APPENDIX 12

TECHNICAL SPECIFICATIONS FOR OVERHEAD LINES

400kV Double Circuit LILO from Isinya-Suswa Transmission Line to Kimuka Substation

&

220kV Single Circuit LILO from Kiambere-Embakasi Transmission Line to Komarock Substation

TECHNICAL SPECIFICATION FOR OVERHEAD LINE SYSTEMS

CONTENTS

APPENDICES:

1. GENERAL

1.1 Definitions

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

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

1.2 Nature of Work

The contract outlines the construction of the following:

1. 5km of 400kV double circuit overhead transmission line connecting the proposed Kimuka 220/66kV substation, to the 400kV Isinya-Suswa Transmission Line. It is intended that part of the circuits will be operated at 220kV on a temporary basis; therefore connections to the proposed future Kimuka 400kV substations will be required.

2. 10km of 220kV single circuit overhead transmission line connecting the proposed Komarock 220/66kV substation, to the 220kV Kiambere-Embakasi Transmission Line

1.3 Extent of Work

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

1.3.1 Definite Work

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

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

b. Work at Time and Material rates:-

   If and when required to do so by the written instructions of the Engineer any work not covered by the Price Schedules, at prices stated in Section X, Labour and Equipment Rates for Extra Field Work.

1.4 Terminal points

At Kimuka 220/66Kv substation:

The downlead connections of conductors and earthwires, from the 400kV terminal towers to the substation gantry structures including any jumpers or droppers required to connect to the substation equipment are included in this Specification. OPGW earthwire downleads will be terminated in a junction box to be mounted on the substation gantries. Connections from the junction boxes towards the substation is included. Part of the line will operate at 220kV on a temporary basis. The line is being built with the intention that upon completion of the Kimuka 400kV substation, part of it will be operated at 400kV. Provisions will be made during design and construction to facilitate any future diversion that may be required to connect the line to the Kimuka 400kV substation. Two terminal towers shall be erected as part of the transmission line to facilitate this connection.

At Komarock 220/66Kv substation:

The downlead connections of conductors and earthwires, from the 220kV terminal towers to the substation gantry structures including any jumpers or droppers required to connect to the substation equipment are included in this Specification.

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

1.5 Details of transmission line routes

Details of the general routing of the overhead lines are provided as route maps and given on a CD together with the bid documents.

1.6 Climate

(a) Rainfall

The minimum annual rainfall is approximately 1000mm. The highest daily rainfall is 150mm for both locations.

(b) Temperatures

Minimum ambient temperature	-1^{o}C
Maximum ambient temperature	35^{0}C
Maximum conductor temperature	80^{o}C

(c) Humidity

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

(d) Isoceraunic Level

An isoceraunic level (storm) of 120 days/year shall be considered for design purposes.

(e) Maximum Solar Radiation

For design purposes, a solar radiation value of 1.200 kW/m² shall be considered.

(f) Earth quake loading

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

(g) Wind load

For design purposes a maximum wind velocity of 140km/h shall be assumed.

1.7 Transport

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

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

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

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

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

1.8 Safety of personnel

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

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

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

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

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

1.9 Compliance with regulations

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

1.10 General particulars and guarantees

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

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

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

1.11 Compliance with standard specifications

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

Where the use of a standard other than IEC or BS is agreed then this standard shall be used, where applicable, throughout the work. Where other standards are proposed in place of IEC or BS standards confirmation shall be provided that the provisions of the standards are equivalent to or exceed those of equivalent IEC or BS standards.

Copies of any standards proposed in substitution for International Electrotechnical Commission Standards or Recommendations or British Standards must be submitted with the Bid accompanied where necessary by English translations of the appropriate sections.

No departures from the Specification are to be made without the written approval of the Engineer.

1.12 Variations from Conditions of Contract

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

1.13 Subcontracted plant, materials and labour

The Contractor shall also provide the Engineer with names and details of local subcontractors before such subcontracts are placed. KETRACO reserves the right to withdraw his consent to local subcontract arrangements if such are considered unsuitable, but consent will not be unreasonably withheld.

1.14 Access to manufacturers' works

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

1.15 Planning, progress reports and project progress meetings

The Contractor shall submit for review, within 4 weeks of the starting date of the Contract, an outline design, manufacture, delivery and construction and erection chart. Within a further period of 4 weeks the Contractor shall provide a detailed programme in a format to be agreed by the Engineer; this programme shall also include details of drawing submissions.

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

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

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

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

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

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

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

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

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

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

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

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

1.16 Quality assurance

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

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

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

The Contractor shall operate systems that implement the following:

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

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

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

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

1.16.1 Quality assurance requirements

The Contractor and subcontractors, shall, for all phases of work to be performed under the Contract, establish and implement quality assurance arrangements which, as a minimum, meet the requirements of ISO 9001 : 2008, “Quality Management Systems - Requirements”.

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

1.16.2 Quality assurance arrangements – quality plan

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

The Quality Plan shall identify as a minimum:

a. the Contractor’s organization and responsibilities of key management including quality assurance personnel;

b. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;

c. the prime project documents, specifications, codes of practice, standards;

d. the correspondence and reporting interfaces, and liaison between the Engineer and the Contractor;

e. the procedures the Contractor intends to use to manage and control the Contract, including:

    i. the duties and responsibilities assigned to staff ensuring quality of work for the Contract;

    ii. hold and notification points;

    iii. submission of engineering documents required by the Specification;

    iv. the inspection of materials and components on receipt;

    v. reference to the Contractor’s work procedures appropriate to each activity;

    vi. inspection during fabrication/construction;

    vii. final inspection and test.

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

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

1.16.3 Monitoring by the Engineer

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

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

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

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

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

1.16.4 Contractor quality audits

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

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

1.16.5 Control of subcontractors

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

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

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

1.16.6 Inspection and tests

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

Inspection and test plans shall be submitted for review.

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

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

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

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

a. Indicate each inspection and test point and its relative location in the production cycle including incoming goods, packing and site inspections.

b. Indicate where subcontract services will be employed (eg subcontractor NDT or heat treatment).

c. Identify the characteristics to be inspected, examined, and tested at each point and specify procedures, acceptance criteria to be used and the applicable verifying document.

d. Indicate mandatory hold points established by the Engineer that require verification of selected characteristics of an item of process before this work can proceed.

e. Define or refer to sampling plans if proposed and where they will be used.

f. Where applicable, specify where lots or batches will be used.

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

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

The Contractor shall advise the Engineer of the readiness of inspection at least 4 weeks prior to a nominated inspection/surveillance witness or hold point. Work shall not proceed beyond a hold point without the written agreement of the Engineer or his nominated representative.

Inspection of the plant/equipment may be made by the Engineer and could include the following activities:

i. Periodic monitoring to confirm the effectiveness of, and the Contractor's compliance with, the established quality plan, system procedures and inspection and test plan.

ii. Witnessing of inspections and tests and/or verification of inspection records to be carried out at the Engineer's discretion covering:

- compliance of raw material with specified requirements
- compliance of manufactured parts, assemblies and final items with specifications, drawings, standards and good engineering practice
- witnessing of inspection and tests
- packing for shipment including check for completeness, handling requirements, and case markings and identification.

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

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

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

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

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

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

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

1.16.7 Construction/installation phase

Within 30 days of mobilization of works, inspection and test plan(s), similar in form and content to that described in Clause 1.16.6 above, shall be submitted defining relevant inspection and test points for all stages of construction/erection, installation and commissioning. The inspection and test plans shall identify activities for which method statements shall be prepared.

Method statements shall be submitted to the Engineer for review.

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

1.16.8 Non-conformances

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

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

a. identification of the item(s);

b. reference to relevant specification/drawings, including applicable revisions;

c. reference to the application inspection and test plan stage;

d. description of the non-conformance, with sketch where appropriate;

e. method by which the non-conformance was detected;

f. cause;

g. proposed corrective action, with technical justification, where necessary;

h. for significant non-conformances, proposed action to prevent recurrence;

i. applicable procedures.

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

Approval of any concession applications is the prerogative of the Engineer, and approval of a particular case shall not set a precedent.

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

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

1.16.9 Records

Records packages to be delivered shall be agreed with the Engineer prior to setting-to-work of each phase, ie design, manufacture, construction, installation and commissioning.

1.16.10 Method statements

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

1.17 Design and standardization

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

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

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

1.18 Quality of material

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

1.19 Language, weights and measures

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

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

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

1.20 Testing and inspection

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

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

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

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

Not less than 4 weeks notice of all tests shall be given to the Engineer in order that he may be represented if he so desires. As many tests as in the opinion of the Engineer are possible shall be arranged together.

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

Measuring apparatus shall be approved by the Engineer and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

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

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

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

1.21 Erection, supervision and checking of work on site

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

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

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

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

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

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

1.22 Drawings, models and samples

The drawings associated with the Specification are given in the Appendices.

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

The Contractor shall submit samples of materials as required from time to time by the Engineer.

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

If the Contractor shall require review of any drawing within 4 weeks of its submission in order to avoid delay in the completion of the Contract Works, he shall advise the Engineer to such effect when submitting the drawing.

The number of copies of each drawing or of any subsequent revision to be submitted to the Engineer is given in Section X. Following review, further copies of the reviewed drawing shall be supplied to the Engineer for distribution to KETRACO and to Site.

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

All drawings shall be drawn to one of the preferred scales quoted in Section 7 of BS Publication PD6031 or available on a standard ruler and on paper of the appropriate size from the International Series of A sizes.

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

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

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

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

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

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

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

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

The drawing format and the indexing system will be agreed at the first Contract meeting between the Contractor and the Engineer.

