete insulator strings/sets shall be sample tested according to IEC 60383-2.

c. Routine Tests

The insulator units shall be routine tested according to IEC 60383-1.

The complete insulator strings/sets, couplings, fittings and accessories shall be subject to visual inspection.

3.4 Hardware and Fittings

3.4.1 General

All hardware components for line conductor, overhead ground wires GSW, OPGW and insulator strings shall be so manufactured that no electrolytic action will occur between the accessories and the conductor and between the components. All parts and components of hardware shall be made of good commercial grade malleable cast iron, steel or aluminium alloy.

No metal parts shall have any rust, risings, lumps, etc., and the jointed parts shall be adequately smooth. All ferrous material, excluding stainless steel, shall be fully zinc-galvanized according to BS 729.

All bolts, nuts and split pins shall be locked in order to prevent dislocation.
The design of all line conductor fittings shall avoid sharp corners or projections, which would produce high electrical stress in normal working.

All fittings must be designed in such a way that no degradation of the optical transmission in the fibres of the wire occur for all service conditions. The optical fibres shall be freely moveable in the wire under service load.

The composition of insulator hardware shall be of that specified in the drawings, but not limited thereto, and the ultimate strength of the hardware for double suspension and tension insulator strings shall be not less than 240 kN and for single suspension and tension string not less than 120 kN.

3.4.2 Suspension Clamps

Suspension clamps shall be free to pivot in the vertical plane containing the conductor with a strain strength of more than three (3) times of 60 % of the maximum working tension of the conductor, galvanized steel ground wire (GSW) and OPGW respectively, and shall be so designed that no slipping or damage to conductor or ground wire occurs at the load less than 60 % of their maximum working tension.

The conductor supporting groove shall be curved at its ends in the vertical plane to a radius of 150 mm and for a sufficient distance to allow the conductor to leave the clamp at the maximum angle of inclination obtained in service. The mouth of the supporting groove shall be slightly flared in plane. The grooves in the clamping piece or pieces shall be bell-mouthed at each end.

All conductor grooves and bell-mouths shall be smooth and free from waves, ridges or other irregularities. Suspension clamps for ground wire shall have a bonding measure to the tower to ensure grounding.

Suspension and tension clamps for fibre optic cables shall be of approved types and shall be as light as possible. All clamps shall be designed to avoid any possibility of deforming the fibre optic cable or of damaging the optical fibres due to concentrated stresses or to radial crushing loads.

Suspension clamps for fibre optic cables shall be free to pivot in the vertical plane about a horizontal axis passing close to and transverse to the centre line of the conductor or cable. Suspension clamps shall permit slippage at tensions between 7-15 Kn but the conductor or cable shall be mechanically clamped in an approved manner. Unless otherwise approved, the suspension clamp unit shall be designed such that there is progressive stiffening of the fibre optic cable up to the suspension clamp, which is a point of maximum bending. Complete protection of the optical fibres from damaging radial crushing loads under the clamps shall be ensured by the use of suitable “positive stops” or rubber clamp liners in the clamp bodies.

All connecting fittings between the fibre optic cable and the tower steelwork such as cleaves to tongue, shackle to plate or link which are subject to a tensile load in service shall comply with appropriate IEC standards.

Suspension clamps for conductor and OPGW shall be installed with armour rods.

At suspension towers the GSW and OPGW suspension clamps shall be securely bonded to the tower steelwork by means of a multistrand aluminum flexible bond wire having propositionally a cross-sectional area of not less than the GSW and covered with a polymer sheath. The bond, which shall be flexible so as not to interfere with the suspension clamp movement, shall be terminated with compression lugs which shall also seal over the polymer sheath.

Evidence of the adequacy of the suspension clamp shall be provided by type tests. The type tests shall at least consist of the following:

- Slip test;
- Bolt torque test: (twice the recommended torque of the bolt);
3.4.3 Tension Clamps for Conductor

The tension clamp to be applied for the conductor shall be compression type and shall have a tensile strength of more than 95% of the ultimate strength of the conductor after being applied and compressed on the conductor. The electrical resistance shall be less than that of the conductor of the same length, and no crack or damage shall be occurred when it is compressed with a die suitable for the clamp.

The compression type tension clamp shall be composed of aluminium body and jumper socket. The jumper socket shall have a tensile strength of more than 30% of the ultimate strength of the conductor.

Compression position shall be marked on the surface of the tension clamp and jumper socket.

Evidence of the adequacy of the tension clamps shall be provided by type tests. They shall at least consist of the following tests:

- Mechanical tensile test (min. 95% of the ultimate strength of the conductor);
- Resistance test (max. 55% of bare conductor).

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanizing test BS 729.

3.4.4 Tension Clamps for Overhead Ground Wire

The tension clamps for the ground wire (GSW) shall be either bolted type or compression type and shall have a tensile strength of more than 95% of the ultimate strength of the GSW after being applied and/or compressed on the GSW.

Tension anchor clamps for fibre optic cable (OPGW) shall be of the preformed or other approved type. The clamps shall be capable of holding the full rated breaking strength of the fibre optic cable.

The tension set must consist of a line guard and preformed dead-end, which is placed on the line guard. The line guard must be laid in the opposite direction to the outer layer on the OPGW and the dead end must be laid in the opposite direction to the line guard.

The OPGW shall be protected against concentrated radial forces in the region of contact between the dead end and the OPGW. All helical rods shall be made of aluminium or aluminium clad steel. The tension set must withstand at least 95% of the OPGW’s rated ultimate strength.

At tension towers, the GSW and OPGW tension clamps shall be securely bonded to the tower steelwork by means of a multistrand aluminum flexible bond wire, having propositionally a cross-sectional area of not less than the GSW and covered with a polymer sheath. The bond, which shall
be flexible so as not to interfere with the suspension clamp movement, shall be terminated with compression lugs which shall also seal over the polymer sheath.

Evidence of the adequacy of the tension clamps shall be provided by type tests. They shall at least consist of the following tests:

- Mechanical tensile test (min. 95 % of the ultimate strength of the ground wire).

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanizing test BS 729.

### 3.4.5 Arcing Horns

The arcing horns shall be made from steel and be hot-dip galvanized according to BS 729.

It shall be possible to install arcing horns on assembled insulator strings/sets. In addition they shall be so designed as to require a minimum of space on the supports.

The attachment of arcing horns shall be on one side and be so designed that disc insulators of the insulator string/set are able to incline at an angle $\beta^\circ$ in accordance with IEC 60120 without damaging any part of insulator disc.

Attachment to fittings shall be one-sided and designed with M12 bolts spaced at 32 mm centres. The bolts shall be attached to the arcing horn in such a way that they are impossible to drop accidentally.

Welds connecting the attachment arm to the arcing ring shall be complete penetration welds. A minimum distance of 45 mm between the arcing ring and the insulators is required.

The arcing horns shall withstand a load of 1500 N, acting at an arbitrary point, without being deformed. Arcing horns subject to fault current shall not be deformed by their own dead weight.

The arcing horn shall trap power arcs over the insulator string/set and divert them outwards.

The arcing horns shall be thermally designed to resist the fault current of the line with a current density not exceeding $80 \text{ A/mm}^2$. Welding shall not occur between the arcing horns contact surface and the fittings. The peak value of the fault current shall be a minimum of 2.3 times the r.m.s. value.

The arcing horns shall conform to the requirements of IEC 61467, clause 12.4.

The arcing horns shall be designed so that the voltage distribution over the insulators is improved and that, in case of an insulator string/set with disc insulators, the voltage does not exceed 20 kV over each individual insulator.

The arcing horns shall be applied on all suspension, tension and jumper support insulator strings/sets.

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanizing test BS 729.
3.4.6 Joint Sleeves for Conductor and GSW

The joint sleeves shall be compression type and shall have a tensile strength of more than 95 % of the ultimate strength of the conductor after being applied and compressed on the conductor. All of the sleeves shall have less resistance than that of the conductor of the same length, and shall not be damaged or cracked when compressed with dies suitable for the sleeves. The compressing position of the sleeves shall be clearly marked on the surfaces. During compression of the sleeves, anti-corrosion coating shall be provided on the conductor inside the sleeve.

The coating materials shall be accommodated in a proper container and supplied together with an instruction manual. A sufficient number of gauges used to check the dimensions of compressed parts and the length of wire to be inserted into sleeves shall be supplied for the purpose of compression work.

Evidence of the adequacy of the joint sleeves shall be provided by type tests. They shall at least consist of the following tests:

- Mechanical tensile test (min. 95 % of the ultimate strength of the conductor);
- Resistance test (max. 55 % of bare conductor).

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanizing test BS 729.

3.4.7 Joint Boxes and Splices for Optical Fibre

Weatherproof units shall be provided. The joint boxes shall include all necessary hardware to terminate, protect and fix the spliced fibre. The location of the boxes shall be 6-10 m above ground level. Preparation and cleaning of the tube and fibre ends shall be done using tools and methods recommended by the supplier of the OPGW. Fusion splicing shall be carried out by trained personnel.

Optical losses shall no more than 0.1 dB per splice, average 0.05 dB. A finished splice shall be supported with the joint box by suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fibre.

The joint boxes shall be provided with two to four inlets to suit the necessary branches. These inlets shall be sealed with thermofit plastics. The outer material of the boxes shall be oil resistant and metallic, preferably aluminium.

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination.

3.4.8 Terminations

The interface between the fibre optical transmission system, OPGW, and the fibres of the optical cable at the terminal sites (substations) is in the OPGW Terminal Joint Box.

Optical losses shall no more than 0.1 dB per splice, average 0.05 dB. A finished splice shall be supported with the joint box by suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fibre.

The Contractor shall provide the OPGW Terminal Joint Box, similar in material and construction than the Joint Boxes, with glands adequate for weatherproof sealing of the lead of the OPGW and the optical fibre cable into the box and fix the box on to the gantry at substation. The OPGW
brought down to the box shall be looped in length sufficient to allow the box being taken down to
ground level for fibre jointing. Adequate brackets shall be provided to fix the loop on the gantry.
The end of the OPGW must be provided with a shrink-on termination for weather protection.

3.4.9 Armour Rods

The armour rods to be mounted on the conductor and OPGW shall be of helical, preformed type
and shall be of anti-corrosion aluminium alloy having an equivalent anti-corrosion property to the
conductor. They shall be uniform and have no such defects as corrosion or cracks.

The armour rods shall be designed so as to be applicable to the conductor specified in Clause 3.1
of this Specification and to effectively protect the conductor from vibration and fatigue.

The direction of the preformed armour rod lay shall be the same as the direction of the outermost
layer of the conductor. The rods shall have a marking in the centre point.

When armour rods are used the instructions of the manufacturer must be followed. Sample tests
shall at least consist of the following:

- Verification of dimensions and visual examination.

3.4.10 Repair Sleeve / Repair Rods

In case of damage to the conductor aluminum strand, approved repair sleeve shall be installed
provided the damage consists of not more than one quarter (¼) of outer layer strands broken, or
knocked deeper than one half of their diameter. When more than one quarter (¼) of outer layer
strands are damaged, the damaged section of the conductor shall be cut off.

Repair sleeve shall be installed in the presence of the Employer.

The repair rods to be mounted on the OPGW shall be of helical, preformed type and shall be of
anti-corrosion aluminium alloy having an equivalent anti-corrosion property to the conductor. They
shall be uniform and have no such defects as corrosion or cracks. The repair sleeve shall have
less resistance than the conductor of the same length.

The repair rods shall be designed so as to be applicable to the OPGW specified in Clauses 3.1
and 3.2 of this Specification and to effectively protect the OPGW from vibration and fatigue.

The direction of the preformed repair rod lay shall be the same as the direction of the outermost
layer of the OPGW. The rods shall have a marking in the centre point.

When repair rods are used the instructions of the manufacturer must be followed. Sample tests
shall at least consist of the following:

- Verification of dimensions and visual examination.

3.4.11 Spacer Dampers

The spacer dampers shall be designed to combine the function of a spacer in maintaining
conductor separation and the function of a damper in controlling Aeolian vibration and
oscillation, and further, to withstand the forces and movements caused by transient conditions
such as short circuit and differential wind loading without either causing damage to the
subconductors or sustaining damage themselves.

The design shall accommodate both longitudinal and transversal movements of the
subconductors, vertical sag differences, as well as compressive and tensile forces.

The spacer dampers shall comply with IEC 61854.
Evidence of the adequacy of the dampers shall be provided by type tests. Type tests should at least consist of the following:

- Dynamic characteristics test;
- Damping efficiency test;
- Fatigue test (min. 10 million cycles, 1mm from peak to peak);
- Functional test to verify that the damper clamps don't damage the conductor;
- Bolt torque test (twice the recommended torque);
- Weight-fastening test (min. 10 kN).

The sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanising test BS 729;
- Clamp slip test;
- Bolt torque test.

3.4.12 Vibration Dampers

Vibration dampers shall be of Stockbridge type or equal and designed according to the specified conductor, ground wire and OPGW. They shall be fitted to the overhead ground wires. The number of dampers shall be in the accordance with the manufacturer's recommendations or other reports.

Vibration dampers shall be attached to the conductors, GSW and OPGW in a manner, which will prevent damage to the Conductor/GSW/OPGW strands due to vibrations and other movement.

The damping power of the damper shall exceed the power by the wind in the frequency range of 7.7 - 60 Hz for the phase conductor and 18 - 139 Hz for the ground wire. The wind power function shall be according to IEC Publication 61897.

The messenger cable of the damper shall be the minimum 19-strand construction.

Clamps for Conductor/GSW shall be of galvanized steel and clamps for OPGW shall be of aluminium alloy. The bolts and nuts shall be of stainless steel or hot-dip galvanised and they shall be locked in an approved manner to prevent loosening by vibration.

Evidence of the adequacy of the dampers shall be provided by type tests. Type tests should at least consist of the following:

- Dynamic characteristics test;
- Damping efficiency test;
- Fatigue test (min. 10 million cycles, 1mm from peak to peak);
- Functional test to verify that the damper clamps don't damage the Conductor/GSW/OPGW;
- Bolt torque test (twice the recommended torque);
- Weight-fastening test (min. 10 kN).
The sample tests shall at least consist of the following:

- Verification of dimensions and visual examination;
- Galvanising test BS 729;
- Clamp slip test;
- Bolt torque test.

3.4.13 **Hold Down Weights**

Weights shall be made of cast iron hot-dip galvanized fixed to the suspension clamps. The weights shall be designed so that they don't damage the conductor.

The sample tests shall at least consist of the following tests:

- Verification of dimensions and visual examination;
- Galvanizing test BS 729.

3.4.14 **Aircraft Warning Devices**

According to international standards and aviation regulations, the transmission lines shall be marked by devices such as aircraft warning spheres and tower painting, when obstruction occurs in the vicinity of airfields and on the crossings of main rivers. In order to determine the locations where aviation warning devices must be applied the Contractor shall consult the local authorities and the Employer to comply with the local applicable laws, rules and regulations, and Employer's practice.

The schedule of aviation warning device locations shall be submitted by the Contractor to the Employer for his approval.

For daylight obstruction, red and white coloured spheres shall be clamped in at 40 m intervals on the GSW. Aviation warning devices shall be coloured spheres of 600 mm diameter, installed as required by ICAO Regulations Annex 14, Chapter 6 – Visual Aids for denoting obstacle.

Furthermore, the upper part of the towers shall be red and white painted.

Sample tests shall at least consist of the following:

- Verification of dimensions and visual examination

3.4.15 **Other Accessories**

If not otherwise agreed concerning load carrying parts the following tests will be required:

a. Type tests:

- Mechanical failing load test BS 3288, Part I, Clause 3.2

b. Sample tests:

- Verification of dimensions and visual examination
- Galvanising test BS 729
- Mechanical test BS 32883
3.4.16 Corona and Radio Interference

The design of all conductor fittings, vibration dampers etc., shall avoid sharp corners or projections. Consequently they shall be free from visible and audible corona discharge and radio interference at the highest system voltage.

3.4.17 Test and Inspection

The tests of line hardware fittings shall be carried out in accordance with BS 3288, “Performance and General requirement”.

The line hardware fittings for sample tests shall be selected at random from each batch. The number of test specimen shall be p, or the nearest whole number greater than p given by the following formula:

\[
P = \begin{cases} 
0 & \text{when } n < 100 \\
4 & \text{when } 100 \leq n \leq 500 \\
4 + \frac{1.5n}{1000} & \text{when } 500 \leq n \leq 20000 \\
4 + \frac{0.75n}{1000} & \text{when } n > 20000 
\end{cases}
\]

Where \( n \) = the number of hardware fittings in the batch.

3.4.18 Bid Drawings, Technical Particulars and Guarantees

3.4.18.1 Bid Drawings and Documents

The design of all insulator set hardware, phase conductor, GSW and OPGW fittings shall be provided showing the minimum general, electrical and mechanical performance requirements specified in this Specification.

The following documents shall be provided:

1. Assembly drawings of fittings and hardware
2. Installation instructions for
   a. Suspension clamps
   b. Tension clamps
   c. Joint sleeves
   d. Preformed armour rods
   e. Repair sleeves
   f. Spacer dampers
   g. Vibration dampers
   h. Hold down weight
   i. Aircraft warning devices
3. Quality assurance plans for inspections and type and sample tests to be performed.

3.4.18.2 Technical Particulars and Guarantees

All data stated and required in Schedules of Guaranteed Technical Particulars concerning fittings and hardware shall be fulfilled rigorously.

3.4.19 Measurement for Payment

There will be no separate measurement for payment for supply of hardware and fittings, which shall be deemed to include in the unit prices of complete insulator sets for conductor, GSW and OPGW (fittings) respectively stated in the Schedule of Prices.

3.5 Towers

3.5.1 General

Towers shall be designed by the Contractor in accordance with the ASCE 10-97 (Design of Latticed Steel Transmission Structures, issued by American Society of Civil Engineers) or equivalent and the loading conditions stipulated in this Specification.

All tower materials shall be manufactured in the factory and entirely galvanized by the hot-dip process.

Steel towers shall be of self-supporting type and designed to hold the line conductors with necessary insulator sets, overhead ground wires (GSW and OPGW) and all fittings under the loading conditions and with the safety factors specified herein.

3.5.2 Basic Design Condition

<table>
<thead>
<tr>
<th>Nominal voltage</th>
<th>kV</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of circuits, Lessos - Uganda border</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

**Conductor** FLINT (AAAC-37)

| No. of conductors / phase | 3 |
| Weight of conductor | kg/km | 1028 |
| Overall diameter | mm | 25.17 |
| Rated strength | kN | 108.5 |
| Allowed stress under load conditions (loads without load factors), % of ultimate stress | % | 60 |
| Recommended Every Day Stress (EDS) | N/mm² | 70 |
| Creep allowance | ºC | 25 |
| Maximum temperature | ºC | 75 |

**GSW**

| No. of ground wires | 1 |
| Weight of ground wire | kg/km | 593.6 |
| Overall diameter | mm | 11 |
| Rated strength | kN | 88 |
| Maximum temperature | ºC | 50 |
| Cross section area | mm² | 71.3 |

j. Other accessories
OPGW

- No. of ground wires: 1
- Weight of ground wire: kg/km 530
- Overall diameter: mm 15.5
- Rated strength: kN 66
- Creep allowance: °C 20
- Maximum temperature: °C 50

Environmental data

- Maximum temperature: °C 40
- Minimum temperature: °C 5
- Maximum temperature: °C 13
- Mean temperature for EDS: °C 25
- Maximum wind velocity (10 minutes wind at 10 m height): m/s 38.9

The mechanical tension limits of conductors and ground wires will be of:

- 20% of the rated tensile strength (RTS) at 13°C without wind, initial state (conductor, Flint AAAC);
- 14% of the rated tensile strength (RTS) at 13°C without wind, initial state (OPGW and OHGW);
- 60% of the rated tensile strength (RTS) for maximum wind at 25°C, final and after load state;
- 25% of the rated tensile strength (RTS) for the conductor at 25°C, final state;
- 20% of the rate tensile strength (RTS) for the OPGW and OHGW at 25°C, initial state.

Maximum working tension of ground wire shall be so verified that sag of ground wire is approximately 85 % of conductor sag at EDS condition.

3.5.3 Types of Towers

3.5.3.1 Selection of Towers

The types of towers shall be as follows:

<table>
<thead>
<tr>
<th>Tower type</th>
<th>Applicable for</th>
<th>Insulator string set type</th>
<th>Range of horizontal angle deviation (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) CA</td>
<td>Tangential positions or points of very light angle deviation</td>
<td>Suspension</td>
<td>0° to 2°</td>
</tr>
<tr>
<td>(b) CB</td>
<td>Positions of light angle deviation</td>
<td>Tension</td>
<td>0° to 15°</td>
</tr>
<tr>
<td>(c) CC</td>
<td>Positions of medium angle deviation and line terminal</td>
<td>Tension</td>
<td>15° to 30°</td>
</tr>
<tr>
<td>(d) CD</td>
<td>Positions of heavy angle deviation and dead end tower</td>
<td>Tension</td>
<td>30° to 70°</td>
</tr>
<tr>
<td>(e) CTT</td>
<td>Positions of transposition</td>
<td>Suspension</td>
<td>0°</td>
</tr>
</tbody>
</table>
3.5.3.2 Design Spans

The design spans (m) to be applied for every tower type will be as follows:

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Ruling span (m)</th>
<th>Wind span (m)</th>
<th>Weight span (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) CA</td>
<td>400</td>
<td>480</td>
<td>680</td>
</tr>
<tr>
<td>(b) CB</td>
<td>400</td>
<td>480</td>
<td>1000/-400</td>
</tr>
<tr>
<td>(c) CC</td>
<td>400</td>
<td>480</td>
<td>1000/-400</td>
</tr>
<tr>
<td>(d) CD</td>
<td>400</td>
<td>480</td>
<td>1000/-400</td>
</tr>
<tr>
<td>(e) CTT</td>
<td>400</td>
<td>480</td>
<td>680</td>
</tr>
</tbody>
</table>

The wind and weight spans will be increased regarding the condition of the terrain.

3.5.4 Extensions of Tower

Body extensions shall be suitable for fitting without any major changes to the basic body of the tower. Body extensions shall be designed for independent single leg extensions for use of steeply sloping ground. The design and arrangement of independent single leg extensions shall be common to standard body extensions.

The actual height of a tower may be increased by certain steps. From the basic heights (= body extension 0 m and leg extension 1.5 m), the following body extensions and leg extensions will be applied:

<table>
<thead>
<tr>
<th>Tower Type</th>
<th>Body extension(m)</th>
<th>Leg extension(m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>4.5</td>
</tr>
<tr>
<td>CA</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>CB</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>CD</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>CTT</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

3.5.5 Design Loads

Design loads shall be calculated in accordance with IEC International Standard 60826 (Last Edition) using reliability level 1 with 50 year return period climatic limit loads.

In accordance with IEC Standard, the loading QT is called the system limit load having a return period T. The calculation process for each component requires that the design load be less than the design strength.

3.5.5.1 Suspension Towers

- Vertical loads
The weights of insulators, all other fittings and actual dead weight of specified span lengths of line.

- Transverse loads

  The specified wind pressure at right angles to the conductors on the whole projected area of the conductor, insulators and ground wires.

3.5.5.2 Angle Towers

The maximum vertical and transverse loadings as described above plus the transverse and horizontal components of the maximum conductor and ground wire tensions stated in Schedules of Technical Guaranteed Particulars resolved for the maximum angle of deviation concerned.

3.5.5.3 Terminal Towers

Loadings for terminal type towers shall be the vertical and transverse loadings as for straight line towers together with the full maximum longitudinal conductor tensions on line side of the tower together with a plan angle of entry on the line side up to 45 degrees.

3.5.5.4 Loading Conditions

The conductors, insulators, accessories and towers shall withstand the following load combinations. All transverse and longitudinal loads in the loading diagrams (loading trees) shall be also reversible. At load attachment points of tension towers the transverse and vertical loads shall be split between front and back face of the tower crossarm in the proportion 75 per cent to 25 per cent respectively.

Design loads under the normal condition shall be simultaneously applied to the towers with all wires intact.

1. Minimum temperature

   - The weight of structures, conductors and accessories; and
   - The conductor loads in min. temperature condition.

2. Maximum wind

   - The weight of structures, conductors and accessories, the conductor loads in max wind conditions; and
   - The wind load on the structure, the conductors and accessories.

3. Broken wire

   - The weight of structures, conductors and accessories,
   - Broken wire loads as in normal condition at EDS temperature.

The unbalanced tension and torsional forces induced either by the breaking of any one of the conductors and any one of the ground wires, or by any two of conductors of same circuit on the same side of the tower, whichever combination constitutes the more stringent condition shall apply for a particular member at its maximum working tension under the normal loading condition.

The unbalance tension at a suspension tower due to breakage of conductor may be reduced to 60 % of the maximum working tension of conductors.
However, the unbalance tension of ground wires for all towers and conductors for tension towers shall be 100% of the maximum working tension.

4. Conductor stringing
   
   - The weight of structures, conductors and accessories; and
   
   - The loads due to stringing of the conductors, in the stringing conditions.

Loading diagrams (loading trees) for each condition shall be attached with the bid document.

3.5.5.5 Temperatures

- Max. temperature

  When calculated the clearances, the maximum temperature of the conductors without current is +40°C and of a current carrying conductors +75°C.

- Every day stress temperature

  The temperature of the conductors in EDS condition is +25°C.

3.5.6 Wind Loads

The critical wind speeds have been determined from meteorological stations located throughout Kenya. The maximum recorded wind speeds taken as three (3) second gusts at a standard height of 10 m above ground (38.9 m/s) have been converted to a ten (10) minute reference wind speed in accordance with IEC Standard 60826.

3.5.6.1 Wind Pressure

The following wind pressures are calculated for terrain type B and a mean elevation of 1500 m for zone 1 at a temperature of 20°C. The dynamic reference wind pressure (qO) is calculated in accordance with the IEC Standard as follows:

$$ qO = \frac{1}{2} \cdot \tau \cdot \mu \cdot (K_R \cdot V_{RB})^2 $$

<table>
<thead>
<tr>
<th>Zone</th>
<th>Elevation</th>
<th>$\tau$</th>
<th>$\mu$</th>
<th>$K_R$</th>
<th>$V_{RB}$ (m/s)</th>
<th>Dynamic Reference Wind Pressure (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1500</td>
<td>0.82</td>
<td>1.225</td>
<td>1.0</td>
<td>28.3</td>
<td>402</td>
</tr>
</tbody>
</table>

3.5.6.2 Loads on Line Components

Limit loads on conductors, overhead and optical ground wires, insulators and structures shall be calculated in accordance with IEC Standard 60826. Appropriate drag, height, terrain type and span factors must be applied in accordance with the IEC Standard.

3.5.7 Load and Material Factors

3.5.7.1 Load Factors

The weather related limit loads calculated in accordance with the IEC Standard are used for the design without additional load factors. Construction loads, however, are subject to greater
variability and risk, and a load factor of 2 should be applied to all stringing and other construction induced loads to ensure safe construction and maintenance conditions.

The characteristic strengths of the line components generally require strength factors in order to maintain a preferential sequence of failure. The following strength factors shall be used.

3.5.7.2 Material Factor

The strength factor is used to cover inaccuracies in the material and fabrication. The critical allowable limit stresses shall be divided by the strength factor below and the achieved reference stress shall be used in the dimensioning of the structural components.

The material factors are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Material factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers - steel structures</td>
<td>1.2</td>
</tr>
<tr>
<td>- lowest body section</td>
<td>1.4</td>
</tr>
<tr>
<td>Insulators</td>
<td>1.8</td>
</tr>
<tr>
<td>Conductors - AAAC</td>
<td>1.6</td>
</tr>
<tr>
<td>- OPGW</td>
<td>1.6</td>
</tr>
<tr>
<td>Fittings - against the yield point</td>
<td>1.2</td>
</tr>
<tr>
<td>- against the failing load for forged steel</td>
<td>1.6</td>
</tr>
<tr>
<td>- against the failing load for cast iron</td>
<td>2.0</td>
</tr>
</tbody>
</table>

3.5.8 Clearances

3.5.8.1 Phase to Earth Clearance

<table>
<thead>
<tr>
<th>Wind Condition</th>
<th>Clearance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>3950</td>
</tr>
<tr>
<td>Under maximum wind load</td>
<td>1600</td>
</tr>
<tr>
<td>Under reduced wind load</td>
<td>2400</td>
</tr>
<tr>
<td>Line maintenance (assuming a man inside a 1 m width x 1 m depth x 2 m height box )</td>
<td>2100</td>
</tr>
</tbody>
</table>

3.5.8.2 Clearances between Phases

\[ dm \geq C + 0.9 \sqrt{(F + L)} \]

Where:

\[ F = \text{sag of the conductor (m) at maximum temperature (} +75 ^{\circ} \text{C)} \]
\[ L = \text{length of the insulator string (m), for tension string } L = 0 \]
\[ C = \text{constant for 400 kV = 2.8 m} \]

The minimum vertical distance between the phases conductors and the guard wires must be greater that 5m, for the 400 kV lines. To this minimum distance, has to be adjusted depending on the span.

The distance between phase conductors and earth wire shall be calculated according to conductor that gives greater value from the formula above.
The distance between conductors belonging to different circuits shall be 1.20 times the distance belonging to the same circuit. However, the distance shall not be smaller than 4.0 m in line towers in which substation gantries are not included.

3.5.8.3 Shielding Angle

The shielding angle in relation to the extreme sub conductors shall be:

<table>
<thead>
<tr>
<th>Tower type</th>
<th>Shielding angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension</td>
<td>≤10°</td>
</tr>
<tr>
<td>Tension</td>
<td>≤15°</td>
</tr>
</tbody>
</table>

Shielding angle shall be calculated from ground wire centre to phase conductor centre in EDS condition taken into account all conceivable combination of spans and angles of deviations for corresponding tower type.

3.5.8.4 Swinging Angle

Calculation of swinging angle shall be carried out in according to DIN VDE 0210.

3.5.8.5 Clearance to Obstacles

<table>
<thead>
<tr>
<th>Object</th>
<th>Condition</th>
<th>Clearance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>Max. temperature</td>
<td>8.1</td>
</tr>
<tr>
<td>Roads</td>
<td>Max. temperature</td>
<td>10</td>
</tr>
<tr>
<td>Waterways</td>
<td>Max. temperature at highest water level</td>
<td>12.1</td>
</tr>
<tr>
<td>Buildings and structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- horizontal</td>
<td>Max. wind</td>
<td>5.3</td>
</tr>
<tr>
<td>- vertical</td>
<td>Max. temperature</td>
<td>7.1</td>
</tr>
<tr>
<td>Parallel lines – horizontal</td>
<td>Max. wind</td>
<td>6.0</td>
</tr>
<tr>
<td>Crossing lines – vertical</td>
<td>Max. temperature</td>
<td>4.5</td>
</tr>
<tr>
<td>Other objects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- trees</td>
<td>Max. temperature</td>
<td>2.5</td>
</tr>
<tr>
<td>- fruit growing trees</td>
<td>Max. temperature</td>
<td>6.5</td>
</tr>
</tbody>
</table>

3.6 Tower Design Basis

All components of steel towers shall be designed and manufactured in accordance with this Specification and the Manual ASCE 10-97 or other approved equivalent standard. The design of tower components and connections is to be made by comparing the calculated stresses (from loads multiplied by load factors) with the reference stresses, which are the ultimate stresses (specified below) divided by the material factor.

1. Tension members shall obtain the stipulated safety factor on the yield point against assumed maximum stress.

2. Compression members shall be designed so as to have an adequate safety factor in buckling strength obtained from the approved formula.

3. The horizontal and sub-horizontal members, which have a slope of less than 30°, shall be designed to withstand the load of a man plus equipment (together assumed to be 1.5 kN) applied at the centre of the member. A safety factor of 1.1 shall be applied and the member shall not be stressed beyond the yield point.

4. In consideration of unexpected load, which may be generated during stringing work, the broken wire condition on cross arm design shall be deemed as the normal condition, i.e., 1.5 of the safety factor.
5. The Contractor shall show on the detail drawings the dimensions required for setting of stub members of foundation.

3.6.1 Compression

The ultimate compression stress of members can be derived from some widely approved specification e.g. such as ECCS-“Recommendations for Angles in Lattice Transmission Towers, Last Edition” or ASCE-No.52 “Guide for Design of Steel Transmission Towers”.

The maximum values for slenderness ratio (KL/r) are as follows:

- compression main members 120
- compression force carrying diagonal, horizontal and vertical members 200
- tensile members, redundant and frame members 250
- tensile members, if the effect of vibration has been eliminated 350

3.6.2 Tension, Bending, Shearing and Bearing

When the material thickness does not exceed 16 mm, the ultimate stresses are to be based on the upper yield point (Fy) of the material as follows:

- ultimate tension = Fy
- ultimate bending = Fy
- ultimate shearing = 0.6*Fy
- ultimate bearing = 1.8*Fy

For materials over 16 mm thick the calculations shall be based on the lower yield point.