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

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

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

1.23 Responsibility of Contractor

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

During the period of maintenance, the Contractor shall make such arrangements as to ensure the attendance on the Site, within a reasonable time of his being called upon to do so, of a competent representative for the purpose of carrying out any work of maintenance for which the Contractor shall be liable and during such part or parts of the said period as the Engineer shall deem it necessary, the said representative shall be continuously available on the Site.

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

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

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

1.24 Additional services of Contractor's staff

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

1.25 Contractor’s employees

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

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

1.26 Alcoholic Liquor or Drugs

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

1.27 Packing and shipment

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

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

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

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

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

Bolts and nuts shall be crated for shipment.

Crating together of components of dissimilar metals is not acceptable.

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

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

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

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

Woodwool shall be avoided as far as possible.

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

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

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

1.28 Accommodation and site storage

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

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

Medical facilities. These will not be provided by KETRACO and the Contractor shall be required to make his own arrangements where these services may be required for his expatriate or locally engaged staff.

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

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

Storage facilities. The Contractor shall make his own arrangements for storage areas and campsites. The Contractor shall in all cases obtain the approval of the Engineer for the places along the route of the lines where he intends to store materials. In no case will this be outside the authorized area unless special arrangements are made with the owners of adjacent property, at the Contractor's own expense. The Contractor is to provide any necessary protection and watchmen to safeguard materials in the areas allocated to him. The handling and storage of any equipment at the site is to be at the risk of the Contractor and without responsibility to KETRACO. The Contractor is to arrange for the protection to the satisfaction of the Engineer, of these materials against vermin attack, corrosion and mechanical damage during storage and erection at site.

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

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

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

2. LINE CONDUCTOR

2.1 General

The line conductor shall consist of Aluminium Conductor Steel Reinforced (ACSR) having the characteristics stated in the Technical Schedules.

Aluminium and galvanized steel material and coatings shall be formulated to resist corrosion (including general pitting and inter-granular, galvanic, crevice and stress corrosion) when exposed to the severe environment of the transmission line detailed in Section 1.6 of this specification and as generally described by pollution level IV of IEC 60815 and by pollution Class 4 to 5 of IS0 9223 (SO_2 Pollution Class P2 and Chloride Pollution Class S1). All overhead conductors shall have a design service life of minimum 30 years. The conductor material and the grease are to be suitable for continuous operation at 90°C without deterioration.

The conductor shall comply in all respects with the requirements of IEC 61089 and ASTM B232 or other approved standard. The outer layer wires shall be pre-formed so that they remain inert when the conductor is cut. The stranding of each layer of the conductor shall be as close and even as possible. The lay of the outermost layer shall be right-hand.

Each layer of conductor except the outer layer shall be covered with an approved grease of applied mass per unit length determined in accordance with IEC 61089 and as stated in the Technical Schedules. The extent of grease to be applied shall be Case 2 as described in IEC 61089. After application of grease and before the outer layer of wires is stranded the penultimate layer of wires shall be thoroughly wiped so that all remaining visible grease on the conductor is between the wires of the penultimate layer. The grease shall conform to the requirements of BS EN 50326 and shall not corrode the wires. It shall be compatible with any wire drawing lubricant present on the conductor wires and shall not flow within, nor exude from, the conductor below the drop point stated in the Technical Schedules. It shall exhibit adequate resistance to oxidation and shall conform to the test requirements stated in BS EN 50326 and as given in the Technical Schedules. The grease drop point shall not be less than 120°C. Unless the Contractor can produce evidence in the form of service records, test certificates, etc. which demonstrate to the satisfaction of the Engineer that this requirement is met, the Contractor shall carry out such tests as the Engineer may require, at no additional cost to the Employer.

The aluminium shall be of the highest conductivity commercially obtainable. The Contractor shall submit certificates of analysis giving the exact conductivity value per m*sqmm .

Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper or other materials that may adversely affect the aluminium.

The line conductor shall be supplied on drums which are constructed in accordance with an approved national standard so as to enable the conductor to be run out smoothly and in lengths as long as can be conveniently handled and erected. Drums shall be marked with type, size and length of conductor and also with an arrow to show the correct direction of rotation for rolling. The inner end of the length of conductor must be passed through the flange and be secured external to the barrel. Wooden drums and battens shall be constructed from seasoned softwoods and be impregnated with a preservative against fungal and termite attack. The preservative shall not react with aluminium and

the barrel and sides of drums shall be covered with a waterproof paper or equivalent so as to ensure no damage to the conductors. All nails to be countersunk and the drum construction must be proved adequate to transport the conductor weight.

The type, size and number of conductors to be installed for each phase of the transmission line shall be as stated in the Technical Schedules. Where the phase is to consist of a bundle of subconductors the shape of the bundle and the spacing between the subconductors shall also be as specified.

2.2 Joints

Joints for connecting line conductor shall be of approved types. Tension joints for ACSR shall be of the compression type. The design of the joint for ACSR conductors shall be such as to make it impossible to position the steel sleeve incorrectly. The electrical resistance of each joint shall not exceed 75 per cent of the measured resistance of the equivalent length of reference conductor. Tension joints shall not permit slipping of or cause damage to or failure of the complete line conductor or any part thereof at a load less than 95 per cent of the ultimate strength of the line conductor stated in the Technical Schedules.

All joints shall consist of as few parts as possible and there shall be no danger of relative movement between individual layers of the conductor during assembly. Non-tension joints shall not permit any slip or damage of the jumper connection at a load of less than 25 per cent of the ultimate strength of the conductor, and shall be designed so that no loosening of the jumper connections can occur in service. The design of the joints and any special tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly and erection. Erection tools and methods shall be to approval, and no alteration in methods of erection or tools shall be made, after approval, without the written sanction of the Engineer.

Where mating surfaces and jumper terminals are to be bolted together they are to be protected at the Manufacturer's Works by a strippable plastic coating or other approved means.

Where downdropper connections to substation equipment require aluminium-to-copper connectors, the aluminium fittings shall be of the compression type and watertight insulating washers shall prevent exposed contact between copper and aluminium.

Where downdropper connections to substation equipment require conductors of different configuration to that for downleads, a suitable connector shall be provided. The connector shall incorporate aluminium bridging pieces between the conductor compressed dead-end fittings and shall have a current carrying capacity not less than that of the complete phase conductors.

2.3 Vibration dampers, spacers and spacer-dampers

Where the phase consists of a single conductor, only Stockbridge type vibration dampers shall be supplied. Where the phase consists of a bundle of two or more subconductors, control of vibration and spacing within the phase conductor bundle shall be by means of a combination of vibration dampers and flexible spacers or spacer dampers.

The Stockbridge type vibration dampers shall be designed to:

- introduce an additional damping effect to that of the conductor and to control aeolian vibration to ensure that the strain level in the conductors at the clamps, both suspension and tension is below the fatigue limit of the conductor strands,

- guarantee that conductor bending strain at suspension and tension clamps shall not exceed the limit of 150 microstrains.

In order to evaluate the efficiency of the damping system the supplier must have developed suitable computer programmes that have been verified against experimental investigations and behaviour of actual transmission lines, so that he is able to simulate the behaviour of the phase conductor when subjected to wind-excited aeolian vibration. Based on the type of conductor and its tensile load the supplier shall submit a damping study, with calculations of vibration amplitude and strain on phase conductors with and without vibration dampers.

Spacers shall be provided in each span and installed in accordance with the manufacturer's recommendation. Notwithstanding these recommendations the distance between spacers shall not exceed 60 m and the spacers shall not normally be uniformly distributed within a span. Spacers in the span shall maintain the spacing of the subconductors in the bundle as specified in the Technical Schedules.

Alternative combinations of spacer dampers, with or without end-span Stockbridge dampers, may be adopted providing satisfactory performance data has been offered for the proposed system.

All spacers (and spacer dampers) shall be designed to maintain or restore the specified geometric configuration of the conductor bundle, even when the latter is subjected to different actions (eg wind, short-circuit, etc). They shall also be designed to prevent any damage to conductor arising from clamp slip occurring after conductor creep or long-term vibration.

Spacer dampers shall be designed, in addition to maintaining the correct spacings of subconductors in the bundle and to restoring their torsional stability after unfavourable conditions, to:

- introduce an additional damping effect to that of the conductor and to control aeolian vibration and subspan oscillation to ensure that the strain level in the conductor at the suspension clamp and at the clamp of the spacer dampers is below the fatigue limit of the conductor strands,

- prevent damage to each subconductor from vertical and horizontal vibration and oscillation,

- prevent physical contact between subconductors arising from wind and electro-magnetic forces (except short-circuit current),

- guarantee that conductor bending strain at suspension and tension clamps shall not exceed the limit of 150 microstrain,

- guarantee that conductor bending strain at spacer damper clamps shall not exceed the limit of 100 microstrain.

The approval of dampers, spacers and spacer dampers shall be conditional on the provision of evidence of satisfactory service life and performance. Evidence must be provided in respect of fatigue resistance, clamp to conductor grip, damping of aeolian vibration and control of subspan oscillation with disposition along the span as recommended by the manufacturers. Evidence shall be provided of resistance to ozone and ultraviolet light as well as to aging in the case of hardware employing elastomers.

In order to evaluate the efficiency of the damping system the supplier must have developed suitable computer programmes which have been verified against experimental investigations and behaviour of actual transmission lines, so that he is able to simulate the behaviour of the bundle when subjected to wind-excited vibrations, either at low frequency (subspan oscillations) or at higher frequency aeolian vibration. Based on the type of conductor and its tensile load the supplier shall submit a damping study, with calculations of vibration amplitude and strain on conductors with and without spacer dampers.

The metallic material of spacer and spacer dampers shall be aluminium alloy. The clamps shall not be less than 120 mm long and shall be provided with an adequate clamping surface secured by not less than two bolts and with a radius at the clamp mouth to prevent damage to the conductor. Alternative designs of clamping can be considered on evidence of satisfactory service experience. All screws and nuts on spacers and spacer dampers shall be locked in an approved manner.