Tension and shearing stresses shall be calculated employing the net area of the tower member shown below:

<table>
<thead>
<tr>
<th>Stress type</th>
<th>Net area</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Compression</td>
<td>F</td>
<td>Where: F= Cross sectional area of member</td>
</tr>
<tr>
<td>-Tension (1)</td>
<td>F-dF</td>
<td>dF = Sum of sectional areas of holes in the most unfavorable cross section</td>
</tr>
<tr>
<td>-Shearing</td>
<td>F_{web}dF</td>
<td>F_{web} = Sectional areas of determinative web cross section, bordering flanges shall be neglected</td>
</tr>
</tbody>
</table>

1) If the member is connected with one bolt the net area shall be 0.8*(F-dF).

The minimum thickness of all material is 4 mm. However for main members, also in cross arms the minimum thickness is 6 mm.
3.6.3 Redundants

Redundants are to be designed to carry axially 2.5 per cent of the axial load of the members they restrain.

3.6.4 Bolts and bolted Joints

Bolted joints shall be calculated as bearing type connections, and no allowance for frictional resistance shall be made. The Contractor shall obey proper tightening torques for the bolts to be used in towers.

The minimum bolt size is M12.

Bolts shall not be threaded on that part of the shaft, which corresponds to the bolt hole. The thread shall terminate under the washer or in some other way outside the stressed material. However it is accepted that the thread run-out enters into the nearest of the jointed stressed materials, but not more than one fourth of the thickness of this material.

The thread of a bolt shall after the assembly protrude beyond the nut a minimum length of 2.5 to 5 mm depending on the diameter of the bolt. The total thickness of the washers shall not be more than 0.6 times the bolt diameter.

3.6.5 Construction

The towers shall be of approved design and construction. The design of all supports, conductors, insulators and fittings shall be such as to minimize the risk of damage or deterioration in service of any part of the transmission line due to vibration.

The design shall be such as to reduce the number of different parts as much as possible and to facilitate transport, erection and inspection. Pockets and depressions likely to hold water shall be avoided and, if not avoidable, shall be properly drained.

The holes necessary for accommodating the specified grounding counterpoise connections shall be provided on each leg of every tower.

The screwed thread of any bolts or studs shall not form part of a shearing plane between members.

The plates of the cross arm ends of the tension towers shall be so arranged that two holes for the attachment for tensioning of conductors and maintenance tackle are provided adjacent to each hole of tension set shackles. It shall be possible to apply full tension of conductors safely.

3.6.6 Material

The steel used in tower structures and stubs shall comply in strength and quality at least with structural steel class St 52 of DIN 17100 or similar quality and strength.

The steel, when stored in the manufacturer’s stockyard prior to fabrication, shall be marked continuously throughout its length with a coloured water paint line for distinction. In addition, the grade number of the steel shall be painted on and ringed with paint.

The tower material shall be hot rolled steel and shall have such silicon content and other chemical composition that ensures the sufficient zinc coating after hot-dip galvanizing process.

3.6.7 Erection Marks

Before leaving the Manufacturer’s Works all tower members shall be stamped in approved manner with distinguishing numbers upon approved drawings or material lists to be submitted by the
3.6.8 **Bolts, Nuts and Washers**

All bolts and nuts shall conform to DIN 267 and DIN 7990 standards. Threads shall be metric. The nuts of all bolts attaching insulators set, droppers’ U-bolts and earth conductor clamps to the structures shall be locked in an approved manner.

The washers used in structures shall be thick type of plain washers according to DIN 7989 standard.

All the bolts used in the assembly of towers shall be at least property class 5.6. The strength of nuts shall comply with the strength of corresponding bolts.

The tightening torques for bolts used in structures shall be as follows:

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>Tightening Torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M12</td>
<td>35±5</td>
</tr>
<tr>
<td>M16</td>
<td>80±10</td>
</tr>
<tr>
<td>M20</td>
<td>140±15</td>
</tr>
<tr>
<td>M24 and greater</td>
<td>200±20</td>
</tr>
</tbody>
</table>

For higher property class bolts the tightening torques shall be defined correspondingly.

All bolts, nuts, washers and fillers shall be furnished with some allowance. The allowance shall be at least five (5) per cent of the actual requirements.

3.6.9 **Galvanizing**

All steel structures and fasteners shall be hot-dip galvanized after treating of all shearing, drilling, punching, bending, etc. Galvanizing shall be carried out in accordance with BS 729 or equivalent approved standard. All bolts and screwed rods in towers shall be hot-dip galvanized including the thread portions. All washers and fillers used in structures shall be hot-dip galvanized.

On removal from the galvanizing bath the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Unsatisfactorily galvanized material shall be replaced. The whole of the expense involved in the replacement of such material shall be borne by the Contractor.

3.6.10 **Tower Signs**

Tower signs, consisting of aerial patrol signs, phasing signs, circuit identification signs, tower number/phase plates and danger signs shall be made of mild steel or aluminium alloy plate of thickness not less than 2 mm.

Phase indication of approved type coloured red, yellow and blue to indicate the line phase, and circuit identification as well, shall be provided.

All signs shall be of anti-corrosive materials. If enamelled steel plates are applied, the whole surface of the plate including back face and edges shall be properly covered so as to resist corrosion. On all plates the colours shall be permanent and free from fading. Bolts and nuts for fixing of danger and identification plates shall be 12 mm in diameter.

The Contractor is required to furnish the relevant tower members with holes and/or auxiliary flat bars for attaching the tower signs at the locations described hereunder:
### Part 2: Section VI – Employer’s Requirements

#### Scope of Supply (TS-1), 400kV Line

<table>
<thead>
<tr>
<th>Sign Type</th>
<th>Quantity per Tower</th>
<th>Location: the sign shall be attached to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerial patrol sings</td>
<td>2</td>
<td>Upper member of top cross arm</td>
</tr>
<tr>
<td>Circuit identification signs</td>
<td>8</td>
<td>Upper member of every cross arm and on number/phase plates</td>
</tr>
<tr>
<td>Phasing signs, sets of 3</td>
<td>4</td>
<td>Upper member of appropriate cross arm and on number/phase plates</td>
</tr>
<tr>
<td>Tower Number/phase plate</td>
<td>2</td>
<td>Bracing members above the ACD at step bolt corners on front face and back face in case of double circuit towers</td>
</tr>
<tr>
<td>Danger signs</td>
<td>2</td>
<td>Same locations as number/phase plates</td>
</tr>
</tbody>
</table>

The details of the number plate and the danger plate shall be as shown in drawings in TS-3.

#### 3.6.11 Anti-climbing Device and Step Bolts

All towers shall be provided with an anti-climbing device (ACD) on each leg at a height of 3m to 5 m above the highest ground level at tower location. The details of ACD shall be as shown in TS-3.

The step bolts assembled with double nuts shall be provided on two diagonally opposite legs from bottom to top extending to within one meter of overhead ground wire at intervals not exceeding 400 mm. Step bolts shall be removed below the anti-climbing device after commissioning of the line. The step bolts shall be at least 160 mm in length and 16 mm in diameter.

#### 3.6.12 Grounding Device

All towers shall be provided with a grounding device in minimum two diagonal legs. Refer to drawing No. 0522011-TLUK-028 for details. Holes for the connection of grounding device and counterpoise shall be provided in each leg and stub angle.

Grounding rods, made of copper-clad steel, with minimum diameter of 19 mm and minimum length of 3.6 m, shall be used for tower earthing.

The grounding device shall consist of a grounding rod and a lead wire of 38 mm² copper of 2.0 m in length with terminal and 16 mm bolt.

Steps to be followed when earthing any given tower shall be as shown in the above mentioned drawing.

Minimum tower grounding shall be one set on two diagonally opposed legs. When measured tower footing resistance to earth is greater than 10 ohms, a second set of rods on diagonally opposed legs shall be used. If insufficient, appropriate measures shall be implemented, such as longer rods, subject to approval of the Engineer.

For towers with a grounding resistance in excess of 10 ohms, one or more counterpoises of 50 m² galvanized steel wire, maximum length 30 m, shall be installed, in addition to the basic grounding devices, buried about 50 cm below the ground surface.

#### 3.6.13 Shop Assembly Tests on Towers

One tower of each type including every combination of body and leg extensions shall be assembled in a horizontal position to make sure a correct fitness of parts, adequate bolt lengths and a proper field erection. Shop assembled parts will be dismantled for shipment. The Contractor shall notify the Employer at least thirty (30) days in advance; in order that the Employer
may visit Contractor’s facilities and witness the shop assembly test of each tower type before proceeding with mass fabrication.

3.6.14 Bid Drawings, Guaranteed Technical Particulars

3.6.14.1 Bid Drawings and Documents

The design of towers and tower accessories shall be provided showing the minimum general, electrical and mechanical performance requirements specified in this Specification.

The following drawings and documents shall be provided:

1. Loading of towers
2. Calculation of swing angles
3. Outline drawings showing tower heights and general arrangement for body and leg extensions
4. Loading trees of towers
5. Detailed design calculations or computer printouts
6. All considered criteria, data and others, used for the design of towers
7. Material lists of each tower type
8. Quality assurance plans for inspections and type and sample tests to be performed. The drawings need have leading dimensions only. Structures and drawings shall have provisional dimensions of principal members and shall indicate the necessary clearance dimensions for structures for still air and maximum swing of insulator strings and jumpers called for in this specification.

3.6.14.2 Technical Particulars and Guarantees

All data stated and required in Schedules of Guaranteed Technical Particulars concerning towers and tower accessories shall be fulfilled rigorously.

3.6.15 Measurement of Payment

Payment for tower design shall be included in the unit prices of each tower type stated in the Schedule of Prices.

3.7 Transposition

3.7.1 General

Transpositions shall be provided according to the drawing shown in the Part TS-3.

There are two methods in erection of transposition depending on the types of towers: on double circuit lines the transposition shall be made by applying a special transposition tower, see Clause 3.5.3.

3.7.2 Required Transpositions

The required number of transpositions is one (1) for Lessos-Tororo overhead line.
3.7.3 Measurement for Payment

There will be no separate measurement for payment for furnishing transpositions, which shall be deemed to include in the unit prices of supply of the transposition insulator string sets.

3.8 Foundations

3.8.1 Scope of work

The work includes to furnish all materials, equipment and labour and to perform all operations required for the design and construction of all foundations as specified herein and as evidently necessary to complete the work. The work related to all foundation types include, but are not limited to, transportation, excavation, installation and where necessary the reinforcement, the formwork, the concreting, filling, compaction as well as the installation of earthing, counterweights and measures of ground resistance.

3.8.2 Foundation Design

3.8.2.1 General

The Contractor shall design the different foundation types according to each type of structure used throughout the power line. The different foundation types shall be specified in this Clause. The foundation design drawings and calculations shall be subject to review and approval by the Employer before construction begins. After the completion of detailed soil test, the Contractor shall select the most technically and economically suitable foundation type subject to the approval of the Employer.

3.8.2.2 Anticipated Geotechnical Conditions

Four main types of soils are expected to be found along the line route: cohesive soils, laterites, alluvial deposits and bedrock. A brief description of each of these soils is presented below.

Cohesive Soils

Cohesive soils are composed of very fine particles with the distinction of molecules adhering together. The particles that make up these soils tend to be interconnected, forming a compact and generally impermeable mass. These soils consist primarily of clays formed by weathering as well as the mechanical and chemical degradation of pre-existing rocks. Along the power line route, many of the clays are formed by the weathering or alteration of volcanic ashes from the quaternary period (< 1.6 million years). This type of clay, generally darker in colour, can be classified as andosols and are expected to be found in depressions, where the accumulation of ashes is facilitated. Cohesive soils are classified in terms of consistency into:

- Soft clays
- Firm clays
- Hard clays

Depending on stratum depth and the presence of water, this type of soil may prove to be problematic. A special type of foundation would then be required and would be designed on the basis of additional geotechnical investigations.

Laterites

Laterites are residual surface soils formed by the weathering or alteration of the underlying parent rock. Appearing as a clayey, gravelly hardpan layer, these soils are often a reddish, brownish colour and also display a form of cohesion. Laterites are probably present over a large portion of the line route. The main laterites along the transmission line are ferrallitic soils, rich in iron oxides.
and aluminum, typical of tropical and humid climates. Lateritic soils are classified by consistency into:

- Soft laterites
- Firm laterites
- Hard laterites

**Alluvial Deposits**

Alluvial deposits are more or less large sediments transported by flowing water. They are usually found in the bottom of valleys, in riverbeds or at the foot of mountains. Depending on the slope of the river, alluvial deposits are expected to be medium to large grained rather than fine grained. It is likely that the large grained deposits are of medium density and the fine deposits are loose. Alluvial deposits are granular soils that are non-cohesive and are classified in terms of their density and placement relative to the water table:

- Medium or large grained, medium density deposits located above the water table
- Medium or large grained, medium density deposits located below the water table
- Fine grained, loose deposits

**Bedrock**

Bedrock may be encountered all along the line route but more often where a slope is more pronounced. The rock quality probably varies from fair to poor depending on the level of alteration or erosion. In some areas, the rock may be so altered that it can almost be considered a soil (e.g. lithosol or skeletal soil). Bedrock is classified into 3 categories according to its degree of weathering and fracturing:

- Friable rock (very poor quality) that can be excavated to at least 2.0 m deep with no explosives or hammer tools
- Poor rock quality less than 3.0 m deep
- Fair rock quality less than 3.0 m deep

**3.8.2.3 Foundation Types**

In order to adapt to the various geotechnical conditions, two main types of foundations have been anticipated and described below

**Reinforced Concrete Slab Foundation**

As illustrated in Figures 1 and 2, these types of foundations are used depending on the type of soil encountered; either cohesive or granular. The foundation consists of a reinforced concrete slab buried about 3.0 m below the ground, one for each tower leg. Backfilling consists of replacing excavated materials but excludes organic surface matter. This foundation is adequate for firm or hard cohesive soils, firm or hard laterite soils, medium to large grained alluvial formations lying above the water table, and friable bedrock. In firm soils the slab may be poured directly into the excavated soil to take advantage of the better capacity of the intact soil (Figure 1). Wider footings will be required for foundations in loose soil or soil below the water table (Figure 2).
The dimensions of the base of the tower leg are in the order of 2.8 m x 2.8 m, totaling an area of about 8 m². Where stronger soils are present, the area can be reduced to about 5 m² (2.1 m x 2.1 m) and where soils with weaker bearing capacities are present, the area can achieve about 11 m² (3.3 m x 3.3 m).

**Rock-Anchored Foundation**

When the bedrock is too hard to be excavated with a mechanical shovel, rock-anchored concrete blocks will be required to support the towers (Figure 3). Reinforced bars are driven and grouted into holes bored into the rock. This type of foundation is appropriate for locations where bedrock is found less than 3.0 m below the surface and is too hard for excavation without hammer tools or by blasting.
Special Foundations

In addition to the standard foundations presented above, a special foundation may be required where the investigation of subsoils has indicated low bearing capacities and/or high water tables in granular soils or other special circumstances. A special foundation will normally be on that has been specifically designed for a site and shall be tailored to fit the geotechnical conditions of the site. These foundations shall be either a reinforced concrete slab with enlarged pad or deep reinforced concrete piles (bored or driven) with reinforced concrete cap.

3.8.2.4 Soil Characteristics for Foundations

The four types of soil (i.e. cohesive soils, laterites, alluvials and bedrock) found along the power line route and used in the foundation design are classified into the following groups with the corresponding soil characteristics that are derived from soil strength (i.e. bearing capacity, soil density and uplift angle).

<table>
<thead>
<tr>
<th>Description</th>
<th>Non-Friable Rock</th>
<th>Good Cohesive Soil</th>
<th>Firm Soil</th>
<th>Loose Soil</th>
<th>Submerged Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Capacity</td>
<td>1000 kPa</td>
<td>300 kPa</td>
<td>200 kPa</td>
<td>100 kPa</td>
<td>100 kPa</td>
</tr>
<tr>
<td>Soil Density</td>
<td>1900 kg/m$^3$</td>
<td>1700 kg/m$^3$</td>
<td>1700 kg/m$^3$</td>
<td>1500 kg/m$^3$</td>
<td>1100 kg/m$^3$</td>
</tr>
<tr>
<td>Uplift Angle</td>
<td>30°</td>
<td>30°</td>
<td>25°</td>
<td>20°</td>
<td>10°</td>
</tr>
</tbody>
</table>

3.8.3 Foundation Design and Construction Details

The quantity of foundations for each different type of tower is provisional and may vary as per final selection of the foundation type at the site.

The geotechnical aspects of the foundation design shall be done according to the principles given in the German Standard DIN VDE 0210: “Planning and Design of Overhead Power Lines with Rated Voltages about 1 kV” Chapter 9: Foundations.

The foundation reinforcement and concrete details shall be designed and calculated according to British Standard BS 8110: “Structural use of concrete” or other equivalent standards.

Stub anchorage calculations shall be made using the principles shown in ASCE 10-97: “Design of latticed steel transmission structures: Chapter 9” or other equivalent standards.

The foundation design loads are derived from the towers strength calculations. The loads used to design the foundations shall be actual working loads (nominal loads, unfactored loads) applied to the foundation by the towers. The foundations shall be designed to take into account the most unfavourable combination of loading conditions. The foundations shall be designed to carry the same loading conditions as the power line towers.

The foundations shall be designed to resist all lateral forces, uplift forces and applied moments with a minimum factor of safety of 2.0.

The unit weight of concrete shall be considered as 2400 kg/m$^3$ but 1400 kg/m$^3$ where located in water.
All steelwork, whether part of the tower or part of the stub angle, shall be completely encased in concrete. The concrete cover to stub angles shall be 100 mm from any part of the stub leg starting from the foundation base up to a level of 300 mm above the ground. All stubs shall have cleats designed to carry all stub loads. Stub and cleats shall be designed as a part of the tower structure, thus having a safety factor of 2.5 instead of 2.0.

Stub angles shall be of galvanized steel and shall have a cross-sectional area of not less than the structure leg member to which it will be attached. The stub angle shall not be included in the reinforcement steel area. The cutting of the stub angle from the bottom end at correct levels shall be made at site.

3.8.4 Stub Setting Template

No particular stub setting template is required to be used provided that other reliable means of securing the placement and position of the stub are employed. The stub assembly method shall be such that the stubs remain in their correct position before, during and after concreting. Should a template be used it shall conform to the following. The templates shall be of such design and construction as to resist distortion and damage and withstand repetitive use. They shall be made of mild steel (St37 DIN 17100).

The proposed method of stub assembly shall be subject to the Employer's approval prior to its use.

There will be no separate measurement for payment for stub setting templates.

3.9 Test and Inspection

Each item of materials to be furnished shall be subject to the manufacturer's routine tests in addition to the tests specified otherwise in this Specification. Upon request, the Contractor shall perform tests in the presence of the Employer.

3.9.1 Shop Tests

Tests at the shop shall be in accordance with the requirements of the appropriate clauses in this Specification.

The Contractor shall submit 30 days in advance to the Employer for approval the testing schedule and procedure. After the tests are performed, the Contractor shall submit to the Employer the test reports within 15 days.

The approval of the Employer of the results of any such inspection or tests shall not prejudice the right of the Employer to reject the Plant if any part, when erected, fails to comply with this Specification or fails to fulfill the purpose for which it was supplied. The cost of inspection and/or test, including the provision of the necessary test equipment at the manufacturer's works, shall be included in the Contract price.

3.9.2 Loading Test (Type Test)

The loading test shall be carried out on full-scale towers listed in Clause 10.3 in accordance with IEC Publication 60652 or equivalent. The prototype tower to be tested shall comply in all respects with this Specification except for galvanizing, which will not be carried out on the prototype tower, and shall be manufactured by the method equivalent to that for the "production run" towers. The test procedures shall be subject to approval of the Employer. The Employer may change the order of the tests, request to conduct further tests or substitute certain test.

For the final 100 % loading test, the load shall be maintained for five (5) minutes without any collapse.

In addition to the loading test, a destruction test on the same tower shall be carried out.
Upon satisfactory completion of the loading test, eight (8) members chosen at random by the Employer from the tested tower shall be taken for physical tests at an approved testing laboratory to establish the yield points.

If any condition is not satisfied, the loading test shall be declared invalid and the prototype shall be rejected.

Acceptance of the design and tower test shall only be taken as complete when the design drawing and loading test report submitted by the Contractor has been approved.

After completion of testing, the tested towers shall become the property of the Contractor. No tested towers or any part thereof shall be shipped to the site or used in the construction for the Project.

These tests will be witnessed by a team of two (2) of Employer’s engineers. The Contractor shall inform of the location and date of the tests at least three (3) weeks prior to the tests.

3.9.3 Tower Types to be Type Tested

The Contractor shall be prepared to test any number of samples of any tower type as indicated below:

<table>
<thead>
<tr>
<th>Tower Type (Basic Body)</th>
<th>Body Extension (m)</th>
<th>Leg Extension (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) CA</td>
<td>4.5</td>
<td>-3</td>
</tr>
<tr>
<td>(b) CB</td>
<td>4.5</td>
<td>-3</td>
</tr>
<tr>
<td>(c) CC</td>
<td>0</td>
<td>-3</td>
</tr>
<tr>
<td>(d) CD</td>
<td>0</td>
<td>-3</td>
</tr>
<tr>
<td>(e) CTT</td>
<td>0</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

The Employer will select the types to be tested when the Contractor submits its tower design for approval for manufacture. The Employer will give final approval for manufacture after successful test only.

3.9.4 Foundation Tests

No foundation testing is required; thus foundation tests are not included in the scope of work for this project. In case foundation tests are later requested by the Employer, the tests shall be done following the principles given IEC Standard IEC 61773 "Testing of Structures Foundations for Overhead Lines".

3.9.5 Measurement for Payment

There will be no separate measurement for payment for shop tests, which shall be deemed to include in the unit prices of supply of the appropriate materials.

Payment for loading tests shall be made according to the unit prices of the tests stated in the Schedule of Prices.
Site and Erection Works (TS-2)

KENYA - UGANDA INTERCONNECTION

400 kV DOUBLE CIRCUIT – LINE
(OPERATED INITIALLY AS A 220 kV OHTL)
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Site and Erection Works (TS-2), 400kV Line*
Part 2 : Section VI – Employer’s Requirements
Site and Erection Works (TS-2), 400kV Line
1 General Works

1.1 Obtaining Right-Of-Way and Compensation

1. Prior to starting and during the construction work, the Employer shall obtain and compensate for the following:

   a. Right of constructing the transmission line along the selected line route;
   b. Acquisition of tower sites, as located by the Contractor;
   c. Right of using a strip of land of 60 m long within the right-of-way along the selected line route and;
   d. Removal of houses and other properties, which are to be removed from the right-of-way.

2. The Contractor shall be responsible for the following, but not being limited to, and shall pay at his expense for all necessary costs for:

   a. Compensation for damages to trees, vegetation, crops and the like during the works up to taking over;
   b. Land for storing the plant materials and the Contractor's equipment, and for camps, offices and Works outside the area specified in the above (1) (a) to (c) except as specified in the Particular Conditions;
   c. Construction and removal of temporary access to site and use of private roads, access, and bridges and;
   d. Repair and restoration of public or private roads, access and bridges damaged by the Contractor.

3. The Contractor shall submit five (5) copies of access maps showing the locations of proposed access at least two (2) weeks prior to the commencement of the works to the Employer.

   If any difficulty or trouble should arise in using the lands and the right-of-way arranged by the Employer, the Contractor shall without any delay inform the Employer of the fact.

4. The Contractor shall also be responsible for giving occupiers of land adequate notice of the commencement of the work before the work commences.

   The Contractor shall take all precautions to avoid damage to land, properties, roads, field drains, fences, gates, walls, trees, hedges, crops and the like and shall ensure that the work is adequately supervised so that damage is to be limited to the minimum.

5. In case the Contractor does not disburse duly the compensation, which he is obligated, the Employer is entitled to pay the unsettled compensation and deduct the corresponding sums from the payments to the Contractor.

6. Measurement for Payment

   There shall be no separate measurement for payment for the works described in this Clause.

1.2 Survey

1.2.1 Scope

The line route survey shall include, but not being limited to, the following tasks:

1. The actual line route survey;
2. Map and profile;
3. Land schedule;
4. Mapping of access roads;
5. Preliminary soil investigation;

1.2.2 Line route

The line route has been marked on the map attached hereby in drawing # 0522011-TLUK-018, which shall be followed generally. However, the scale of the available maps is not suitable for specifying the line route in details. Angle points coordinates are provided in drawing # 0522011-TLUK-017 for the transmission line when built at 220kV and in drawing # 0522011-TLUK-030 for a 400kV line.

The surveyor shall follow the route considering the requirements of every single tower location, especially, when locating the route angle points. If the route on the map cannot be surveyed as straight line, the line should be drawn smoothly using angles up to 15 degrees to left and right as needed. Greater angles can be used if necessary.

At the Kenya/Uganda border, it is the Contractor’s responsibility to ensure that the last section of the Kenya/Uganda line is compatible with the alignment of the last section of the Kenya/Uganda line.

1.2.3 Survey Work

1.2.3.1 Line survey

The line survey shall be done in accordance with the described line route and marked on the map attached hereby in drawing # 0522011-TLUK-018.

The surveyed line route shall be clearly marked by concrete or wooden posts or plastic tubes so that the line route can be identified in every section of the line. All route angles shall also be marked by the posts.

All buildings, overhead lines, cables, pipelines, roads, walls, fences, tanks and other firm obstacles, which differ from the general shape of the ground, reaching to the right-of-way area, shall be measured by location, length, height, level and slope and drawn on the line route map. The ground level and slope shall be determined by adequate intervals (20 m) and where the ground slope changes. If the ground slope across the line exceeds 1:25, the level of ground left and right of the centre line shall be recorded at the horizontal distances of 6 and 12 m.

The boundaries of plots of land shall be also mapped up to an offset distance of 16 m on both sides of the centre line.

The line route shall be mapped to the distance of 60 m on both sides of the centre line.

The following levels of objects are to be measured:

1. Roads
2. Crossing of overhead lines and towers
3. Water levels (actual water level with date and time and HW-level)
4. Buildings, tanks
5. Fences and walls, etc.

Water levels in and near waterways at flood stage shall be determined by statistics or approximation by landmarks.

The accuracy of survey shall be such that the vertical tolerance between levels forming the profile and actual ground level shall not exceed 30 cm and the horizontal distance to the accuracy of not more than 0.2%.
1.2.3.2 Map and Profile

After the survey, the map and profile of the line route shall be produced. The right-of-way shall be shown on the map in scale 1:2000 reaching 50 m on both sides of centre line.

The profile of the centre line shall be drawn in horizontal scale 1:2000 and in vertical scale 1:500 (1:200). If the ground slope across the line route exceeds 1:25, the contour of the ground left and right of the centre line shall be shown at distance of 6 m.

All vertical 0.5 m transition points shall be shown on the profile and also the levels the following objects:

1. Roads
2. Crossing of overhead lines and towers
3. Water levels
4. Buildings
5. Fences and walls, etc.

1.2.3.3 Land Schedule

The land schedule of the line route shall be made, showing sheet number, plot numbers, name of owner, area on the line route up to an offset distance of 16 m of the line on both sides of the centre line, particulars of permanent structures and obstructions including major trees, bushes, if there are any on plots of land along the route of transmission line up to an offset distance of 16 m of the line on both sides of centre line.

All trees and bushes which must be cut shall be marked in this schedule, as well as all buildings, which shall be pulled down.

1.2.3.4 Access Roads

All the existing access roads on the line route area shall be marked on the route map. The existing roads from main road to the line route if any shall be listed with description of condition. The possible routes for necessary access roads shall be looked for and described.

1.2.4 Preliminary Soil Investigation

The bearing capacity of soil and soil type shall be estimated visually at adequate intervals and soft soil areas on the right-of-way shall be mapped in order to avoid tower setting at these areas.

The areas, where there is risk of landslides above or below the tower shall be mapped as well as the areas of exposed to erosion.

1.2.5 Soil Resistivity Measurement

The soil resistivity shall be measured at 500 m intervals for characteristics of soil changes. The results shall be recorded in the report mentioning the exact distance from the starting point of the line and the measurement result as well as the soil type.

1.2.6 Estimation of Environmental Impacts

In addition to items mentioned above concerning the environmental impacts as the land use, housing, cutting of trees on the right-of-way, the risk of erosion and landslides, the following areas shall be recorded:

1. Ecologically sensitive areas on the right-of-way or in the vicinity of the line;
2. List of historical and cultural sites with location and description recorded;
3. Settlements, being in the vicinity of the line;
4. List and locations of the bird migration routes, such as valleys crossing with the line.

1.2.7 Route Clearing

During the survey work the bush clearing must be kept as minimum as possible, only such clearing shall be done which is necessary in performing the survey.

1.2.8 Measurement for Payment

Payment for survey work shall be based on the unit prices stated in the Schedule of Prices((will be provided later).

1.3 Transmission Line Design

1.3.1 Tower Plotting

Tower plotting shall be started immediately after the Employer’s approval of map and profile drawings. Tower plotting shall be done either by using approved sag templates or by using PC and approved plotting program.

1.3.2 Tower List

After tower plotting the tower list shall be furnished. The tower list shall include at least the following information:

- Tower number
- Survey number
- Chainage
- Span (tower-to-tower)
- Ruling span
- Horizontal angle
- Wind span
- Weight span
- EDS
- Tower type
- Body extension
- Leg extensions
- Foundation type
- Foundation protection
- Insulator string data (suspension s/d, tension s/d, normal/inverted, jumper support and counter weight)
- Support level
- Support difference
- Span slope: $h_1/S_1$, $h_2/S_2$ and $\Sigma h/S$
Minimum clearance: ground, river, power/telecommunications line, road and other

Remarks: crossing type and land item.

Plotted map and profile drawings and tower lists shall be submitted to the Employer for approval.

1.3.3 Tower Spotting

Immediately after approval of plotted map and profile drawings, the Contractor shall start tower spotting. One concrete centre peg shall be located at the station of the proposed tower location.

In addition to, two reference pegs shall be located so that centre of tower can be found and re-pegged in the case that original centre peg has been moved or destroyed. The size of centre peg shall be 10 cm x 10 cm x 45 cm. The reference pegs can be concrete, wood or steel.

If proposed tower location as plotted in the profile drawing is not suitable by reason of topographical, geological or any other affecting conditions, the Contractor shall be required to recommend the proper location of tower to the Employer for consideration. The Contractor shall carry on the work in accordance with the Employer’s decision.

Tower spotting and measuring of levels shall be performed by the qualified and experience personnel and supervised by the qualified surveyor. Not less than 15 days prior to the commencement of work, the Contractor shall submit qualification of surveyor(s), work program and list of survey equipment for approval of the Employer.

During tower spotting the Contractor shall also make soil investigations at every tower location by using approved method.

In addition to, the Contractor shall measure the earth resistivity at every tower location by using approved method.

All the works concerning this chapter should be carried out under strict supervision and coordination of the Employer.

1.3.4 Measurement for Payment

There will be no separate measurement for payment for transmission line design. Payment for transmission line design shall be included in the unit prices of the survey work stated in the Schedule of Prices.

1.4 Right-Of-Way Clearance and Access Tracks

1.4.1 Right-of-Way Clearance

Clearing shall consist of cutting at the approved or specified heights and disposing of all trees, bush and other vegetation within areas to be cleared; reference shall be made to the drawing # 0522011-TLUK-027.

Clearing of trees and shrubs in the area of right-of-way shall be carried out in compliance with the local applicable laws, rules and regulations, and Employer’s practice.

In addition to the above, all tall trees or other obstructions outside the right-of-way which may fall down within 3.5 m of any line conductor under still air or which will likely interfere with the operation of the transmission line (called as danger trees) shall be checked by the Contractor and to be trimmed, cut down or dismantled by the Contractor upon direction by the Employer.

For spans across deep valleys, the right-of-way need not be cleared for the bottom of the valley but must be cleared for a distance of 8 m from any tower leg.

Clearing shall be completed (final clearing) by the Contractor one month before starting of operation of the transmission line and the Employer will compensate for trees to be cut in the right-of-way.
1.4.2 Access Tracks

The Contractor shall construct, maintain and demolish the temporary access tracks for approaching the construction sites. The route and construction programme for temporary access tracks including associated drainage, stream crossing facilities, bridges, etc., to and around the working sites; and the construction schedules shall be submitted by the Contractor to the Employer for his approval.

The Contractor shall adhere strictly to ADB’s Environmental Assessment Guidelines, local environmental regulations, the Employer’s practice and stipulations in Scope of Supply, Clause 2 when constructing the temporary access tracks. The most salient principles of the Environmental Management are, but not being limited to, such as:

- Minimize the need to construct of new access tracks wherever possible;
- Employment of existing access roads and tracks wherever available;
- Decommission additional temporary access tracks at end of construction; and
- Where access is required across agriculture lands use temporary access paths during dry season involving placement of geotextile over which aggregates shall be placed.

1.4.3 Measurement for Payment

There will be no separate measurement for payment for temporary access tracks.

Payment for right-of-way clearance work shall be based on the unit prices stated in the Schedule of Prices.

2 Foundation Works

2.1 Soil Test

2.1.1 Scope

This specification covers all the work required for geotechnical investigations at tower locations and laboratory soil tests. The work includes all necessary equipment and labour required for carrying out the soil investigation as specified hereafter. The work includes a detailed report on soil investigations and laboratory tests. The methods and the amount of soil tests shall be described herein.

The purpose of the soil test is to determine and verify the soil parameters used in foundation design. The subsoil conditions shall be determined at each tower location by using light static dynamic sounding method (LSD-sounding). At a certain number of tower locations additional and more detail soil tests shall be carried out with standard penetration test (SPT-probing) and laboratory analysis.