Elastomers or other non-metallic materials if used shall have good resistance to ageing and be capable of withstanding temperatures between +0°C and +110°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultraviolet radiation and air pollution over the entire temperature range and shall have a semi-conductive property.

Each jumper connection shall be provided with at least two spacers, fitted symmetrically, which may be of rigid design and which may incorporate jumper weights if the latter are necessary to limit jumper swing. Additional spacers shall be provided where necessary to ensure that the maximum distance between spacers is 5 m.

Downleads shall be fitted with spacers at a maximum distance apart of 30 m. The spacers shall provide the spacing of the subconductors in the bundle as specified in the Technical Schedules.

Spacers, spacer-dampers and vibration dampers shall satisfy the requirements specified in IEC 61284, 61854 and 61897 as relevant.

2.4 Armour rods

Approved pre-formed helical armour rods shall be fitted to the line conductor, or each subconductor, at all suspension towers.

The armour rods shall be of a material that is compatible with the material of the line conductor or subconductor to which it is attached such as to eliminate any effects arising from dissimilar metals corrosion.

Armour rods shall have an end form appropriate to the application and operating voltage. The lay of the armour rods shall be right handed.

Identification marking shall be provided on a durable label attached to each set of armour rods. This label shall include details of the conductor material and diameter range. In addition each armour rod shall be provided with a discrete painted colour coding and a marking indicating the conductor size and starting point for application respectively.

Pre-formed helical armour rods may only be removed and reapplied after the original application for the purpose of adjustment during line construction procedures, in strict accordance with the manufacturer's recommendations.

3. EARTH CONDUCTORS

3.1 General

On double circuit lines there shall be one OPGW and one aluminium clad steel earth conductors as specified in the Technical Schedules.

Where a single earth conductor is used this shall be optical fibre (OPGW) conductor as specified in the Technical Schedules.

All aluminium and aluminium alloy material and coatings shall be formulated to resist corrosion (including general pitting and inter-granular, galvanic, crevice and stress corrosion) when exposed to the severe environment of the transmission line detailed in the Technical Schedules and as generally described by pollution level IV of IEC 60815 and by pollution Class 4 to 5 of IS0 9223 (SO_2 Pollution Class P2 and Chloride Pollution Class S1). All overhead conductors shall have a design service life of minimum 30 years and for OPGW a warranty of at least 5 years is also required.

OPGW. OPGW earth conductor shall consist of at least two layers of aluminium alloy wires with an optical fibre communication cable enclosed in one or more aluminium alloy or stainless steel tube. Aluminium-clad steel wires may be incorporated to provide the necessary mechanical strength characteristics but shall not be used in the outer layer of the OPGW. Only aluminium alloy wires are permitted in the outer layer of OPGW.

The OPGW earth conductor shall have the characteristics stated in the Technical Schedules and shall comply as far as possible with the requirements of IEC 61089 or other equivalent national standard, including where approved the requirements of BS EN 187200.

Aluminium alloy wires shall be aluminium-magnesium-silicon grade in accordance with BS EN 50183. Close control of the ratio of Mg/Si alloying elements and the proportion of impurities shall be exercised in order to minimize the risk of corrosion degradation during the service life of the OPGW. The Contractor shall submit certificates of analysis giving the composition of the alloy and the percentage and nature of any impurities in the metal of which the wires are made. The type of alloy shall be proposed by the conductor manufacturer and is subject to the approval of the Engineer.

Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper and iron or other materials that may adversely affect the aluminium.

Where aluminium-clad steel wires are used they shall be to IEC 61232 or ASTM B415 class 20SA and their use is restricted to the inner layer. Aluminium-clad steel wires are not permitted in the outer layer of the OPGW.

All wires, aluminium alloy and aluminium-clad, 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 Schedules. Aluminium-clad steel wires shall be pre-formed so that they remain inert when the conductor is cut. The outer layer shall be right-hand lay. There shall be no joints in individual wires in a drum length unless specifically approved by the Engineer.

The optical fibres shall be housed in a tube inside the OPGW earth conductor. Tube , or tubes where appropriate, shall be of aluminium alloy or stainless steel material. The optical fibres shall be protected from water ingress by the application of a waterproof gel, applied between the buffer tubes and the plastic sheath or seamless metallic tube during manufacture.

The OPGW shall be designed to withstand lightning strokes, short-circuit current, ambient and extreme temperatures and loadings specified in the Technical Schedules with no effect on the attenuation of the optical fibres and no permanent damage to the data transmission characteristics of the fibre optic cable.

The optical fibre cable shall be of the loose tube type, with the fibres contained in a buffer or buffer tubes contained in the central core of the OPGW earth conductor.

The buffer tubes housing the optical fibres shall be coded for ready identification at either end. Buffer tubes shall be filled with a compound to provide resistance to water penetration, vibration damping and for shock absorption.

The number of fibres to be contained within the optical fibre cable shall be as stated in the Technical Schedules. The fibres shall be Non-Zero Dispersion-Shifted Single-Mode type, suitable for operation at wavelengths of both 1550 nm and 16250 nm and shall conform to ITU-T recommendation G.655 with transmission of information at minimum data rates of 620 Mbit/s.

Each individual fibre shall be colour coded for identification purposes and details of the colour coding scheme adopted shall be stated in the bid.

Jointing of fibres shall be by the fusion splice method.

The optical fibre cable shall be designed so that the fibres shall be free from longitudinal strain under all conditions of loads and ambient temperatures specified. The design of the fibre optic cable shall be such that an extension of 0.6 per cent of the OPGW will not produce strain in the fibres and not result in an increase in attenuation.

Under all conditions, prior to and after installation, the maximum fibre attenuations shall be 0.22dB/km at 1550 nm and 0.24 dB/km at 1625 nm.

The optical fibres shall be able to withstand temperature cycling in the range –5°C to +60°C without changing the optical values during installation, stocking and transportation.

The cable shall be rated to operate at 80°C continuously and at intermittent short-term temperatures up to 200°C without any degradation of performance.

Full details of the cable offered must be submitted with the bid, including:

Cable construction and materials, including the Mechanical Failure Load (MFL), Rated Tensile Strength (RTS) and Specified Maximum Working Tension (SMWT).

1. Installation methods and materials.
2. Jointing methods, materials and mounting arrangements.
3. Physical protection against the ingress and transmission of moisture.
4. Identification marking and fibre coding.

ACS. The earth conductor shall consist of All Aluminium Clad Steel having the characteristics stated in the Technical Schedules. The earth conductor shall comply in all respects with the requirements of ASTM B416 or IEC 61232 or other approved standard. The outer layer wires shall be pre-formed so that they remain inert when the conductor is cut.

The stranding of each layer of the conductor shall be as close and even as possible. The lay of the outermost layer shall be right-hand.

Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper or other materials that may adversely affect the aluminium.

At suspension towers the earth conductor suspension clamp shall be securely bonded to the tower steelwork by means of a multistrand aluminium flexible bond wire having a cross-sectional area adequate to carry the current of 31.5 kA for not less than one second. The bond shall be terminated with compression lugs and shall not interfere with the suspension clamp movement.

At tension towers the earth conductor clamps shall each be securely bonded to the tower steelwork by means of suitable lengths of multistrand aluminium flexible bond wires having a cross-sectional area adequate to carry the current of 31.5 kA for not less than one second. The bond shall be terminated with compression lugs.

Suspension towers shall be provided with the facility to accommodate suspension and tension clamps and bonds.

The provisions of the Specification in relation to line conductor drums shall also apply to OPGW and ACSR earth conductor drums.

3.2 Joints

Joints for connecting earth conductors shall be of approved types.

a. **OPGW**. There shall be no connecting joints in OPGW earth conductor. Optical fibres shall only be jointed at approved joint boxes, in accordance with the requirements given in this Technical Specification.

b. **ACS**. Tension joints for ACS earth conductor shall be of the compression type. The electrical resistance of each joint shall not exceed 75 per cent of the measured resistance of the equivalent length of reference conductor. Tension joints shall not permit slipping of or cause damage to or failure of the complete earth conductor or any part thereof at a load less than 95 per cent of the ultimate strength of the earth conductor.

The design of the joints and any special tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly and erection. Erection tools and methods shall be approved and no alteration in methods of erection or tools shall be made, after approval, without the written sanction of the Engineer.

Where mating surfaces and jumper terminals are to be bolted together they are to be protected at the Manufacturer's Works by a strippable plastic coating or other approved means.

3.3 Vibration dampers

Vibration dampers shall be fitted to all overhead earth conductors, both OPGW and Aluminium Clad Steel Conductor.

The earth conductor vibration dampers shall be designed to:

a. introduce an additional damping effect to that of the earth conductor and to control aeolian vibration to ensure that the strain level in the earth conductors at the clamps, both suspension and tension, is below the fatigue limit of the earth conductor strands,

b. guarantee that the earth conductor bending strain at suspension and tension clamps shall not exceed the limit of 150 microstrains.

OPGW. The optical fibre earth conductor (OPGW) shall be fitted with approved vibration dampers, either Stockbridge type of four response format using 19 strand minimum messenger cable or spiral vibration type fabricated from suitable material resistant to corrosion, ozone, ultraviolet radiation and the effects of electric fields.

ACS. The Aluminium Clad Steel earth conductor shall be fitted with approved Stockbridge type vibration dampers of four-response format using 19 strand messenger cable.

Successful service history of the proposed damping system in environments at least as hostile as that for the present project shall be demonstrated and the efficacy of the proposed system for damping aeolian vibrations shall be demonstrated by calculation, as detailed below.

The number of dampers per span of individual earth conductor shall be as stated in the Technical Schedules.

The approval of vibration dampers shall be conditional on the provision of evidence of satisfactory service life and performance. Evidence must be provided in respect of fatigue resistance, clamp to conductor grip and damping of aeolian vibration with disposition along the span as recommended by

the manufacturers. Evidence shall be provided of resistance to ozone and the ultraviolet light as well as to aging in the case of spiral vibration dampers.

In order to evaluate the efficiency of the damping system the supplier must have developed suitable computer programmes that have been verified against experimental investigations and behaviour of actual transmission lines, so that he is able to simulate the behaviour of the earth conductor when subjected to wind-excited aeolian vibration. Based on the type of conductor and its tensile load the supplier shall submit a damping study, with calculations of vibration amplitude and strain on earth conductors with and without vibration dampers.

Stockbridge type vibration dampers shall satisfy the requirements specified in the Tests section of the Technical Specification and in IEC 61897.

Spiral type vibration dampers shall be to the approval of the Engineer.

3.4 Armour rods

The provisions of the Specification in relation to armour rods shall also apply to armour rods for OPGW and ACS earth conductors. In addition, the number of layers making up the armour rod for OPGW shall be in accordance with the recommendations of the supplier of the suspension clamp for OPGW and shall be to the approval of the Engineer.

3.5 Optical joints and joint boxes

The Contractor shall design, supply and install optical fibre cable joints for the OPGW earth conductor. Each joint shall include its joint box and mounting hardware, optical fibre splice kits, entry seals and all accessories required to produce a permanent optical joint. Details of the proposed optical fibre joints shall be submitted by the Contractor for the approval of the Engineer.

All fibre joints shall be individually mounted within the box. Optical fibre splices shall be of the fusion type and optical attenuation of each splice shall be less than 0.1 dB.

Variations in the quality of workmanship in making the fusion splice shall have a minimal effect on the efficiency and reliability of the joint.

Joint boxes designed to protect all optical fibre joints from the environment shall be provided and located on appropriate joint towers immediately above the anti-climbing devices. Joint towers may be either tension or suspension towers, the latter being specifically modified to accept the optical termination fittings. Each joint box shall be capable of being hermetically sealed after jointing and hermetically resealed after reopening and reclosing.

The boxes, which shall be fitted with a bolted and lockable lid, shall be manufactured from stainless or galvanized steel or from a high stability polypropylene material and shall provide protection to Class IP 54 of IEC 60947-1. Access on the bottom edge of the box shall be by means of weathertight glands sized for the incoming and exiting OPGW earth conductor. The box shall be made weatherproof by the use of corrosion-resistant sealing compound. Where the joint box is made of steel an integral earth terminal shall be provided.

The joint boxes shall provide adequate protection for splices and shall provide storage for sufficient length of fibre for at least ten future splices. The size of the boxes shall be sufficient to meet the minimum bending requirements of the OPGW earth conductor.

At termination positions the box shall be of an adequate size and the access holes shall be capable of accepting glands suitable for the termination and jointing, by others, of an optical fibre cable for connection to the substation equipment. This terminating joint box shall be located on the substation gantry structure.

The boxes shall be securely clamped to the tower. Due account shall be taken of the weight and wind area of the joint box and its effect on the design of the towers. Each box shall be labelled “Keep Off – Danger of Death” in Swahili & English language. The conductors or cables and integral optical cables shall be brought into the box.

The OPGW earth conductor shall be supported on and electrically bonded to the structure by means of cleats at 1000 mm centres on vertical members and 600 mm centres on horizontal members. The cleats shall be designed so that no damage during installation is caused to the galvanized surface of the steelwork.

To permit the joint box to be moved to the ground for jointing purposes a suitable length of OPGW earth conductor, minimum 3 m, is to be coiled and supported on the structure as specified before entering the joint box.

All required materials for fixing the OPGW earth conductor and for the installation of the joint boxes shall be supplied by the Contractor and the costs for these materials and joint boxes shall be deemed to be included in the cost of the OPGW earth conductor, as shall the costs for carrying out all the necessary jointing and splicing.

4. INSULATORS AND FITTINGS

4.1 Insulator sets and earth conductor sets

Insulator units shall be the long rod polymeric (composite) type with metal fittings and shall comply in all aspects with the requirements of relevant IEC standards.

4.2 Types of insulator

Insulators shall be special aerodynamically shaped insulators designed to minimize the adherence of dust and other solids. The insulators shall be used to determine tower top geometry and dimensions.

The long rod polymeric (composite) insulators with shed material formed from RTV silicone elastomer, shall comply with the requirements of the Specification and shall be to the approval of the Engineer. The materials used for the polymeric insulators shall be of proven quality and formulation and shall meet all the technical and test requirements given in IEC Standard 61109, IEC Standard 61466-1, ANSI Standard C29-11 and ANSI/IEEE Standard 987. The Contractor shall provide documentary evidence to confirm that any composite insulators being proposed have proven service histories, when operating at voltages at least as high as that for which they are now being offered and in environments at least as aggressive. Confirmation shall be provided that both the material from which the insulators are made and the method of manufacture are identical for the insulators being proposed and for those whose service history is being presented. Copies of previous type test reports shall be provided.

Insulators on straight-line towers shall normally be of the suspension type. Suspension insulators shall have alternate large and small diameter sheds. Phase conductors shall be supported on suspension and tension sets of types specified in the Technical Schedules. Alternative “V” string configured insulators may also be considered. Yoke plates of a suitable design shall be used to support bundled conductors.

Composite long rod insulators shall be preferably provided with ball and socket fittings in accordance with IEC 60120 and “W” type security clips for the insulator units themselves, in accordance with IEC 60372.Other types of end fittings shall be to the approval of the Engineer.

The locking devices shall be so formed that when set and under any conditions there shall be no risk of the locking device being displaced accidentally and that nothing but extreme deformation of the locking device shall allow separation of the insulator units or fittings. Locking device design shall be such as to allow easy removal or replacement of the insulator units or fittings under live line conditions. Locking devices when in position shall be independent of rotation, and the efficiency of the locking shall be independent of the degree of opening applied to the locking device after insertion. The locking device shall be of austenitic stainless steel or phosphor bronze and of the same design for all the complete insulator sets.

4.3 Grading rings & Corona devices

Grading rings and other corona shield equipment, formed from galvanized mild steel and of approved types, shall be attached in an approved manner to all suspension and tension insulator sets. The devices shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the devices shall be such as to reduce, as far as reasonably possible,

damage to the line conductors, clamps, insulator strings and devices themselves under all flashover conditions. The general shape and method of attachment of the live end device shall also not restrict the replacement of insulators under live line conditions.

The grading rings of the insulator sets must fulfil simultaneously the functions of arcing rings, corona shield and potential distribution devices. As arcing device, the guard rings shall be designed to protect insulators and conductors when flashover occurs. The arcing fittings shall be made of hot dip galvanized steel and must have the capability to withstand a short circuit current of 10 kA for 1 sec.

The arcing fittings must be designed such that in case of a flashover the arc will be led to the end burning spot. They may reach a final temperature not exceeding 600°C during the short-circuit. The function of arcing protection must not be greatly altered by the power arc.

As corona shield devices, the grading rings shall be designed to ensure a corona-free insulator and string set.

As potential distribution devices, the grading rings must be designed to ensure that for each insulator fin a potential value as required by the insulator manufacturer is ensured.

The design of the grading rings shall consider and optimize simultaneously all the functions required. The rings shall be strong enough to support a maximum point load of 90 kg.

Grading rings shall be supplied for all composite long rod insulators and the Contractor shall provide data and previous service histories to confirm that suitable protective devices have been offered.

All suspension and tension insulator sets for the general run of lines shall be provided with grading rings at both line and earth ends

4.4 Electrical design

All insulators and insulator sets shall comply with the technical requirements of the Technical Schedules.

4.5 Mechanical design

The mechanical strength of the insulators shall be as stated in the Technical Schedules.

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to the development of defects.

Insulating material shall not engage directly with hard metal. All fixing material shall be of approved quality and applied in an approved manner and shall not enter into chemical action with the metal parts or cause fracture by expansion in service.

4.6 Marking

Each insulator unit shall be legibly and indelibly marked with the name and trademark of the manufacturer, the year of manufacture and the SML (specified mechanical load) in accordance with IEC 61109.

4.7 Clamps and fittings

Suspension and tension anchor clamps for line and earth conductors shall be of approved types and shall be as light as possible. All clamps shall be designed to avoid any possibility of deforming the stranded conductor or of separating the individual strands.

All connecting fittings between the conductor and the tower steelwork such as a clevis to tongue, shackle to plate or link which are subject to a tensile load in service shall comply with IEC 61284 except that each fixing pin shall be secured by a threaded nut and a split pin. A backing washer is not required and the unthreaded shank of the fixing pin shall extend 3 mm through the clevis or shackle. The nut shall, during erection, be tightened to the end of the thread and be backed by a phosphor bronze or austenitic stainless steel split pin. A clevis or shackle opening shall not exceed the thickness of the corresponding tongue, plate or link by more than 3 mm. Adequate bearing area between fittings shall be provided and point contacts shall be avoided wherever this is possible without adversely affecting the flexibility of the fitting.

Fittings made of steel or malleable iron shall be galvanized in accordance with the Specification. All bolts and nuts shall comply with the requirements for tower bolts and nuts and shall, unless otherwise specified, be locked by locknuts. The mechanical strength of the fittings shall be as stated in the Technical Schedules and the minimum failure load of each fitting shall be stated on the drawings. All clamps and fittings (except grading rings) which could be the subject of direct or indirect lightning or short circuit current shall withstand at least 31.5kA for 1 second without alteration of their electrical or mechanical performance values.