2.1.2 Codes and Standards

All work shall be carried out in accordance with the relevant international standards such as BS, DIN, ANSI, etc. Preferably British Standard shall be used whenever practical.

2.1.3 Field Work

2.1.3.1 General

The survey and mapping team will be accompanied by a soil investigation team (LSD sounding team). This will comprise of a supervisor and the necessary number of assistants. The supervisor shall be a qualified and experienced engineer, geologist or similar. The SPT tests shall be taken at a certain number of locations as agreed upon with the Employer. The SPT tests and laboratory tests shall be carried out by a qualified company and testing laboratory.

The details for LSD-soundings and SPT-tests shall be subject to approval by the Employer.
2.1.3.2 Method of Drilling

Drilling or augering in soil shall be done according to instructions and standards regarding the probing method. Dynamic methods (hammering, hitting, Dynamic cone penetration) may be used when hard soil strata is met and hand augering is no longer possible. The drilling log diagrams, SPT N-values or LSD blow counts, ground water table observations, soil description and thickness of different soil strata shall be reported at each investigation point.

The drill hole depth is usually 6 metres, minimum depth being 3 metres in case of very hard soil stratum that contains big stones, cobbles or boulders. In case of very soft clay or clayey soil the drilling shall be continued up to one metre depth inside the hard soil stratum. The maximum drilling depth for SPT in this case may be about 20 metres.

2.1.3.3 Soil Sampling

Sampling shall be done according to BS or other equivalent standards.

Disturbed soil samples may be taken with the split spoon sampler of the SPT test equipment and the samples shall be securely sealed and systematically labelled in plastic bags. The number of disturbed soil samples to be taken will be determined at the time of the detailed soil investigations.

Undisturbed soil samples for in-situ density, unconfined compression and consolidation tests shall be collected by means of an open tube sampler. The number of undisturbed soil samples will depend on the occurrence of the cohesive soil or very soft clay at the actual tower location. Undisturbed soil samples shall be taken sufficiently to define the required soil properties by laboratory analysis.

Numbering and labelling of all soil samples shall be clear and unambiguous. The samples shall be properly packed and securely transported to the testing laboratory.

2.1.3.4 LSD Soundings

The light static dynamic soundings shall be carried out at each tower location according to the detail description, which shall be given for review and approval by the Employer.

2.1.3.5 Standard Penetration Test (SPT)

Standard penetration tests shall be carried out at one-metre intervals according to BS or other equivalent standards. The number of blows (N-values) for every 150 mm penetration shall be recorded.

2.1.4 Laboratory Tests

All the laboratory tests shall be done in proper soil testing facilities and shall be performed by qualified and experienced personnel. The tests shall be carried out according to the BS standards or equivalent.

The final number and quality of laboratory testing shall be subject to approval by the Employer. The scope of laboratory tests together with SPT tests include:

a. tests for determining the physical properties of the soil such as moisture contents, specific gravity, grain size distribution etc. (sufficiently per each SPT investigation point)

b. unconfined compression tests for cohesive undisturbed soil samples (two to four tests for the length of the transmission line)

c. direct shear tests for non-cohesive soils (one or two tests per each SPT investigation point).

The quantity of laboratory tests to be performed shall be limited to those mentioned in parentheses above.

2.1.5 Formal Report of the Test Results

The Contractor shall draw up and submit a full test report of the soil tests for review and approval by the Employer.
The report shall contain test results and observations as well as recommendations for foundation types to be used. The report shall also contain a brief geological description of the line route, history for regional seismic activities, recommendations for types of foundations to be used, soil bearing capacities and considerations for deleterious effects of the soil (soil aggressivity) for concrete foundation structures.

2.1.6 Measurement of Ground Resistance

The Contractor is required to perform ground resistance tests at every support location. Methods of measurement, tools and instruments shall be submitted to the Employer for approval.

2.1.7 Measurement of Payment

There will be no separate measurement for payment for soil tests. Payment for the soil tests shall be included in the unit prices of the survey work stated in the Schedule of Prices.

2.2 Earthworks, Excavation and Backfilling

2.2.1 General

This specification covers the requirements for all necessary earthworks for tower foundations, grounding, foundation protection work, and possible access roads. Excavation and backfilling and other related earthworks including dewatering and shoring the excavation pit, removal, storage and stockpiling of the soil are also specified herein.

The Contractor shall furnish all tools, equipment, machines, labour, and supervisory personnel to perform the work as specified herein.

The Contractor shall carry out a check survey of the site before excavation and properly set all lines and levels for foundations.

2.2.2 Excavation and Backfilling

The soil types encountered on this line route are specified in Foundation Application Schedule (will be provided later). Soil is defined as material, which can be removed and excavated by shovels and pick axes. Excavated material suitable for backfilling the foundations shall be stockpiled for later use. Unsuitable material shall be disposed. The stockpiles should be sloped and protected from rainfall.

Rock excavation shall mean excavation made in "hard rock" as specified. Definition for "hard rock" shall mean hard stratum, which in excavation requires to be loosened by blasting or pneumatic tools or if by hand, by wedges and sledge hammers. Rock excavation shall also include loosening, stripping and excavating large embedded boulders, which are larger than 500mm in any direction. Also loose or semi-detached rock boulders close to the excavation may need to be removed. The volume of this rock excavation shall be measured or estimated from the drawings, and the payment shall be based on the volume of the excavated rock and the unit price as given in the Schedule of Prices (will be provided later) for "Rock Excavation".

Excavation for foundations shall conform to the dimensions and elevations as shown in the approved design drawings. When foundations are built directly on the excavated soil, special care shall be taken not to disturb the bottom of the excavation pit.

All excavation work, shoring of the excavation and stockpiling of the excavated soil shall be done in such a manner to ensure the safety of site personnel or any other person.

The clearing of the tower site is specified elsewhere in this specification. However, when roots or stumps of trees are met during the excavation they shall be removed, if necessary.

All gold, silver, oil, mineral, coins, and other precious objects or archaeological findings, which may be found at tower sites or during excavation, shall be the property of the Employer.

For excavations where the base is unstable or very soft and/or lies below the groundwater level, shall be covered with a compacted layer of gravel, select borrow or crushed stones, if found necessary for carrying out the work as specified and approved by the Employer. Blinding concrete C10 of 10-15 cm in thickness may also
be used. The payment of this soil strengthening shall be based on the volumes measured at site or estimated from the design drawings. The unit price for this work shall be given in the Schedule of Prices for "Blinding concrete C10" or "Compacted gravel".

At the nominal excavation depth for the foundation as stated in the approved design drawings, the bottom of the excavation shall be graded and examined by the Contractor and the final determination of the applied foundation type shall be done. The Employer shall verify the final foundation type at site by signature.

Backfill shall be placed in layers not exceeding 300 mm in thickness before compaction. The compaction shall be done by mechanical or pneumatic equipment or by other appropriate means approved by the Employer. Large stones, trash, wood, roots or other organic materials may not be used in backfill. Rock particles larger than 100 mm may be used in backfilling, if they are not in direct contact with the foundation.

No separate payment will be made to the Contractor for excavation and backfilling of the tower foundation. All costs incurred in connection therewith shall be included in the unit price for the construction of the various foundation types.

The following, however, shall be priced separately:

a. Soil strengthening by blinding concrete C10 and/or compacted gravel
b. Excavation and backfilling for foundation protection

2.2.3 Dewatering

All excavations shall be kept free of water, if found necessary for carrying out the foundation construction work as specified.

The Contractor shall remove by pumping or by other proper means all rainwater or ground water accumulated in the excavation pit, in case the water may disturb the soil in the excavation pit or harm the foundation work. Suitable pumping equipment shall be provided and used for dewatering so that all installation work and backfilling can be performed in a dry state. The method of pumping shall be adequate to ensure proper construction work and subject to approval by the Employer.

No separate payment will be made to the Contractor for dewatering the tower foundation. All costs incurred in connection with dewatering shall be included in the unit price for excavation.

2.2.4 Timber Shoring

Timber shoring may have to be used in open excavations for foundations.

Timber shoring, when constructed, shall be built strong and safe to prevent the sides of the excavation from collapsing. Depending on the soil type and the depth of the excavation, the shoring shall be of closed or open type. Closed timbering is used to cover the excavation walls completely leaving no gaps in between adjacent timber boards. The type of timber shoring shall be subject to approval by the Employer.

No separate payment will be made to the Contractor for timber shoring. All costs incurred in connection with timber shoring shall be included in the unit price for the construction of the various foundation types.

2.3 Foundation Construction

2.3.1 General Requirement

The Contractor shall furnish all material and labour required for the construction of foundations.

a. The Contractor will be required to remove and replace at his expense any material incorporated in the work that does not conform to these specifications.

b. The Contractor shall furnish the Employer without any extra cost all materials required for testing. The scope and amount of testing will be specified here in this specification. The cost of specified tests shall be borne by the Contractor.
The preliminary selection of the foundation type to be actually constructed will be done by the Contractor after the soil test and shall be subject to the approval of the Employer. The final selection of the type of foundation is done at the tower location after excavation.

### 2.3.2 Measurement for Foundation Payment

Measurement for payment for the Contract item "Foundations" shall be on the basis of the actual number of each type of structure foundations constructed by the Contractor.

### 2.3.3 Payment

Payment for the contract item "Foundations" will be made at the unit price per tower foundation type. The unit prices for each different foundation type are to be given in the Schedule of Prices. The unit price for "Foundations" includes:

- **a.** Strength calculations, detailed foundation design and construction drawings of the foundation types listed in the Schedule of Prices (will be provided later).
- **b.** Supply and transporting of all foundation materials to the tower site.
- **c.** Foundation orientation.
- **d.** All equipment and labour required for completing the specified work.
- **e.** Excavation, dewatering and timber shoring when necessary, and backfilling for the foundation.
- **f.** Concreting and reinforcement including all material and work.
- **g.** Stub setting.
- **h.** All other foundation works specified here in this specification.
- **i.** The following, however, shall be priced separately:
  - **j.** Blinding concrete C10 and compacted gravel
  - **k.** Additional concrete C20 and reinforcement
  - **l.** Special Foundation types

These items will be paid by quantities measured at site or calculated from the drawings and the corresponding unit price given in the Schedule of Prices (will be provided later).

### 2.3.4 Standard Specifications

In general, all international standards, BS, ACI, ASTM, DIN or equivalent shall be used to perform the required construction works. Preferably British Standards (BS) shall be applied whenever practical. All materials and workmanship shall also comply with the local applicable laws, rules and regulations.

### 2.3.5 Concrete

The Contractor shall design concrete mixes to meet the strength requirements for Grade C20 concrete according to BS 8110 and BS 5328: Part 1. The characteristic compressive cubic strength shall be $f_{cu} = 20 \text{ N/mm}^2$ at 28 days. The minimum cement content of concrete shall be 300 kg/m$^3$.

Prior to start of construction work, the Contractor shall be responsible of selecting and testing the concrete mix proportions in laboratory conditions to achieve the required concrete strength and other requirements. The test cube set consists of three 150 mm test cubes, and the laboratory testing shall be done using two different water/cement-ratios. The test cubes shall be made and tested in accordance with the applicable standards (for instance: test cubes and testing methods according to BS 1881: Part 108 and Part 116 and the test results according to BS 5328: Part 4).
After the laboratory tests the Contractor shall submit the test results for review and approval to the Employer. The Employer shall notify the Contractor within 14 days of the acceptance of the test results and design mixes.

The concrete may be ready-mixed, site-mixed or hand-mixed concrete. The concrete shall be composed of cement, fine and coarse aggregates and water. Only approved admixtures are allowed being used, if found necessary. The fresh concrete shall be well mixed at site to make a homogenous and plastic paste, which workability suits the methods of transport and placing.

The water/cement ratio shall be maintained.

When placing concrete in hot weather the recommendations of the ACI publication "Hot Weather Concreting" (ACI 305) or equivalent shall be followed. The temperature for the fresh concrete at placing should not exceed 35 degrees centigrade.

Concrete to be placed under water (submerged concrete) shall be deposited by tremie, when no other means can practically and reliably be used. Normally, the water should be pumped out from the pit before concreting.

2.3.6 Cement and Aggregates

In locations where conditions do not require high sulphate resistance, cement shall conform to the requirements of BS 12 Portland Cement (or ASTM C150 type I, type T or type V).

At least compressive strength and setting times of the cement shall be tested initially, and the cement manufacturer's test certificates (delivery tickets) are required. The cement used shall be subject for the approval of the Employer.

Fine aggregates (sand) and coarse aggregates shall be clean, natural or crushed material.

Maximum particle size for fine aggregate shall be 5 mm. Coarse aggregate shall have particle sizes between 5 - 40 mm. Each source of the fine and coarse aggregate shall be tested initially.

The following tests shall be carried out:

a. sieve analysis according to BS 882 or US Standard sieve analysis according to ASTM C 33;

b. the amount of fines (passing 75 mm sieve, should not exceed 2-4 %) according to BS 882;

c. water absorption test (BS 812 Part 2: should not exceed 3 %);

d. mechanical strength by Los Angeles abrasion test by ASTM C 131, limits given in ASTM C 33 or alternatively by ten per cent value test according to BS 812: Part 111, limits given in BS 882;

e. specific gravity ;

f. chemical analysis showing the mica content and for finding out if the aggregates contain any deleterious organic impurities.

2.3.7 Water and Slump

The water used for mixing concrete may be obtained from locally available sources and should be clean, potable water. The water shall be free of harmful quantities of organic material such as sugar, oil, silt, humus, alkali, sulphates or acids. The water cement ratio of the concrete should be kept as low as possible (maximum free water cement ratio w/c = 0.60), especially when using hand mixing. The main effort shall be put on achieving workable and homogenous concrete paste. Recommendations for different water cement ratios are specified for instance in BS 5328.

The slump, measured in laboratory conditions only for design mix, should be between 50 - 125mm. The slump for hand mix concrete is not an essential factor to be tested in field conditions.

The slump for ready-mixed concrete or site mixed concrete by batch mixer shall be controlled and maintained between the above values.
2.3.8 Storage of Material

Cement and aggregates shall be stored at site in such manner as to prevent deterioration or intrusion of foreign matter. Special care shall be taken in storing cement to keep the cement thoroughly dry at all times.

Cement should not be kept in storage for more than three months. When pressed between fingers the cement is usable if it powders easily.

The reinforcing steel shall be protected in order to prevent excessive rust development. Excessive rust shall be removed before usage.

2.3.9 Concrete Mixing and Placing

Prior to any concreting work the Contractor shall do the following checks:

a. Before any concrete mixing is begun, all equipment for mixing and transporting shall be cleaned of all dirt and debris.

b. All mechanical equipment shall be checked to be in good operating condition before any concreting work is begun.

c. The stock of construction material (cement, sand, coarse aggregate, and water) shall be checked to ascertain their sufficient quantities.

d. The Contractor shall notify the Employer when the foundation location is ready for concreting and the Employer shall give the permission to start concreting by signature.

e. The Contractor shall insure that the excavation pit is free of water, mud and debris, the excavation bottom is well levelled and compacted, the reinforcement is properly installed, the formwork is properly braced and the stub angles are securely fixed at the correct level and location.

All concrete components shall be accurately measured. Measuring on a weight basis is preferred, however, measuring on a volume basis will be allowed if careful controls are maintained.

Normally, the concrete is mixed manually (hand-mix). The mixing shall continue as long as it is required to make a homogenous, plastic and workable concrete paste. When using mechanically operating batch mixer, the mixing shall be continued for at least one and half minutes. Fresh concrete should not be kept in the mixer for more than thirty minutes before placing. Fresh concrete shall be placed, compacted and finished as quickly as possible.

When concrete is to be placed on hard rock or hardened concrete, the existing surface shall be properly wet. The first batch of concrete shall be a grout made of cement, sand and water only.

The concrete should not be placed dropping more than two meters.

The concrete shall be compacted during and after placing by vibration. The concrete vibrators shall be efficient enough for the purpose and shall be kept in good operating condition at the location of the work.

2.3.10 Concrete Test Cubes

The Contractor shall make one set of test cubes (one set = three cubes) for each tower place until satisfactory quality of concrete is proven by repeatedly passing test results. Thereafter the Employer can accept a reduced number of test cubes. The test cubes shall be made and tested in accordance with the relevant BS standards as directed in the other parts of this specification. The costs for the concrete compressive strength tests shall be borne by the Contractor. Tests shall be witnessed by the Employer.

The standard methods for making, handling and testing of the test cubes are described in detail in BS 1881: Part 101, Part 108 and Part 116. The test results shall meet the requirements given in BS 5328: Part 4. Two of the test cubes shall be tested at 28 day of age and the remaining one cube shall be tested at 90 day only if the first two cubes fail to fulfill the specified 28 day strength requirements.
Should the 90 day test fail to produce specified results additional tests such as the Swiss hammer or testing of the core drilling samples from the ready, hardened structure shall be made to prove the strength of concrete. Whenever the quality of the concrete becomes under suspicion the Employer shall immediately make a written site note for the Contractor.

2.3.11 Concrete Formwork

Formwork shall be strong and rigid enough to withstand the pressure resulting from placing and vibrating the concrete. Forms shall be tight enough to prevent loss of mortar from the concrete.

All permanently exposed concrete corners (above ground level) shall be chamfered.

Templates made of mild steel can be used to hold the stub angles at their correct position during the concreting work. Other sufficient means of assuring the accurate stub location may also be used. Also the lowest part of the tower body may be used for bracing and supporting the stub angles at their correct position.

The material used for formwork may be steel, timber, plywood or wood. Before concrete is placed, the surfaces of all forms shall be oiled with suitable form oil.

Forms shall be removed only when sufficient strength of the concrete is achieved. As a rule, the forms shall not be removed until 48 hours after concreting. Any concrete damaged by form removal shall be repaired.

The tolerances for stub setting dimensions, foundation dimensions etc. shall be subject to the Employer’s approval and stated in the assembly/design drawings.

2.3.12 Concrete Finishing and Curing

The exposed top surfaces of all concrete foundation piers shall be wood floated and steel trowelled and shall be slightly sloped to prevent the accumulation of water.

After the removal of forms, the holes left by form tie rod fasteners shall be filled with mortar and all damaged or defective concrete shall be repaired or removed and replaced. Improperly consolidated concrete shall be chipped off and the remaining openings or recesses shall be carefully filled with patching material. Dry pack mortar is recommended in patching concrete voids.

To ensure proper curing, the concrete shall be kept moist for a period of at least 7 days. Burlap, other equivalent material or frequent watering shall be applied over exposed concrete surfaces. The burlap (or foundation top) shall be kept moist at all times. If the foundation is backfilled before the week’s (7 days) curing time has elapsed, the burlap (watering) protection shall remain on the exposed projection.

The foundation shall not be backfilled before the possible defects and voids are identified and properly repaired. The foundation shall not be subjected to any additional loads from the tower until the curing period has elapsed.

2.3.13 Payment

No separate or direct payment will be made to the Contractor for the concrete of foundation. All costs incurred in connection therewith shall be included in the unit price for the construction of the various foundation types. All exceptions to this are mentioned elsewhere in this Specification, especially the items that will be paid by measured quantities and corresponding unit price. However, the concrete used in protection works for foundation will be made at unit price.

2.3.14 Steel Reinforcement

Steel reinforcement shall be deformed, high yield ($fy \geq 400 \text{ N/mm}^2$) steel bars conforming to the requirements of international standards such as BS 4449 or equivalent. The Contractor shall obtain the Employer’s approval for the supplier and quality of the steel reinforcement.

Mill scale, loose rust, oil, mud or other harmful substances shall be removed before reinforcing steel is placed.

All reinforcement shall have a protective concrete cover of not less than 80 mm on the bottoms of the footings and 50 mm on the vertical faces of the excavation pit, formwork and foundation top.
Steel reinforcement bars shall be securely and accurately placed at their correct position. Reinforcement bar intersection points and splices shall be tied together with annealed wire or suitable clips. Concrete blocks shall be used at the bottom of the foundation to support the reinforcing steel. Proper means shall be used to ensure the required concrete cover between the forms and the reinforcing bars.

2.3.15 Payment

No separate or direct payment will be made to the Contractor for the steel reinforcement of foundation. All costs incurred in connection therewith shall be included in the unit price for the construction of the various foundation types. All exceptions to this are mentioned elsewhere in this specification, especially the items that will be paid by measured quantities and corresponding unit price.

However, the reinforcement steel used in protection works for foundation will be made at unit price.

2.4 Foundation Protection Work

Structure foundations located near river banks or at steep hillsides or ridges or other required places shall be protected by gabion or stone masonry walls. The tower locations, which require protection work, shall be determined during the execution of foundations and are subject to approval by the Employer. The final number of towers to be protected and the quantity of protection will be defined only after completion of the foundation work.

The design of the gabion walls or stone masonry walls shall be done by the Contractor and shall be included in the unit prices of these items in the Schedule of Prices (will be provided later). The design shall be completed in detail at the tower location by taking into account the surrounding terrain and other conditions.

2.4.1 Gabion Walls

The standard type gabion shall be made of hot dip galvanized steel wire mesh. The steel wire shall be at least 3 mm thick and the size of the mesh shall not be more than one third of the smallest stone filled in the gabion. Locally available mild steel wire mesh and mesh sizes may be used. The standard gabion box dimensions are: length 2.0 m, width 1.0 m and height 0.5 m. If needed, the size of the gabion wall boxes may vary from the standard dimensions. Usually, the gabion boxes are buried at least 0.4 m in the surrounding ground.

All edges of the gabion shall be mechanically selvedged to prevent unravelling of the mesh. The wire used for the selvedge shall be of greater diameter than the original mesh wire. The adjacent gabions shall be tied together with sufficient quantity of lacing and connecting wire.

The stones for filling in the gabion mesh shall be taken from the river deposit material if not otherwise agreed with the Employer. The stones shall be strong and solid having no visible cracks or holes or loose rock material or laminations. The stone blocks shall be of natural irregular cubical shape. Thin sliced stone blocks shall not be accepted. The size of the stone shall be at least 10 cm.

2.4.2 Stone Masonry Walls

The stones shall be hand placed with uncoursed close joints to the lines and grades as designed. The rubble stone shall be placed with 1:3 cement mortar after having joints thoroughly moistened. The surface joints shall be finished with 1:3 cement mortar. After completion of the masonry wall, it shall be cured with water for more than 10 hours. The top of the masonry wall shall be capped with smooth layer of concrete.

The width to height ratio for stone masonry structures shall be 0.6.

Weep holes for drainage shall be perforated PVC pipes of diameter not less than 5 cm. The pipes shall be buried in the stone masonry wall at two metres intervals with a 10 % slope. Vertical drainage ducts of size 0.2 m x 0.4 m shall be made of gravelling to allow drainage water to flow into the pipes.

In cases where stone masonry is used for upper foundation legs, there may be a need of stone masonry water ditches, which shall be designed in a way the water flows away from the lower foundation legs. Stone masonry water ditches may have to be designed and constructed whenever there is a need to control water flow at tower locations.
2.4.3 Measurement for Payment

Measurement for payment of gabion walls shall be based on the constructed volume of gabions in cubic meters. The corresponding unit price for "Gabion Wall" is given in the Schedule of Prices. The unit price shall include all labour, tools and equipment, material, transporting and placing, and all other costs necessary for completion of the gabion walls.

Measurement for payment of stone masonry shall be based on the constructed volume of stone masonry in cubic meters. The corresponding unit price for "Stone Masonry" is given in the Schedule of Prices. The unit price shall include all labour, tools and equipment, material, transporting and placing, and all other costs necessary for completion of the stone masonry.

2.4.4 P.C.C. works

P.C.C. works (plain concrete) used for foundations of gabion walls or stone masonry works shall be of grade C10 plain concrete.

2.4.5 Excavation and Backfilling

The scope of excavation and backfilling as stated herein shall cover the excavation and backfilling works for:

a. foundations for gabion walls or stone masonry works, or

b. cutting of earth in places where sufficient ground clearance of the line is not available, or

c. levelling at the tower location to fit the foundation tower leg height differences.

2.4.6 Reinforcement

The additional reinforcement used for gabion or stone masonry wall foundations shall be covered here.

The detail specification for the reinforcement bars (rebars) shall be the same as in the tower foundation works.

2.4.7 Measurement for Payment

Payment for the contract items P.C.C. works, excavation and backfilling and re-bars used for foundation protection works will be made at the unit price. Therefore the unit price given in the Schedule of Prices shall include full compensation for all costs incurred in furnishing all materials and labour.

3 Erection of Towers

3.1 Erection Work

At least two months prior to commencement of erection work the Contractor shall submit to the Employer for approval his method of tower erection and particulars and quantities of main tools and equipment.

No tower shall be erected until 7 days after placing of the foundation concrete and before proper backfill and compaction without the Employer's approval.

If shop errors in the steel members are discovered, the Contractor shall notify the Employer who will decide whether the errors may be corrected in the field, or the members returned to the Manufacturer for correction or replacement at the Contractor's expense.

Erection/assembly of towers shall be carried out in strict accordance with the Erection Drawings and the Tower List approved by the Employer and the conditions stated hereinafter.

On the occasion of assembling the joining parts of the posts of each section, all bolts to be applied for the section shall be inserted by hanging up the posts, and at least four (4) pieces of bolts for upper and lower positions and both sides shall be completely finish-fastened.
Bracing materials shall be attached to each section, and finish fastening shall be carried out so that no torsion of whole of the steel tower or no gap between each part is produced.

Tower members shall not be strained or bent during erection. No gin poles or wire ropes shall be directly mounted on tower members without adequate protection with burlap. Contact surface of joints shall be cleaned and cleared of foreign material and dirt before assembly.

Reaming or drilling of bolt holes to enable connection to be made at the site shall not be permitted without approval by the Employer. Such drilling or reaming if approved shall be repainted with zinc rich paint as directed by the Employer.

All bolts shall be so installed that their heads are in the "down and in" position. The Contractor shall verify the propriety of tightness of bolts with calibrated torque wrenches with the Employer’s witness. The required tightening torque is shown in the table of Clause 8.8. Wrenches used for bolt tightening shall be subjected to the approval of the Employer. The use of any wrench which may deform the nut/bolt head or cut or flake the galvanizing will not be permitted.

Damage to galvanized surface shall be brushed out, washed off and painted with two coats of zinc rich paint without extra cost.

Members that are bent, twisted or otherwise deformed in storage, transportation, handling or erecting operations shall be straightened or replaced by the Contractor. Straightening shall be done only by the use of methods that will not injure the galvanized coating. The method of straightening shall be approved by the Employer. Tolerances for lateral variations of straightened members shall be as follows:

<table>
<thead>
<tr>
<th>Member Type</th>
<th>Tolerances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression Members</td>
<td>2/1000</td>
</tr>
<tr>
<td>Tension-only Members</td>
<td>6/1000</td>
</tr>
</tbody>
</table>

Number plates, danger plates, phase indication and circuit plates shall be fixed on front and back faces of each tower at height of approximately 3.0 m from the ground as indicated in the Erection Drawings.

Anti-climbing devices shall be fitted at a height of 3m to 5 m above the highest ground level at tower location as instructed by the Employer.

After erection, all towers shall be cleaned of all foreign materials and dirt. Climbing step bolts below the anti-climbing devices shall be removed immediately after the stringing work is completed and they shall be returned to the Employer before the completion of the line.

For threads of all bolts below anti-climbing device shall be punched or jagged as to render the removal of nuts almost impossible and as measure against vandals and shall be coated with zinc rich paint after punched or jagged.

In case that the leg extensions are provided, cost for erection of such extended portions shall be deemed to be included in the prices for erection of tower.

### 3.2 Grounding of Tower

All towers shall be grounded by means of grounding device on minimum two diagonal legs. Refer to drawing 0522011-TLUK-023, and to Scope of Supply, Clause 3.6.12.

### 3.3 Measurement for Payment

Payment for tower erection work shall be based on counting the number of towers completed at the unit prices stated in the Schedule of Prices.

Payment for supply and installation of notice plates and anti-climbing devices shall be based on the unit prices stated in the Schedule of Prices.
4 Stringing Work

4.1 General

Conductor erection shall be carried out entirely by approved methods keeping conductor off the ground at all times when the conductor is in motion.

At least two months before stringing commences the Contractor shall submit to the Employer for approval comprehensive work proposal (stringing schedule) that shall include, but not being limited to, the following:

1. Methods for stringing and details of stringing equipment
2. Location of conductor drums and stringing equipment
3. Temporary stay arrangements and temporary support strengthening
4. Scaffolding positions and types
5. Position of mid span joints
6. Procedures and methods for making joints and dead-end clamps
7. Schedule of conductor accessories to be fitted
8. Sag and tension charts

4.2 Tension Stringing Equipment

Tensioning bull wheels shall have a minimum diameter of 35 times the outside diameter of the conductor and will have multiple grooves lined with neoprene. Brakes and controls shall be hydraulically operated to minimize danger or brake failure. The tensioner design shall be such that once the required tension is obtained, the conductor will remain at that tension so long as the brake setting remains unchained.

Conductor stringing pulleys shall be so designed as to allow conductors to be pulled out smoothly and shall have a minimum diameter of 35 cm. Stringing pulleys will be of low friction and the pulleys groove shall be lined with neoprene. Pulleys are to be designed so that the pilot wire does not damage the neoprene lining during conductor running. Pulleys shall be inspected daily for proper operation. The use of defective pulleys shall not be permitted.

4.3 Stringing Procedure

The Contractor shall string and sag the conductors and the ground wires in accordance with the Drawings and Specifications. After sagging, the point of attachment shall be marked on each conductor in a manner satisfactory to the Employer. The insulator assemblies shall be attached to the conductors at the points marked on the conductors.

Care shall be taken during handling and storage to prevent abrasion or other damage to the cables. Prior to installation, reels of conductor shall be stored blocked-up off the ground and adequately supported so as to avoid damage to reel, lagging and conductor. Cables and reels shall be kept free of standing water, dust and mud.

Lagging or other protective covering shall be removed at the job site and the outside layer of each reel shall be examined by the Contractor and the Employer to ensure that the cables are in good condition and that no nails, staples or other sharp objects, which would damage the cables during unreeling, protrude on the inside of the reel heads. At no time shall the cables be dragged over the ground or any other rough surface.

4.4 Stay and Scaffolding

1. All such towers which may be subjected to excessive loading during stringing and sagging of the conductor
and ground wires shall be reinforced with backstays in an approved manner.

2. Such cross arms as may be subject to heavy vertical loading shall be reinforced with armtie guy wires. Methods of stringing and sagging procedure as may be subject to unbalanced loading and torsional force on both sides of arms shall be avoided whenever possible. The Contractor shall submit for approval to the Employer his proposed practice of stay-wire when he submits his detailed account of stringing procedure.

3. The Contractor shall provide, at his own expenses, suitable scaffolding during the stringing work where the line crosses over national roads, local roads, power lines, telephone lines, etc., which the Employer considers to be protected.

4. The height of scaffolding shall be such that the clearance of conductor may not be less than 7 meters to road, 1.5 meter to 20 kV power lines, 1 m to 6.6 kV lines and 0.6 meter to low voltage lines and telephone lines. No part of the scaffolding shall approach power or telephone lines within the distance aforementioned. The cost for the scaffolding and preliminary works shall be included in the rate of appropriate stringing works.

5. The Contractor shall be responsible for giving necessary notice to and obtaining the approval from the related authorities prior to the erection of such scaffolding. Two (2) copies each of such notice and approval shall be submitted to the Employer.

4.5 Stringing of Conductors and Ground Wires

Conductors shall be pulled out and strung by an approved tension stringing method. Cables shall, as a principle, never be allowed to touch ground.

The Contractor shall submit in writing, for the approval of the Employer, a complete and detailed description of the stringing equipment and the stringing and sagging procedure intended for use.

Not later than 2 months before commencing the cables installation work, the Contractor shall submit a general stringing plan to the Employer, for approval. The plan shall describe the Contractor’s proposed work schedule, method of stringing, temporary guying, scaffolding, personnel required in performing the work and a list of tools, communication equipment and stringing equipment to be employed.

In addition, not later than 2 weeks before commencing stringing work in any section of the line, the Contractor shall submit details of the unreeling section, location of reels, pullers, tensioners, snubs and temporary guying, scaffolding, splices and lengths of cables to be strung to the Employer for approval.


Unless otherwise approved by the Employer, the tension stringing procedure shall be in strict conformity with the recommendations of the manufacturer of the stringing equipment. Only specially trained linesmen who are well acquainted with the handling and running of the particular equipment to be used shall be employed.

Reliable means of instantaneous two-way communication shall be available between the pulling and the braking crews, and between these crews and any observation posts that may be placed along the stringing section.

The stringing equipment shall be set up so as not to cause excessive vertical loads on the towers. The distance to the nearest tower through which the cables are being strung shall be selected with due regard to the relative levels of the pulleys on the tower and the stringing equipment. A reasonable allowance should also be made for possible accidental over-tensioning of the cables.

Stringing pulleys shall preferably be located at approximately the same levels as that which the conductors and the galvanized steel ground wire will occupy when installed.