Fittings shall be provided in all insulator sets to allow live line replacement of insulator units to be carried out. Insulator sets shall be fitted with shouldered extension links, at each end of the insulator strings, suitable for standard strain carrier yokes of live line maintenance equipment and for bundled line conductor, an attachment plate behind the tension clamp to enable the load on the tension set to be relieved when making adjustment to the sag-adjusting links.

Suspension clamps for ACSR line conductor and ACS steel earth conductors shall be free to pivot in the vertical plane about a horizontal axis passing through and transverse to the centre line of the conductor. Suspension clamps shall permit the complete conductor to slip at approximately 15% of the UTS tension stated in the Technical Schedules, but the conductor shall be mechanically clamped in an approved manner. The supporting groove beyond the clamp shall be curved in the vertical plane to allow for the conductor leaving the clamp at the maximum inclination to be obtained in service. The mouth of the supporting groove shall also be slightly flared in plan. The grooves in the clamping piece or pieces shall be bell-mouthed at each end. All conductor grooves and bell-mouths in ferrous clamps shall, after galvanizing, be smooth and free from waves, ridges or other irregularities. Suspension clamps for earth conductor shall be designed for attachment of the required flexible earthing bond that is to be bolted between each suspension clamp and the tower steelwork. Suspension clamps (except pilot/auxiliary suspension string clamp) for ACSR line conductor and ACS steel earth conductors shall sized for the use of amour rods. Suspension clamps in pilot/auxiliary suspension strings for single line ACSR conductors shall have the facility for attaching 200kg of counterweights. Use of Armour Grip Suspension clamp or cushion clamp with integrated preformed rods may also be offered subject to approval of the Engineer.

Bundled line conductors shall be supported on suspension sets with a yoke plate that provides a conductor centre to centre separation as specified in the Technical Schedules. All yoke plates shall be rigidly constructed and shall withstand the maximum vertical, transverse and longitudinal forces applied simultaneously or separately without sign of deformation. Yoke plates shall be designed to permit swings of the conductor clamps to angles at least 90° from the vertical. Attachment of a yoke plate to a vertical string of suspension insulators shall be by means of a single bolt allowing the conductors to swing transversely. Each string comprising an insulator set shall be separately bolted to a yoke plate. Provision shall be made in the manufacture of yoke plates for attaching 200 kg of counterweights.

Suspension clamps for optical fibre (OPGW) earth conductors 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. The conductor shall be mechanically clamped in an approved manner. Suspension clamps shall permit controlled axial movement of the conductor through the clamp, without causing damage to the conductor, under unbalanced load conditions. The tension unbalance at which this slippage can occur shall be approximately 15% of UTS. Unless otherwise approved, the suspension clamp unit shall be designed such that there is progressive stiffening of the optical fibre conductor 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 clamp shall be ensured by the use of a suitable armoured suspension clamp, of either the Armour Grip Suspension (AGS type with Armour Rods and an internal elastomeric clamp liner) or an armoured metallic suspension clamp which is specially designed for the specific size OPGW and incorporates armour rods and positive metallic 'stops' in the suspension clamp body. Suspension clamps for OPGW earth conductor shall be designed for attachment of the required flexible earthing bond that is to be bolted between each suspension clamp and the tower steelwork.

Elastomers or other non-metallic materials used in suspension clamps shall have good resistance to ageing and be capable of withstanding temperatures between +0°C and +110°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultraviolet radiation and air pollution over the entire temperature range.

Tension anchor clamps for ACSR line and ACS earth conductors shall be of the compression type and shall comply in all respects with the provision of the Specification for line conductor joints where applicable to either the tension or non-tension components. The mechanical efficiency of such tension clamps shall not be affected by methods of erection involving the use of auxiliary erection clamps before, during or after assembly and erection of the tension clamp itself.

For bundled line conductors tension insulator sets shall be equipped with sag-adjusting plates, links or other devices to provide a total range of longitudinal adjustment for each separate conductor from plus to minus 150 mm in steps not greater than 25 mm.

Tension anchor clamps for OPGW earth conductor shall be of the pre-formed helical type. They shall comply with the provision of the Specification for line conductor joints, but shall also support the OPGW earth conductor such that up to the Specified Maximum Working Tension (SMWT), the maximum increase in attenuation in the optical system does not exceed 0.05 dB/km.

All fittings for OPGW earth conductor shall be in accordance with the recommendations provided by CIGRE in the series of Reports entitled “Guide to fittings for optical cables on transmission lines,

Part 1 Selection and Use" Electra No 176 (1998) and "Part 2 Testing Procedures" Electra No 188 (2000).

Tension insulator sets and clamps shall be arranged to give a minimum clearance of 150 mm between the jumper conductor and the rim of the live end insulator units.

Suspension and tension string tower attachments shall be of 'hinge' type. U-bolt or shackle attachment type shall not be allowed. Use of turnbuckles shall not be allowed.

The single suspension insulator set shall be used as standard set on suspension towers.

The double suspension insulator set shall be used for significant crossings as well as on the suspension towers where the weight span is greater than 500m.

A single tension insulator shall generally be used for overhead lines with a single phase conductor.

A double tension insulator set shall be used for overhead lines with bundled multiple phase conductors.

A double tension insulator set shall be used for significant crossings of the overhead line with single phase conductors.

For the full length of the OHL route, all types of insulator sets shall be fitted with arcing devices on both ends, i.e. live end and line end of the respective insulator string.

The double suspension insulator set shall be orientated in the longitudinal plane of the overhead line.

Spacing between double strings shall be sufficient to prevent clashing of adjacent insulator units.

In order to enable the installation of double tension insulator sets, double point attachments for all tower cross arms shall be provided.

Double insulator strings shall be designed to ensure that following the breakage of one insulator string, the set shall remain intact and withstand the resulting static and dynamic loadings imposed.

The electrical and mechanical performances required for the insulator sets are shown in the Technical Schedules.

All insulator sets including their clamps and fittings shall, in fair weather, be free from corona discharges. This shall be proven by test. An extinction corona voltage at least 5% higher than the phase-to-earth value of the specified highest voltage for equipment shall be obtained.

All insulator sets must be equipped with all necessary shield devices in order to keep their radio and television noise as low as possible. The radio interference (RI) performance of the insulator sets shall be proven by test. A noise level less than 45 dB above 1 microvolt must be ensured.

5. STEEL TOWER DESIGN

5.1 General

Towers shall be of self-supporting type with the configurations stated below and specifications as specified in the Technical Schedules:

1. At Kimuka Substation, double circuit towers of Danube configuration.

2. At Komarock Substation, single circuit towers of Horizontal configuration.

The towers shall be designed to carry the line conductors with the necessary insulator sets, earth conductors and all fittings under the conditions specified.

The line conductors of each circuit shall be symmetrically arranged with two overrunning earth conductors to provide the shielding angle as specified in the Technical Schedules. Both the Double circuit and Single circuit terminal towers shall be capable of terminating two earth conductors.

The methods of attachment of the earth conductor(s) to the towers shall be by means of suspension clamps at the suspension towers and by means of tension anchor clamps at tension towers. The towers at Kimuka shall be capable of accommodating OPGW suspension and tension clamps.

5.2 Types of tower

The towers shall normally be of the following standard types, and as stated in the Technical Schedules.

400kV Double Circuit Towers - Danube Configuration

Type	Position of use	Angle of deviation or entry	Type of insulator
400S	Straight line	0° - 2°	Suspension
400T10/30	Angle	0° - 30°	Tension
400T60/90/Trm	Angle/Terminal	30° - 90°	Tension

220kV Single Circuit Towers - Horizontal Configuration

Type	Position of use	Angle of deviation or entry	Type of insulator
220S	Straight line	0° - 2°	Suspension
220T10/30	Angle	0° - 30°	Tension
220T60/90/Trm	Angle/Terminal	30° - 90°	Tension

The duties of two or more tower types may be combined into a single type if this should be economically advantageous to KETRACO.

The standard height of towers shall be based on the sag of the conductor specified in the Technical Schedules at the maximum temperature specified in the Technical Schedules and at the specified basic span length plus the specified normal ground clearance.

The standard types of tower shall be designed so that, where required by the Engineer, the towers may be extended by the heights stated in the Schedules. An extended tower shall be designated by the addition to its standard designation of the symbol + followed by the height of the extension in metres, and a reduced height tower by the symbol - followed by the reduction in metres. Variations in height from the standard height tower are to be achieved with the minimum change to the common portion of the tower. The range of body extensions shall be from -3m to +12m

Standard, extended and reduced towers shall be designed for and provided, where necessary, with independent single leg extensions from 0m metres to +6 metres in steps of 0.5 meter for use on sloping ground.

Extensions and reductions shall be designed so that the towers and their foundations shall comply with all the specified requirements for the standard towers and foundations.

If, during the finalizing of the line route, it is learned that special towers are required for any reason a modified tower from the range being supplied under the contract shall be used wherever possible. A specially designed tower may only be used where circumstances are such that a modified standard tower would be impracticable. The Contractor shall inform the Engineer immediately the need for such a tower becomes apparent.

Special towers, special extensions and special parts for standard towers shall be provided where required and shall be of approved designs.

The type of tower to be used at each position shall be approved by the Engineer.

5.3 Use of standard towers

The standard types of towers shall be designed for use as follows:-

Where the transmission line route is a straight line, Type 400S or Type 220S towers with suspension insulator sets shall normally be used.

Where the transmission line route makes any deviation not exceeding 2°, Type 400S or Type 220S towers with suspension insulator sets shall normally be used subject to an appropriate reduction in the sum of adjacent spans and with the approval of the Engineer.

Where the transmission line route makes a deviation exceeding 2° angle towers with tension insulators shall be used.

Where in a long straight run of transmission line route it is, in the opinion of the Engineer, desirable to arrange for sectioning and tensioning off of the line and earth conductors, Type 400T10/30 or

Type 220T10/30 towers shall be provided at approved positions for this purpose. Section lengths shall not normally exceed 5 km.

The towers shall be designed in such a manner that they will sustain the loads with one or two circuits erected

The transmission lines shall be terminated on Type 400T60/90/Trm or Type 220T60/90/Trm towers with tension insulator sets. The maximum angle of entry of the line to the terminal tower is 45º. Type 400T60/90/Trm or Type 220T60/90/Trm towers shall be designed to withstand all specified loadings with and without downleads erected. The downleads shall be assumed to exit from the Type 400T60/90/Trm or Type 220T60/90/Trm towers at any angle up to but not exceeding ±45º from the tower line centre and at any vertical angle to the horizontal between 0º and 45º. The downlead conductors between the terminal tower and the transforming station gantry or anchor blocks shall be erected with substantially reduced tensions, as given in the Technical Schedules, and shall normally be supported at both ends on light duty tension insulator sets. Earth conductors shall be included in downlead spans.

Due to the 'Danube' configuration, special transposition towers are not envisaged although auxiliary steelwork and additional insulator strings may be required.

5.4 Final sags and tensions

The line and earth conductors shall be erected so that the final tensions at the "everyday temperature" in still air shall be the figures stated in the Technical Schedules and shall be equal in all spans, excepting for sections with spans differing considerably from the basic span where compliance with the specified tensions under the assumed maximum loading conditions may necessitate a lower figure for the "everyday temperature" still air tension.

At "everyday temperature" in still air, in any span, the earth conductor sag shall be approximately 10 per cent less than the line conductor sag.

At an early stage of the contract, and prior to the commencement of tower design, the Contractor shall submit for approval the final sag and tension calculations which shall clearly indicate the basis upon which the line conductor and earth conductor will be designed and the standard tower heights determined. The calculations shall consider the tension limitations specified in the Technical Schedules together with the mass of grease and spacers and spacer-dampers and the mass of Aircraft Warning Markers where appropriate. The requirements for differential sagging of the earth conductor as specified in this Clause shall be included.

The Contractor shall submit for approval curves showing the correct initial and final sags and tensions of the line and earth conductors at various temperatures and spans, the former making allowance for such permanent stretch as may take place in service i.e creep compensation.

5.5 Span lengths

The expression "span length" shall be taken to mean the horizontal distance between the centre lines of adjacent towers.

The design spans are specified in the Technical Schedules and their respective meanings are as follows:

- **Basic span** shall mean the horizontal distance between the centres of adjacent supports on the ground level from which the height of standard supports is derived with the specified conductor clearances to ground in still air at the maximum specified conductor temperature.
- **Wind span** shall mean half the sum of adjacent horizontal span lengths supported on any tower.
- **Weight span** shall mean the equivalent span length of the conductor mass supported at any tower at minimum temperature in still air.

All standard towers, where used with corresponding specified maximum angles of deviation, and straight line towers where used at straight line positions, shall however be designed so that where the ground contours are favourable the sum of the two adjacent spans may not exceed the maximum sum of adjacent spans stated in the Technical Schedules. No single span shall normally exceed the maximum single span length stated in the Technical Schedules, except on special towers.

Where towers designed for straight-line positions are used at locations other than straight-line positions the sum of the two adjacent spans shall be reduced in an approved manner to compensate for the increased loading due to the conductor tensions.

Where the ground contours are favourable all standard towers, except straight-line towers, may, at the discretion of the Engineer, be used at straight-line positions or at relatively small angles of deviation, with the sum of spans exceeding 2.2 times the basic span length.

5.6 Conductor spacings and clearances

The spacing between individual conductors, phases and the clearance between the clamps, arcing horns, jumper loops or other live metal and the tower steelwork under all specified conditions shall be not less than the figures stated in the Technical Schedules.

The specified clearance between line conductors and support steelwork shall be obtained on the assumption that the conductor may leave the support point at the following angles to the horizontal measured in the plane containing the conductor (+ is below the horizontal):

Suspension towers	0° to 15°
Tension towers	-10° to 20°

It shall be assumed for tower design purposes that, under wind loading, jumper loops will swing transversely, as shown on the tower line diagram. If required, each complete jumper shall be provided with not less than two jumper weights in order to limit the swing of the jumper to the angle stated in the Technical Schedules. Designs to determine the swing of the jumper loops and the required mass of any jumper weights, where necessary, shall be provided. For bundled line conductors and, where appropriate, jumper weights may be designed to act as jumper spacers. The Contractor may provide alternative design proposals and calculations based on the use of unweighted

or weighted pilot sets or post insulators to control the swing of jumper loops. Regardless of the solution chosen the costs of the method to provide the required electrical clearances between jumper loops (whether wind loaded or not) and tower metal shall be included in the cost for the tower structure.

The minimum clearance between line conductors and ground or other objects shall be as specified in the following table. These clearances shall be obtained under conditions corresponding to the final still air sag of the line conductors at their maximum operating temperature and with any angle of swing of the conductors from the vertical between zero and 45°, it being assumed (for simplicity) that the aforementioned sag is always applicable. The minimum clearances shall be as follows:

Situation	Minimum clearance (metres)	Minimum clearance (metres)
	400 kV	220 kV
Normal ground,	8.10	7.50
*Roads – road level	8.60	8.00
Power transmission & Telecommunications lines:		
- Lowest line conductor of upper line to highest conductor or earthwire of lower line	4.40	3.70
- Lowest line conductor of upper line to support of the lower line on which a person may stand	5.30	4.60
Railway crossing		
- Rail level	8.80	8.20
- Electrified Railway crossings, building, gantries, or other structures on which a man can stay	6.10	4.60
Ground level at roads or yards where road mobile cranes are likely to be employed	12.2	11.5
Any wall, building or other structure on which a man may stand, or on which a ladder may be placed	5.30	4.60
Street lighting	4.00	3.30

* Any road that is normally maintained by Government and/or other recognized public authority.

Where obstructions of other types are met, the clearances shall be approved.

Attention shall be given to pipeline crossings. Measures shall be taken to avoid any damage to the pipeline due to a fault current flowing through the footing of the tower. Such measures shall be discussed and agreed with the Engineer and the owner of the pipeline. Towers to be located at least tower falling distance away from any pipeline.

5.7 Applied loads, normal loading conditions

The assumed maximum simultaneous loadings on the towers, based on the appropriate angles of deviations and span lengths and with the particulars given in the Technical Schedules shall be as follows:-

a. **Transverse loads**

i. **Wind normal**. The normal transverse load shall be the wind pressure stated in the Technical Schedules acting at right angles to the line on the whole projected area of the line and earth conductors over the specified wind span stated in the Technical Schedules and the transverse horizontal resultant of the maximum line and earth conductor tensions, stated in the Technical Schedules, together with the wind pressure stated in the Technical Schedules on the projected area of the insulators and on the projected area of the members of one face of the towers. Suitable allowance shall be made for the projected area of crossarms, earthwire peaks, any fibre optic transmission system equipment mounted on the tower and Aircraft Warning Markers. The full wind span shall be taken regardless of the angle of line deviation. The transverse components of line and earth conductor tensions shall be computed for the full range of specified angles of deviation.

ii. **Wind at 45°**. As i., but with wind acting at 45° to the line. For wind at 45° the length of conductor to be considered shall be taken as the projected length at right angles to the wind direction.

iii. **Wind perpendicular to phase conductors**. As i., but with wind perpendicular to conductors in one span and taken as the projected length at right angles to the wind direction on the other span. This to be considered for minimum and maximum angles of deviation.

iv. **Reversed wind**. As i., ii. and iii. but with wind acting in the opposite direction to the transverse and horizontal resultant of line and earth conductor tensions calculated on the minimum angle of line deviation and the conductor tension given in the Technical Schedules.

b. **Vertical loads**

i. **Normal**. For normal load conditions the mass of the line and earth conductors, the mass of the insulators, insulator fittings, earth conductor fittings, spacers, dampers and ancillary apparatus where applicable. It shall be assumed that the normal vertical loads shall include the actual mass contained in the weight spans specified in the Technical Schedules.

ii. **Minimum**. For the minimum load condition the mass of line and earth conductors shall be considered to be zero. The mass of the insulators shall be ignored.

iii. **Uplift**. The uplift force acting on the towers shall be assumed to be equivalent to the mass of line and earth conductors contained in the uplift span specified in the Technical Schedules

c. **Longitudinal loads**

i. **Normal**. The longitudinal components of the line and earth conductor tensions stated in the Technical Schedules (checked at all angles of entry) (terminal towers only).

ii. **Section**. All tension towers shall be designed for the out-of-balance longitudinal components of loading. The magnitude of these loads shall be 15 per cent of the maximum actual line conductor and earth conductor tensions stated in the Technical Schedules.

At load attachment points of tension towers, other than those on the tower transverse centre line (eg at pointed crossarms) the normal vertical load as defined in b. i. and the uplift load defined in b. iii. shall be applied to one face of the crossarm, with zero load on the other face and the transverse load due to wind on conductors shall be split between the front and back face of the tower in the proportion 75 per cent to 25 per cent respectively.

All standard types of tower shall be designed for the loading conditions shown in Appendix A of this Technical Specification.

All towers shall be designed to accommodate Aircraft Warning Markers that may be located on the earth conductor in accordance with the requirements of Clause 5.14 of this Technical Specification. The Contractor shall give details of any reductions required to the lengths of spans where the Aircraft Warning Markers are used.

Care shall be taken in the design to allow for any additional loads to which the towers may be subjected during the erection of the towers themselves and of the conductors and insulators.