At all times during stringing, the conductors shall be handled and protected so as not to be scratched, nicked, abraded, kinked or otherwise damaged. If during stringing it should prove inevitable to lower the conductors to the ground, suitable non-metallic lagging shall be placed underneath.
Stringing pulleys shall have adequate strength and shall be of approved design. They shall be equipped with ball or roller bearings. The sheave diameter measure at the bottom of the groove shall not be less than 15 times the outside diameter of the conductor or galvanized steel ground wire. The groove shall be wide enough for the passage of compression joints. Stringing pulleys for the conductors shall have the sheave grooves lined with electrically conductive neoprene or equivalent.

Pulleys shall be inspected daily for proper operation. The use of defective pulleys will not be permitted.

Cables, which have been subject to bird-caging during stringing, will not be accepted. Stringing tensions shall, at no times, exceed corresponding sagging tensions by more than 20%.

Clamps for attaching the conductors to the hauling device shall be of approved design and shall prevent relative movements of strand or layers of the conductors or galvanized steel ground wires. Freely rotating ball bearing swivels shall be used for each cable to be strung.

If, for any reason, stringing operations in progress must be interrupted, the conductors may be left in the stringing pulleys, but their tension shall be reduced as far as possible. In all cases, however, the cables must be kept completely clear of the ground, by approximately 2 m, and sufficiently far from any obstacles, which might cause abrasion of the cables, if touched by them.

If the interruption lasts for more than 40 hours, or if stormy weather has prevailed, the cables shall be closely inspected for damage. Such inspection applies particularly to the suspension points where the cables have been resting in the pulleys sheaves.

At all times during stringing, sagging and clamping operations, the conductors, reels and hauling equipment shall be effectively grounded.

The Contractor shall make suitable arrangements for temporary staying of towers, where necessary. Suitable plates (detachable or otherwise) shall be provided on the towers for attachment of any temporary stays.

### 4.6 Insulators

Insulators shall be packed in wooden crates and shall be delivered to the job sites in their original containers. They shall not be unpacked until their utilization.

All insulators shall be inspected before their assembly in accordance with the required number to form the appropriate sets. The Contractor shall ensure that the insulating material, the caps and pins are free from any defects.

All damaged insulators shall be rejected, whatever damage it may be, and whether it is on the insulating material, the metal parts or the galvanized coating.

Prior to installation and immediately before hanging, the insulators shall be thoroughly cleaned and all cotter pins shall be checked for correct positioning and freedom from defects.

Insulator strings shall be carefully lifted into position without undue strain being imposed on any part by using suitable lifting equipment.

### 4.7 Suspension and Dead-end Accessories

Suspension and dead-end hardware for conductor shall be handled in such a manner that it shall not be broken, scratched or damaged.

All accessories shall be installed in the location and in the manner shown on the assembly drawings. All nuts, lock nuts, washers, cotter pins, etc., supplied with the accessories, shall be installed in the correct order and location. No substitutes or omission will be permitted without the specific approval of the Employer.

All accessories found to be incorrectly assembled or placed, shall be reassembled correctly or changed by the Contractor at his expense, and the Contractor shall be fully responsible for any damages resulting from this incorrect installation.
4.8 Joints

1. Compression joints and dead-end fittings shall be installed in accordance with the manufacturer's recommendation. The Contractor shall submit detailed written instructions for the complete installation procedure for the approval of the Employer. The fullest possible use of maximum conductor length shall be made so as to hold the number of joints to a minimum. Joints shall in no case be installed closer than 15 m to the centre of suspension clamps or closer than 50 m to dead-end fittings. There shall not be more than one joint per conductor or ground wire in any one span.

2. No joints shall be made in spans, which cross main roads, power lines, or in the major river crossings, nor, whenever conductor drum lengths permit, in spans immediately adjacent thereto.

3. Cutting of layers of aluminium strands shall be so made that underlying steel strands are not damaged.

4. The Contractor shall follow a detailed account of joints given by the Employer including the practice of jointing, the dimensions before and after compression, device for centering the sleeves, the methods of impregnation of anti-corrosion coating, checking gauges for dimensions after compression, cleaning, compressing pressure and practice, etc.

5. Joints made at the drum site shall be protected for passing through the pulleys during stringing with approved protectors of suitable design.

4.9 Sagging

The Contractor shall submit, for the approval of the Employer, sag and tension charts for use during erection, which shall be established with due regard to the specific stringing and sagging methods to be employed so that remaining creep after clamping may be assessed and taken into account with reasonable accuracy.

Erection sagging charts or tables shall display sag in still air against span length for temperatures between 15 °C and 60 °C in increments of 5 °C.

Sagging temperature shall be read from a certified thermometer, the bulb of which has been inserted in an approximately 50 cm long piece of conductor with the inner layers removed. The thermometer so equipped shall be freely suspended in the air without any shielding and not less than 3 m above ground. Temperature readings will be taken only after 20 minutes’ exposure.

After finishing stringing operations, the conductors shall be sagged in accordance with agreed sagging procedure and relevant erection sagging chart or table. It is essential that prescribed hold periods before definite sagging are rigorously observed.

Immediately after conductors have been regulated and clamped in, the mean sag of the conductors shall not deviate from the correct erection sag by more than plus or minus 2 per cent. In addition, the sag of anyone line conductor in a span shall not deviate by more than 15 cm from the mean sag of the line conductors in the same span.

The Contractor shall check the sag of each conductor of a sagging section in at least one span of approximate average length. The sags shall also be checked in all spans exceeding 600 m and in spans on each side of angle structures and sharp breaks in profile. Intermediate spans shall be inspected for uniform sag.

If the Employer wishes to check the sag at any locations, the Contractor shall furnish such assistance in equipment and personnel as may be required for this purpose.

Sagging sections shall be limited to such length as can be sagged satisfactorily but shall not be in excess of 15 spans or 6 km, whichever is less.

Work shall be planned so that cables can be pulled and sagged as specified within 24 hours period. Conductor tension shall be equalized between sagging sections so that the insulator strings will assume the proper position when successive sagging sections have been clamped in.

The Contractor shall keep a record on approved schedules of the particulars of the sagging of conductors and
galvanized steel ground wires on each sagging section.

4.10 Clamping in

1. After the conductors or ground wires have been finally tensioned to their correct sags, the position of tension clamps shall be carefully marked. Compression type tension clamps shall be compressed on the conductors in a similar manner to mid-span tension joints. Bolt type tension clamp shall be bolted tightly in a proper manner. Tightening torque of clamp bolts shall be as recommended by the Manufacturer.

2. Clamping in shall be done within 48 hours after completion of sagging unless otherwise agreed but cables shall hang in the stringing blocks for a minimum of two (2) hours before the clipping operation is started.

3. When fitting the tension clamp to insulator set or tower, care shall be taken so that no excessive stress may be given to tower members.

4. All markings of the conductors, e.g. for the centering of clamps or armour rods, shall be done with tape or other inoffensive means. Scratch marks or similar must not be permitted.

5. Temporary short and grounding arrangement shall be installed on each of conductors at interval not exceeding 3 km. A report of each grounding arrangement installed shall be made to the Employer in writing, giving the tower number and date of installation. Such temporary shorts or grounds shall be removed before testing of the complete line.

6. The Contractor shall ensure that the suspension clamps are properly assembled over the armour rods in such a manner as the insulator set being hung vertically. Armour rods shall be installed in accordance with the Manufacturer's instruction. They shall be centered within plus or minus 5 cm. When installed, the difference between the ends of rods shall not exceed 5 mm.

7. Suspension insulators shall be plumbed longitudinally within plus or minus 30 mm.

8. All split pins of insulators, hardware and clamps shall be faced toward the centre of the tower and upward.

9. Immediately after clamping-in, sag tolerances shall be plus or minus 2 % of specified sag, provided that specified clearance to ground will be obtained.

4.11 Jumpering

Jumper conductor shall be provided in such a manner as forming a smooth ellipse and providing necessary clearance to tower members, which shall be checked after installation of each jumper.

Where instructed by the Employer, the jumper shall be supported by a jumper support insulator set. The designer has the liberty to decide the jumper support insulator set to be used.

4.12 Vibration Dampers

Vibration dampers shall be installed immediately following the clamping in of a section.

Before installation, all dampers shall be thoroughly cleaned and inspected. Damaged dampers shall not be installed.

Vibration dampers for conductor or ground wire shall be fitted as specified below in Tables 4-1 and 4-2.

Table 4-1 Number of dampers per conductor or ground wire in one span

<table>
<thead>
<tr>
<th>Span length L (m)</th>
<th>Number of vibration damper (pcs/phase/span)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L ≤ 150</td>
<td>2</td>
</tr>
<tr>
<td>150 &lt; L ≤ 300</td>
<td>2</td>
</tr>
<tr>
<td>300 &lt; L ≤ 600</td>
<td>4</td>
</tr>
<tr>
<td>L &gt; 600</td>
<td>6</td>
</tr>
</tbody>
</table>
Table 4-2  Distance from a suspension or tension clamp

<table>
<thead>
<tr>
<th></th>
<th>1st damper</th>
<th>2nd damper</th>
<th>3rd damper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductor</td>
<td>1.3 m</td>
<td>2.6 m</td>
<td>3.9 m</td>
</tr>
<tr>
<td>Ground wire</td>
<td>0.5 m</td>
<td>1.0 m</td>
<td>1.5 m</td>
</tr>
</tbody>
</table>

Double torsional type vibration dampers shall be mounted so as to maintain their damper weights horizontally and incline their clamp axis at an angle of 60 degrees to the horizontal plane. The first damper for each phase conductor shall be mounted so as to strengthen the twist of the outermost layer of the conductor, and the second damper, if any, to loosen the twist.

4.13 Repair Sleeve

In case of damage to the conductor aluminium strand, approved type of repair sleeve shall be installed provided the damage consists of not more than the following limits. Wherever damage exceeds the following limits for ACSR, the damaged portion shall be replaced:

1. Damage is restricted to the outer layer of aluminium strand.

2. The steel core is undamaged.

3. The number of damaged aluminium strands is less than one quarter (1/4) of the number of outer layer aluminium strands.

Repair sleeve shall be installed in the presence of the Employer.

4.14 Communications

The Contractor shall maintain good communications between personnel at the tensioner end, the puller end and intermediate points at all times during stringing operations. Running boards shall be observed as they pass through each traveller. The running board observers shall have reliable communications with both pulling and tensioning ends. Dual systems of communication shall be available during stringing in case one system fails.

4.15 Measurement for Payment

Payment for stringing work shall be based on the length of the transmission line route, measured in horizontal plane, at the unit prices stated in the Schedule of Prices (will be provided later).

Payment for stringing work shall be included in the erection prices of conductor and ground wire stated in the Schedule of Prices (will be provided later).

5  Stringing of Optical Ground Wire (OPGW)

5.1 General

This Specification sets out installation parameters, which are specific to OPGW. These are additional to the requirements of Scope of Supply, Clause 3.2.3.

Care shall be taken to avoid damaging the OPGW during handling and stringing operations. The Contractor shall avoid sharp bends to the cable and take precautions to prevent crushing the OPGW during placement. To avoid degradation of the transmission quality of the optical fibres, the Contractor shall not subject the OPGW to excessive pulling tensions or excessively small bend diameters.

OPGW cable reels shall always be transported and handled in an upright position. Reels of OPGW cable shall not be laid on its side.
5.2 **Stringing**

OPGW shall be pulled out and strung by an approved tension stringing method. The Contractor shall submit in writing, for the approval of the Employer, a complete and detailed description of the stringing equipment and the stringing and sagging procedure intended for use. This procedure shall be approved by the OPGW’s manufacturer.

The Contractor shall make sure that:

1. The pulling line shall have the same direction lay as the OPGW to help resist the tendency to rotate under stringing load.
2. The stringing block shall have neoprene lined grooves.
3. The tensioner and puller shall be positioned for a 3:1 ratio to the stringing block on the first structure adjacent to the equipment.
4. An anti-torsion device shall be installed between the OPGW and the pulling line.
5. The OPGW shall not be cut with ratchet cutters or other type of tools which could crush the aluminum pipe.
6. The following values shall be followed in order to prevent damage to the OPGW:
   - Minimum Bull Wheel Diameter 70 x D (OPGW)
   - Recommended Block Diameter 40 x D (OPGW)
   - Permanent Bend Radius (no tension) 15 x D (OPGW)
   - Maximum Stringing Tension 20 % of the OPGW Rated Breaking Strength

5.3 **Sagging and Clamping in**

The Contractor shall submit for approval the sag and tension data provided by the OPGW’s manufacturer.

Sagging and clamping in procedures shall be such as described in Clauses 4.9 and 4.10, respectively.

A temporary grip shall be installed on the OPGW for tensioning. The grip shall be designed to hold the OPGW without damage, and in particular not pinch the cable or crush the aluminum pipe.

5.4 **Dead-Ending and Clipping In**

Dead-ends shall be installed on OPGW spans which terminate at splicing towers or ends of the system. Dead-ends shall also be used at angle structures when the angles are too great to use suspension clamps. Suspension clamps are normally used at the remaining towers.

The OPGW shall not be allowed to lay in the stringing blocks for more than 48 hours after being sagged.

To lift the OPGW from the stringing blocks in order to install the hardware, comealongs or preformed wire grips shall be attached on both sides of the block and a coffin hoist shall be placed over the tower arm. The hooks of the coffin hoist shall be attached to the comealongs and jacked up to form a small loop in the OPGW. The block shall then be removed and the armour rods can be placed on the OPGW then attached to the structure.

5.5 **Splice Points**

Splice points shall be located at the beginning and end of each OPGW reel. After completion of sagging and clipping, the surplus OPGW shall be coiled and attached temporarily to the tower. Coils shall be approximately 1 to 1.5 meter in diameter. The coils shall be fixed on the tower to prevent any damage to the OPGW prior to...
splicing.

The exposed ends of the OPGW shall be re-sealed to prevent moisture from entering the aluminum pipe.

The OPGW shall be trained down the tower and to the ground for splicing. The excess length of the OPGW shall not be cut off at this time. To facilitate splicing, the OPGW shall extend a minimum of 20 meters beyond the bottom of the tower. The length of OPGW running down the tower shall be attached to the structure using appropriate guide clamps, spaced every 1.5 to 2.5 meters of running length.

The splice enclosure shall be installed above the anti-climbing device in such way that this will allow the splice box (joint box) to be removed and lowered to the ground if necessary.

5.6 Measurement for Payment

Measurement for payment for work of this Clause shall be on the same basis as stated in Part TS-1, Clause 3.2.

Payment shall be included in the erection prices of optical ground wire stated in the Schedule of Prices.

6 Testing, Final Inspection and Commissioning

6.1 General

Completion of the transmission line work shall be followed immediately by a clean-up and a final inspection, including outstanding remedial work, the repair of damages and testing in accordance with the Specifications.

6.2 Inspection and Test

On request by the Employer, the following inspections and tests shall be carried out by the Contractor. The inspections and tests shall cover all necessary transport, materials, tools, instruments required, etc., and the record of inspections and tests shall be submitted to the Employer.

1. Survey
   a. Inspection on check surveys from time to time.

2. Foundation works
   a. Inspection of dimensions of excavated pits and stub setting.
   b. Screen test of sand and coarse aggregate before work commencement and periodic tests throughout work execution.
   c. Concrete mixture test before work commencement.
   d. Inspection of concrete mixers before work commencement and periodic tests through work execution.
   e. Concrete slump tests and sample moulding.
   f. Inspection of arrangement of reinforcing bars in foundations before concreting.
   g. Inspection of concrete curing and hardness test of concrete.
   h. Inspection of backfilling of foundations and density test of backfilled soil.
   i. Inspection on land formation.
   j. Inspection of excavation and installation of counterpoise before backfilling.
3. Tower erection
   a. Inspection of size, direction, length, torque etc., of members, bolts and fillers.
   b. Grounding resistance test on the towers selected at random in accordance with the record submitted by the Contractor.

4. Stringing
   a. Inspection of stringing tools, equipment and machines before work commencement and periodically.
   b. Inspection of scaffolding, guys and stay wires before and during stringing.
   c. Inspection of construction, perpendicularity, cleaning and arcing horn gaps of insulator sets and/or ground wire sets.
   d. Inspection of surface conditions of conductors and ground wires during stringing and tensioning.
   e. Compression test on samples of tension joints and tension clamps before work commencement.
   f. Inspection of tension joints, repair sleeves and tension clamps.
   g. Inspection of sags of conductors and ground wires during tensioning at spans selected at random.

5. Safety measures
   a. Inspection of measures related to all required work.

In addition to the inspections and tests specified herein or elsewhere in the Particular Technical Specifications, the Contractor shall, upon order by the Employer, undertake any engineering test necessary to satisfy the acceptability of all electrical work covered in this Contract.

6.3 Clean-up
   1. The Contractor shall remove from the vicinity of the work, all plant, building, equipment, rubbish, concrete forms and other like materials. Unused materials shall be incinerated or disposed of at places which will not be unsightly or objectionable to the inhabitants of the area and as approved by the Employer.
   2. The Contractor shall restore:
      a. all irrigation facilities to the condition existing before arrival on site;
      b. natural drainage in areas where temporary facilities have been made for construction purposes;
      c. any fences, gates, etc., which have been damaged during construction;
      d. access roads to their original condition.