5.8 Applied loads, unbalanced loading conditions

All standard types of tower shall be designed for the unbalanced loading conditions shown in Appendix B of this Technical Specification and in the Technical Schedules. This applies to all loading cases referred to in Clause 5.7 of this Technical Specification. At the conductor attachment points not affected by the unbalanced loads, all loads shall be the normal transverse, the normal, minimum (or uplift) values for vertical loads and the longitudinal loads specified in Clause 5.7 of this Technical Specification. For terminal towers the longitudinal loads shall be the tensions specified in the Technical Schedules. The longitudinal unbalanced loads shall be assumed to act at right angles to the crossarm and the same direction when more than one attachment point is assumed to carry unbalanced loads.

5.9 Applied loads – construction and maintenance loading conditions

In addition to the loadings specified for normal and unbalanced conditions in Clause 5.7 and Clause 5.8 respectively of this Technical Specification, towers shall be designed to withstand all the construction and maintenance loading conditions recommended in Clause 3.5 of IEC 60826.

Still air conditions shall be assumed. Conductor tensions shall be calculated assuming the temperatures stated respectively in the Technical Schedules for initial construction conditions and for everyday maintenance conditions.

All tension towers shall be designed to withstand temporary terminal conditions under initial stringing and sagging conditions.

All applied loads shall be multiplied with the factors of safety stated in Technical Schedules.

As a minimum, towers shall be designed to withstand the construction and maintenance loading conditions given in Appendix C of this Technical Specification and in the Technical Schedules.

The Contractor shall ensure all towers can safely withstand any other loading condition that may exist during construction operations with the minimum factor of safety as recommended by IEC 60826.

5.10 Tower design

Each type of tower shall be so designed that no failure or permanent distortion shall occur in any part of the tower when tested with applied forces equivalent to the specified maximum or minimum applied loads and the specified maximum simultaneous unbalanced loadings with the factors of safety specified in the Technical Schedules.

Each tower type shall also be so designed that no failure or permanent distortion shall occur in any part of the tower when tested with applied forces equivalent to construction and maintenance loads with the relevant factors of safety.

ASCE10-97 would be the recommended design code substantiated by the data mentioned in those specifications. Should another design code be considered, proof will be required that the end product is similar.

Double circuit towers shall be designed for two circuits or one circuit (either) erected.

For unbalanced loading conditions all members shall be designed for either span broken

The stresses in the various parts of all towers, extensions and stubs and cleats shall not exceed the figures stated in the Technical Schedules.

Unstressed members when employed to reduce the slenderness ratio of leg or bracing members shall be designed in an approved manner to provide the necessary support.

Tower members on which a man may stand (defined as being at an angle of less than 45° to the horizontal) shall be capable of withstanding an ultimate point load of 1.5 kN at any point on the member.

The arrangement and methods of carrying out the tests stated in the Technical Schedules on standard towers shall be approved.

The Contractor shall submit to the Engineer such drawings, stress analyses and calculations as he may require for the checking of the designs of all standard or special towers. These shall specifically include the design of all members, whether main or redundant, and the design of all plates, with particular attention to earthwire and conductor take-off arrangements.

Computations shall be presented in a clearly arranged format and worked out in detail to demonstrate clear evidence of each stage of the work. The use of computers and appropriate software programs is desirable. Computer input data shall be provided. Stability calculations shall be computed in accordance with the 1st order theory. Graphical calculation of forces will not be admissible. The applied formulae for computation of tower member stability shall be clearly stated to enable subsequent checking.

The software used shall be freely accessible to the Engineer and KETRACO for checking tower designs. A copy of the software shall be handed over to KETRACO on completion of the project.

Stubs shall be considered as part of the foundations. Therefore the Safety Factors of foundation shall apply to stubs.

5.11 Foundation reactions

Upon completion of the tower design the Contractor shall submit the foundation reactions applicable to that tower. The foundation reactions shall consider all the loads applied to the tower for the complete range of its utilization and include the effects of tower self weight and the component of wind force applied at the top of concrete. The horizontal and vertical reactions shall be presented for each leg under each loading case considered for the tower design (including differential leg extension sheer factors). A schedule shall be presented summarizing the loading cases that are critical for each of the foundation classes, as appropriate.

For the calculation of foundation reactions the factors of safety specified for foundations in the Technical Schedules shall be applied except that the maximum vertical uplift loads shall include the dead weight of the tower with a factor of one.

5.12 Anti-climbing devices, step bolts, anti-theft bolts and bird guards

Each tower shall be fitted with an anti-climbing device of an approved design fixed at a height of between 3.0 and 5.0 metres above ground. The anti-climbing device should be the best available construction to prevent unaided access up the tower, lockable gates shall be provided. No barbed wire is to be used on towers within national park boundaries. The position of the anti-climbing device on the tower should preferably be such that a standard device is used regardless of the tower body or leg extensions that may be employed. The suitability of such devices shall be checked by assembly on towers erected for test or assembled as part of the check erection process.

On each double circuit tower, two diagonally opposite legs, shall be provided with step bolts of approved type fixed at equal centres of between 300 mm and 380 mm throughout the height of the tower starting immediately above the anti-climbing device and continuing to the earth conductor peak. Where, for structural reasons, it is not possible to maintain the equal centres it shall be acceptable to change the centres by not more than 30 mm. Below the anti-climbing devices, holes shall be

provided for removable step bolts at the centres stated above. Sets of step bolts to fit these holes shall be provided where required by the Engineer, at the price stated in the Price Schedules.

Step bolts shall not be permitted in stressed connections.

Anti theft bolts shall be provided from ground level to 2m above the anti-climbing device.

Towers shall be equipped with approved devices immediately above each suspension insulator attachment point to prevent birds perching above the insulators. The devices shall be easily removed and replaced to facilitate maintenance work.

5.13 Notice plates

Conspicuous danger and tower number plates, circuit number and phase sequence plates of approved types, vitreous enamelled and resistant to fading under the climatic conditions at Site, shall be provided and fixed in approved positions on all towers.

Plate and lettering sizes are to be as shown on the bid drawings. The back of the plates shall be coloured black.

The danger and tower number plate shall be fixed above the anti-climbing device.

The line code identification plate shall be attached centrally immediately below the danger plate.

Phase sequence plates of approved types coloured red, yellow and blue respectively to indicate the line conductor phases shall be provided for each circuit and fixed in approved positions on all towers.

Circuit number plates shall be coloured in accordance with KETRACO's standard requirements. The first plate is to be fixed just below the anti-climbing device, the second halfway up and the third just below the lowest crossarm.

Aerial tower number plates shall be provided and fixed in an approved position on the earth conductor peak of every tenth tower. The plates shall have yellow numbers on a black background.

Enamelled plates shall be provided with fibre washers, front and back, at the securing screws or bolts.

All inscriptions shall be in the Swahili and English language.

Flags are utilised during maintenance works to identify specific circuits. Flag fixing brackets are therefore to be fitted to each step bolt leg of the tower, one immediately above the anti climbing device and one on the climbing leg adjacent to each crossarm.

25 wristlets shall be provided. A wristlet shall consist of a curved stainless steel disc 34 mm diameter and 2 mm thick fitted to a good quality 12 mm wide nylon strap, with buckle, suitable for all sizes of wrist diameter. The steel disc shall be colour coded for line identification finished in vitreous enamel.

5.14 Aircraft warning markers, obstruction lights and tower painting

In restricted areas and pipeline crossings Aircraft Warning Markers (AWM) shall be fitted to the earth conductors and Air Traffic Obstruction Lights (ATOL) on the towers in order to satisfy requirements of Authorities. Where required by KETRACO, ATOL shall also be installed on the highest phase line conductor(s) and the towers shall be painted as specified.

a. **Aircraft Warning Markers**. Where required AWM shall be spherical of 600 mm diameter and manufactured in fibreglass. The spheres shall be coloured International Orange which shall not fade when subjected to the direct rays of the sun. They shall be manufactured in two halves and designed such that assembly and attachment to the earth conductor is simple.

Provision for drainage shall be provided. Suitable clamping devices shall be provided which will not damage the conductor but will prevent the sphere from twisting or slipping on the conductor. All metal parts used for holding the spheres in position shall be of mild steel and galvanized.

The warning spheres shall be fixed on the earth conductor in any required span and shall be erected, as required by Chapter 6 of Annex 14 to the ICAO Regulations, at intervals of not more than 30 metres on the overall earth conductor system.

The first and last spheres in any span shall be approximately 10 metes from the towers defining the span.

With twin earth conductors, provided the spacing of the spheres on either earth conductor is suitably staggered to provide the above requirements, the placing of the spheres can be alternated between the two earth conductors at uniform spacing.

b. **Air Traffic Obstruction Lights on Towers**. Where required ATOLs shall be installed on the towers defining the span, of International Standard red in colour, and having the following general features:

i. conforming to Chapter 6 of Annex 14 to the ICAO Regulations

ii. two lamps per tower of which only one may be lit at a time (by utilizing a switch-over relay)

iii. having minimum luminous flux of approximately 10 candela, steady aviation red light

iv. having minimum lamp life time of approximately 20 000 hours

v. all components shall be corrosion-proof for use in marine and damp tropical climate conditions.

The system offered shall be comprehensive and complete in every respect. If a system fed by cables is proposed, it shall be designed to withstand the induced high

voltage that can occur during earth fault conditions. It shall consist of a constant current regulator, high voltage cable, dimmer switch, protection equipment, insulating transformers, lightning arresters, etc. The connection and cabling to the nearest available safe mains supply shall be deemed to be included.

Should a solar powered system be proposed, the battery supplied shall be able to maintain the minimum luminous flux of 10 candela under the condition of dusty solar cells. A battery maintenance interval of 5 years minimum shall be guaranteed. Photovoltaic panel output shall be de-rated, over and above age de-rating, by 40%, on account of dust accumulation on the panel surface. The upper edges of the solar panels shall be fitted with stainless steel needle strips, effectively preventing birds from sitting in these locations.