6.4 Final Inspection

The Contractor shall carry out a final inspection of the completed work in the presence of the Employer prior to tests or completion.

During this inspection, the Contractor shall remedy all defects immediately, and in particular, ensure the following:

1. Requirements for footings on sloping ground, disposal of excess earth, etc., have been completed.
2. Concrete protruding above ground is correctly shaped, finished and sealed.

3. Bitumastic painting has been correctly applied.

4. Towers are true to line and are vertically acceptable.

5. Tower accessories and signs are complete and correctly fitted.

6. Tower framework is free of all foreign matter.

7. Scratches or like damage to galvanizing has been carefully repaired to the Employer’s approval.

8. Insulators are free from conspicuous foreign material, and all units are undamaged.

9. Conductor and galvanized steel ground wire have been erected in accordance with the drawings and are complete, and line conductor and galvanized steel ground wire are correctly clamped.

10. All conductor stringing pulleys, hooks and other equipment has been removed from the line.

11. All bolts, nuts and cotter pins, washers and split pins on all fittings are properly fitted, tightened and locked.

12. Conductors and galvanized steel ground wires are clean, without strand damage and free of foliage, loose wires, etc. The sag of all cables is in accordance with sagging documents and clearances are correct.

### 6.5 Records and As-Built Drawings

Upon successful completion of electrical integrity test, the Contractor shall submit to the Employer the following records and drawings for provisional acceptance and subsequent maintenance of the transmission line:

1. As-built drawings and inspection/test records as requested by the Employer.

2. Other construction records particularly requested by the Employer.

### 6.6 Taking Over

The following steps shall be taken before and as leading to the Taking Over:

1. The appearance of constructed facilities and a clearance check of the cleared site shall be examined by the Employer.

2. The Contractor shall carry out line parameter measurements to each line section separately in order to determine positive, negative and zero sequence impedances of the line sections.

3. The Contractor shall carry out electrical integrity test on the whole or part of the transmission line by using a 500 volt or 1000 volt megger in the presence of the Employer, and shall report the test results to the Employer.

4. The line shall be energized successfully for 24 hours with the operation voltage before Taking Over.

5. The arrangement for this and other tests that the Employer may desire to make on the completed line shall be assisted by the Contractor who shall provide such labour, transport and other assistance as is required without extra charge. Apparatus for such tests shall be provided by the Contractor.

6. All records of the tests shall be detailed in an approved manner. Sample log sheets, charts, etc., shall be submitted to the Employer for approval.

7. All data shall be submitted to the Employer in triplicate copies upon satisfactory conclusion of the tests.
8. Upon successful tests under this section and receipt of records thereof, the Employer will issue the Taking Over Certificate to the Contractor as stipulated in the General Technical Requirements.

6.7 Measurement for Payment

Payment for testing, final inspection and commissioning shall be made under the lump sum price for the relevant items in the Schedule of Prices.
Part 2: Section VI – Employer’s Requirements
Drawing List (TS-3), 400kV Line

Drawings (TS-3)
Part 2 : Section VI – Employer’s Requirements
Drawing List (TS-3), 400kV Line
# Drawing List (TS-3)

Lot A: Transmission Line, Lessos Substation – Uganda Border
Kenya-Uganda Interconnection

400 kV Double Circuit Overhead Transmission Line

The following drawings form an integral part of this Specification:

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<tr>
<th>Item No.</th>
<th>Drawing Title</th>
<th>Drawing No.</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>Selection Suspension Tower, Conductor and Ruling Span</td>
<td>0522011- TLUK-021</td>
</tr>
<tr>
<td>2.</td>
<td>Tangent Tower Type CA - 0° @ 2°, Tower Outline</td>
<td>0522011- TLUK-022</td>
</tr>
<tr>
<td>3.</td>
<td>Typical Concrete Foundations</td>
<td>0522011- TLUK-023</td>
</tr>
<tr>
<td>4.</td>
<td>Angle Tower Type CB - 0° @ 15°, Tower Outline</td>
<td>0522011- TLUK-024</td>
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<tr>
<td>5.</td>
<td>Angle Tower Type CC - 15° @ 30°, Tower Outline</td>
<td>0522011- TLUK-025</td>
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<tr>
<td>6.</td>
<td>Angle Tower Type CD - 30° @ 70°, Tower Outline</td>
<td>0522011- TLUK-026</td>
</tr>
<tr>
<td>7.</td>
<td>Typical Right-of-Way Diagram</td>
<td>0522011- TLUK-027</td>
</tr>
<tr>
<td>8.</td>
<td>Earthing of Tower</td>
<td>0522011- TLUK-028</td>
</tr>
<tr>
<td>9.</td>
<td>Conductor insulator strings</td>
<td>0522011- TLUK-029</td>
</tr>
<tr>
<td>10.</td>
<td>Line Route Coordinates</td>
<td>0522011- TLUK-030</td>
</tr>
<tr>
<td>11.</td>
<td></td>
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<td>12.</td>
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NOTE: ALL DIMENSIONS SHOWN ARE BRUT.

SECTION A-B

SECTION C-D

SECTION E-F

SECTION G-H

SECTION I-J

SECTION K-L

SECTION M-N

SECTION O-P

SECTION Q-R

SECTION S-T

SECTION U-V

SECTION W-X

SECTION Y-Z

SECTION AA-BB

SECTION CC-DD

SECTION EE-FF

SECTION GG-HH

SECTION II-JJ

SECTION KK-LL

SECTION MM-NN

SECTION OO-PP

SECTION QQ-RR

SECTION SS-TT

SECTION UU-VV

SECTION WW-XX

SECTION YY-ZZ

SECTION AAAA-BBBB

SECTION CCDD-DDDD

SECTION EEEE-FFFF

SECTION GGGG-HHHH

SECTION IIJJ-JJJJ

SECTION KKKK-LLLL

SECTION MMMM-NNNN

SECTION OOOO-PPPP

SECTION QQQQ-RRRR

SECTION SSSS-TTTT

SECTION UUUU-VVVV

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SECTION WWWWWWWW-XYYYYYYYY

SECTION YYYYYYYYYYYY-ZZZZZZZZZ
The Contractor will be responsible for the supply and installation of conductors, earthwires and insulators up to and including the first tower in Uganda.
Annex 9 – Schedules of Guaranteed Characteristics

KENYA - UGANDA INTERCONNECTION

400 kV DOUBLE CIRCUIT – LINE
(OPERATED INITIALLY AS A 220 kV OHTL)

(Revision 1)
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### Conductor

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<th>Description</th>
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<tr>
<td>a) Aluminium wires</td>
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<td>37</td>
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<tr>
<td>b) Aluminium wire diameter</td>
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<td>3.59</td>
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<td>c) Aluminium alloy</td>
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<td>round aluminum-alloy 6201-T81</td>
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<td>Total Sectional Area</td>
<td>mm²</td>
<td>375.5</td>
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<td>Overall diameter</td>
<td>mm</td>
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<td>Unit weight:</td>
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<td>kg/km</td>
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<td>Rated strength (ultimate tensile strength):</td>
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<td>Modulus of elasticity:</td>
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<tr>
<td>a) Initial, minimum</td>
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<td>b) Initial, maximum</td>
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<td>c) Final</td>
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<td>Coefficient of linear expansion</td>
<td>x10⁻⁶°/C</td>
<td>23.04</td>
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<td>Direction of outermost layer</td>
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<td>Every day stress</td>
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<td>Current rating at 25°C ambient</td>
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<td>DC resistance at 20°C:</td>
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<td>Aluminium wire minimum conductivity at 20°C</td>
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### Steel Overhead Ground Wire

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<td>Coating</td>
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<tr>
<td>Construction</td>
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<tr>
<td>No. of wires per strand</td>
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<td>Nominal wire diameter</td>
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<td>Helical form</td>
<td></td>
<td>concentric left lay</td>
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<tr>
<td>Total Area</td>
<td>mm²</td>
<td>71.3</td>
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<td>Overall diameter</td>
<td>mm</td>
<td>10.6</td>
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<td>Unit weight</td>
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<td>Minimum ultimate tensile strength</td>
<td>kN</td>
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<td>Every day stress</td>
<td>N/mm²</td>
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<td>Galvanised steel wire minimum tensile strength</td>
<td>N/mm²</td>
<td>1314</td>
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<td>Galvanised steel wire minimum elongation in 250mm</td>
<td>%</td>
<td>1.0</td>
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<tr>
<td>Galvanised steel wire minimum stress at 1% elongation</td>
<td>N/mm²</td>
<td>1200</td>
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### Optic Overhead Ground Wire (OPGW)

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<td><strong>Properties of optical fibers contained inside OPGW cable</strong></td>
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<td>Manufacturer</td>
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<td></td>
<td></td>
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<tr>
<td>Material</td>
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</tr>
<tr>
<td>Index profile</td>
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</tr>
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<td>Standard</td>
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<tr>
<td>Number of fiber glass cores</td>
<td>µm</td>
<td>&lt; 1</td>
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<td>Concentricity error at 1550m (core to cladding)</td>
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<tr>
<td>Cladding diameter</td>
<td>µm</td>
<td>125 ± 1</td>
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<tr>
<td>Mode field diameter at 1550 nm (MFD)</td>
<td>µm</td>
<td>8 - 11</td>
<td>Should not exceed ±10%</td>
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<tr>
<td>Attenuation at wave length 1550 nm</td>
<td>dB/km</td>
<td>&lt; 0.25</td>
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<td>Attenuation at wave length 1625 nm</td>
<td>dB/km</td>
<td>&lt; 0.27</td>
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<td>Chromatic dispersion at W.L. 1530 to 1565 nm</td>
<td>ps/(nm.km)</td>
<td>2.0 – 6.15</td>
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<tr>
<td>Chromatic dispersion at W.L. 1565 to 1625 nm</td>
<td>ps/(nm.km)</td>
<td>4.5 – 12.4</td>
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<tr>
<td>Polarization Mode Dispersion (PMD)</td>
<td>ps/sqrt km</td>
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<td>Average splicing loss</td>
<td>dB/joint</td>
<td>0.05</td>
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<td>Maximum splicing loss</td>
<td>dB/joint</td>
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<td><strong>Construction and properties of OPGW cable</strong></td>
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<td>Manufacturer</td>
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<td>International Standards</td>
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<td>Material of conductor</td>
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<tr>
<td>Number and diameter of wires</td>
<td>No./mm</td>
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<tr>
<td>Conductor overall diameter, nominal</td>
<td>mm</td>
<td>15.5</td>
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<tr>
<td>Tolerance of overall diameter</td>
<td>%</td>
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<td>Cross-section area, total</td>
<td>mm²</td>
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<tr>
<td>Stranding direction (outer layer)</td>
<td>Right-hand</td>
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<tr>
<td>Standard mass</td>
<td>kg/km</td>
<td>&lt;530</td>
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<td>Ultimate tensile strength (UTS)</td>
<td>kN</td>
<td>&gt; 66</td>
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<tr>
<td>Maximum load in worst climatic condition (40% UTS)</td>
<td>N/mm²</td>
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<td>Every day stress (20% UTS)</td>
<td>N/mm²</td>
<td>180</td>
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<tr>
<td>Mechanical permissible tension (70% UTS)</td>
<td>N/mm²</td>
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<tr>
<td>Standard resistance at 20 °C</td>
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<td>Minimum short circuit current capacity (1 sec)</td>
<td>kA</td>
<td>8.0</td>
<td>(min. 138 kA²s)</td>
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<td>Lightning Charge Transference</td>
<td>C</td>
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<tr>
<td>DC resistance at 20°C</td>
<td>Ω/km</td>
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<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>°C</td>
<td>-30 to +50</td>
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<tr>
<td>Minimum bending radius</td>
<td>mm</td>
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<tr>
<td>Minimum length of conductor on drum</td>
<td>km</td>
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## Glass Suspension Insulators

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<tr>
<td>Type</td>
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<td>Material</td>
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<td>Unit spacing</td>
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<tr>
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<td>Mechanical routine test load</td>
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<td>Withstand voltage</td>
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<tr>
<td>Impulse</td>
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<tr>
<td>Minimum flashover voltage</td>
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<tr>
<td>50% impulse Positive</td>
<td>kV</td>
<td>105</td>
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<td>50% impulse Negative</td>
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<td>Power frequency dry flashover</td>
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<td>Power frequency wet flashover</td>
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<td>Max. RIV at 1 Mhz</td>
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## Suspension Glass Insulator String/Set

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<td>Single suspension string</td>
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<tr>
<td>Double suspension set</td>
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<tr>
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<td>kV</td>
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<tr>
<td>Wet power frequency withstand voltage</td>
<td>kV</td>
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<td>Breaking strength of complete</td>
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<td>Single suspension string</td>
<td>kN</td>
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<td>Double suspension set</td>
<td>kN</td>
<td>240</td>
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Glass Tension Insulator String/Set

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<td>Applicable voltage</td>
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<tr>
<td>No of insulator units (U120BS)</td>
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<td>Single tension string</td>
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<td>Double tension set</td>
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<tr>
<td>Triple tension set</td>
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<td>Dry lightning impulse withstand voltage</td>
<td>kV</td>
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<td>Single tension string</td>
<td>kN</td>
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<tr>
<td>Double tension set</td>
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Jumper Support Glass Insulator String/Set

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<tr>
<td>Applicable voltage</td>
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<tr>
<td>No of insulator units (U120BS)</td>
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</tr>
<tr>
<td>Dry lightning impulse withstand voltage</td>
<td>kV</td>
<td>1060</td>
<td></td>
</tr>
<tr>
<td>Wet power frequency withstand voltage</td>
<td>kV</td>
<td>710</td>
<td></td>
</tr>
<tr>
<td>Breaking strength of complete</td>
<td>kN</td>
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Transposition Suspension Glass Insulator String/Set

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<tr>
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<tr>
<td>No of insulator units (U120BS)</td>
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<tr>
<td>Dry lightning impulse withstand voltage</td>
<td>kV</td>
<td>1130</td>
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<tr>
<td>Wet power frequency withstand voltage</td>
<td>kV</td>
<td>750</td>
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</tr>
<tr>
<td>Breaking strength of complete</td>
<td>kN</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Armour rods</td>
<td></td>
<td>Applied</td>
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</table>
Hardware and Fittings

Generally the composition of insulator hardware shall be of that specified in the drawings, but not limited thereto, and the ultimate strength of the hardware for double suspension and tension insulator strings shall be not less than 240 kN and for single suspension and tension string not less than 120 kN.

Suspension Clamps for Conductor

<table>
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<th>Description</th>
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<td>Material of body</td>
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<td>Applied conductor</td>
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<td>FLINT (AAAC)</td>
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<td>Ultimate body strength</td>
<td>kN</td>
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<td>Armour rods</td>
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<td>Applied</td>
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<td>Galvanising, if applicable</td>
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Suspension Clamps for GSW

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<td>GSW 70</td>
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<td>kN</td>
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Suspension Clamps for OPGW

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### Tension Clamps for Conductor (Full Tension)

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<td>FLINT (AAAC)</td>
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<tr>
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### Tension Clamps for GSW (Full Tension)

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### Tension Clamps for OPGW

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### Arcing Horns

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### Joint Sleeves (Full Tension)

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<td>– For conductor tensile strength</td>
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<td>– For GSW tensile strength</td>
<td>kN</td>
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### Joint Boxes and Splices for OPGW

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<tbody>
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<td>– Optical losses</td>
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### Terminations for OPGW

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<tbody>
<tr>
<td>– Optical losses</td>
<td>dB</td>
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### Armour Rods for Conductor

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<tr>
<td>- Colour code</td>
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<tr>
<td>- Rod diameter</td>
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<tr>
<td>- Direction of lay</td>
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<tr>
<td>- Length</td>
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<td>- Number of rods</td>
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### Armour Rods for GSW

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<td>- Direction of lay</td>
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<tr>
<td>- Length</td>
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<tr>
<td>- Number of rods</td>
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### Armour Rods for OPGW

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<td>- Rod diameter</td>
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<td>- Direction of lay</td>
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## Repair Sleeve for Conductor

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<tr>
<td>– Length</td>
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## Repair Sleeve for GSW

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<td>– Applied conductor</td>
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## Repair Sleeve for OPGW

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<td>– Material</td>
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<td>– Applied conductor</td>
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### Spacer

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<td>Applied conductor</td>
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### Vibration Dampers for Conductor

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<td>Applied conductor</td>
<td>FLINT (AAAC)</td>
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<td>Slip strength</td>
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### Vibration Dampers for GSW

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<td>Slip strength</td>
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### Hold Down Weight

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### Aircraft Warning Devices

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<tr>
<td>Type</td>
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