It shall be noted that the supply of equipment shall include the necessary spare parts as per the manufacturer's recommendations, for a service period of five years, the cost of which is to be included in the price quoted.

The tower obstruction light system shall be to the approval of the Engineer.

c. **Towers**. Where required and to comply with requirements of Authorities certain towers may need to be painted with two coats of approved epoxy resin type paint with red and white strips of widths complying with ICAO Regulations. The life span of the paint system shall be not less than 10 years and the colours shall not fade within this time under strong sun radiation.

6. FOUNDATION DESIGN

6.1 General

All standard and special foundations shall be designed to resist the reactions resulting from any height of tower and its extensions. The stresses in the various parts of all foundation structures shall not exceed the figure stated in the Technical Schedules.

Concrete where necessary shall be reinforced and shall be designed, detailed and constructed, using design mixes to BS EN 206:2013, in accordance with EN 1992 (Eurocode 2) or other equivalent approved standard.

The connection between tower and foundation shall, for self-supporting towers, be by means of stub angles with bolted-on cleats designed to transfer the leg loads, as required in the Technical Schedules, into the main concrete block comprising the foundation. The stub for each tower type shall be standard for all heights of tower and, where practical, foundation class. The stub shall be fully encased inside the pad or extend to the bottom of the foundation.

The stub is considered as part of the foundation, therefore the safety factor of the foundation shall apply to the stub and cleats calculation

All steelwork below ground except reinforcement bars, whether part of the tower or part of the foundation shall be galvanized and be completely covered with encasing concrete not less than 75 mm thick from a point 300 mm above ground down to the main foundation block, or, for rock foundations, down to the rock. Where necessary, the encasing concrete shall be keyed to the steelwork or to the main foundation in an approved manner. Cover over the reinforcement bars shall not be less than 50 mm.

Where the Contractor wishes to use rock or ground anchor array foundations, he shall provide evidence of his previous successful use of anchors in rock and in ground (if such anchors are proposed) for overhead line foundations and of their satisfactory service life. He shall provide a Method Statement defining procedures to be used for design and installation of the anchors, including specific details about quality controls and the actual equipment which will be used for drilling and grouting. The Contractor will be expected to carry out sufficient testing of his proposals, in the presence of the Engineer, to confirm that his methods for design and installation will produce anchor foundations that are fit for purpose, prior to approval by the Engineer of the system.

Design and/or proof testing to IEC 61773 shall be carried out for all anchor foundations; a suitable proposal and work programme shall be submitted by the Contractor for the Engineer’s approval together with the initial submission to use anchor foundations.

The type of foundation to be used at each tower position shall be to approval and shall normally be decided on the most economic solution.

Special foundations and their extensions shall be provided where required and shall be of approved designs.

Single footings of each standard class of tower foundation designed in accordance with the particulars given in the Technical Schedules and any special foundations when instructed by the Engineer shall be tested in accordance with the requirements of the Tests section of this Technical Specification.

6.2 Foundation types

The foundations for the towers shall be of the following types and shall be designed in accordance with the particulars given in the Technical Schedules.

Self-supporting suspension and tension towers:

- Concrete pyramid (or pad) and chimney foundation
- Augered shaft foundation (suspension towers only)
- Rock anchor array foundation
- Special foundation. (Pile array foundation, rock foundation, extended pad or pyramid foundation, ground anchor foundation, raft foundation).

Foundations shall conform to the following general requirements:

a. **Concrete pyramid (or pad) and chimney foundation**. Where necessary, the concrete shall be reinforced. All steelwork below ground level (except concrete reinforcement) shall be completely galvanized and firmly keyed and grouted and designed to withstand the load due to the specified conditions in accordance with the particulars given in the Technical Schedules. The stubs shall be directly buried in concrete and loads in the stubs shall be transferred to the main concrete block by means of bolted-on cleats, which shall comply with the requirements of the Technical Schedules.

In no case shall the allowable bearing capacity of the ground be exceeded and any eccentricities created by biaxial loading shall fall within the middle third of the base on both axes. In no case shall the area of the base in uplift due to the effect of the eccentricities be greater than 25 per cent of the total area of the base.

It should be noted that all concrete block foundations which are founded in rock strata shall be constructed such that the bottom pad of the foundation shall be cast directly against either a vertical wall of rock for a minimum height of 250 mm or against an undercut into the rock of at last 15° to the vertical and extending for a height of at least 250 mm. Formed concrete pyramid foundations shall not be used in rock.

In areas where black cotton soils are encountered, pad and chimney foundations shall be installed where soil parameters permit. Imported fill to the approval of the engineer shall be used for backfilling.

b. **Augered shaft foundation**. Where suitable ground conditions occur the Contractor may propose for the approval of the Engineer the use of foundations

consisting of a single augered shaft per leg. Holes for the foundation shall be vertical and bored to a minimum diameter of 1 metre with an undercut at the base of not less than 1.5m diameter. A construction depth for each footing shall be first determined from a penetrometer test at the site and confirmed by a knowledge of the soil strata. Great care shall be exercised on selecting areas suitable for augered foundations which shall be founded in dense dry sands suitable for containing an undercut or in sandstone strata. Soft to firm clays and fine grained soils generally shall not be considered for single auger bore foundations. The bottom of each excavation shall, after removal of loose spoil, be penetrated by driving an iron bar to ensure continuity of the foundation bearing strata.

Construction of reinforced concrete footings shall be carefully supervised at all times and holes shall be dry with no sign of collapse of the walls. Tower stubs, shortened if necessary, shall be held by template and encased in concrete from 0.3m - 0.8m above the ground line. The concrete shall be fully reinforced with deformed steel rebar so as to ensure no tensile loading of the concrete itself. Sufficient anti-bursting steel shall be installed adjacent to stub and cleats as required. Any requirement elsewhere in the Specification for stub to leg joints to be embedded in concrete below the ground line shall not apply to auger foundations. If necessary, bentonite or slurry shall be used to prevent the collapse of walls or permanent casings shall be provided subject to approval from the Engineer.

The capacity of an augered footing when subject to bearing or uplift combined with horizontal loading shall be demonstrated in accordance with the specified test procedures. Tower stub and reinforced concrete cap design and construction shall be tested separately.

Foundation dimensions shall be estimated for bid purposes on the basis of a depth of 6 m plus the undercut.

c. **Rock anchor array foundation**. These shall be offered in solid rock and in fractured rock which is encountered between the ground surface and the setting depth of the normal pad and chimney foundation. Anchors may be either passive or stressed; special care must be taken to ensure protection of the tendons against corrosion. The anchor array shall be terminated in a reinforced concrete cap set a minimum depth of 300 mm into the rock. The cap shall provide the resistance to compression and shear loads, with the anchors being used to resist uplift. A concrete chimney shall be provided around the stub from the top of the cap to the required height above ground level. The anchorage hole shall be minimum 100mm diameter to ensure required reinforcement cover can be achieved and maintained. The contractor shall provide all necessary rock parameters (RQD and UCS) to prove the rock strata encountered.

d. **Special foundation**. In addition to the standard foundations, where the investigation of subsoils according to the Specification has indicated ground of very low bearing capacity and/or high water table in granular soils or other special circumstances, special foundations are to be provided. A special foundation will

normally be one that has been specifically designed for a site, and shall be tailored to fit the geotechnical conditions for the site. These foundations shall be designed in accordance with established principles of soil mechanics and shall be of one of the following types – either concrete pad and chimney with enlarged pad, concrete raft or deep reinforced concrete piles (bored or driven) with reinforced concrete cap.

In addition, special foundations may include the use of ground anchor array foundations, which in certain circumstances could be designed to cover a specific and agreed range of ground conditions, as well as extended pad or pyramid and chimney foundations, which may be used for a pre-defined range of ground conditions.

i. Extended pad foundations can be used to extend the range of soil parameters for which the original standard foundation was designed. The extended reinforced concrete pad shall be cast under and tied into the standard foundation. This foundation type is used frequently for ground conditions where water is encountered in reasonably compact frictional soils.

ii. Raft foundations are infrequently used, they are an expensive alternative, but they are sometimes employed in areas which have been subject to mineral working and which perhaps have been backfilled. The large pad, encircling all four legs, shall be designed to maintain the relative position of the legs.

iii. Pile foundations shall comprise multiple reinforced concrete piles bored or driven to a depth determined by the Site soil investigation.

iv. Bearing for pile foundations shall be composed of pile end bearing or shear resistance of the soils developed over the effective surface area of the piles depending on whether the pile is end-bearing or designed in friction. The under-surface of the pile cap shall be considered as not contributing to the bearing surface of the foundation.

v. Ground anchor array foundations may also be offered as an alternative in compact dry frictional ground conditions. The general design requirements shall be as for the rock anchor array foundations, but design parameters shall be proposed by the Contractor based on his investigations and experiments.

All types of foundations shall be designed to withstand uplift, settlement, overturning and sliding when subjected to the specified conditions of tower loading. Allowance shall be made in foundation design for hydrostatic pressure where this may occur and the effects of seasonal rains, drying out, cyclic loading and wind induced vibration of tower members. All foundations shall make adequate provisions to resist horizontal shear forces in the region of the ground line, making due allowance for the effects of hillside leg extensions.

All standard foundations shall accommodate a range of chimney extensions which shall be designed to cater for ground level differences between the available heights of tower hillside leg extensions, when these are employed in sloping terrain. The cost of these concrete chimney extensions are deemed to be included in the cost of the standard foundation.

For all tower types the design of the footings for the compression legs shall not differ from those for the tension legs.

As far as practicable, for any one standard tower type, the foundation stub joint and also the dimensions of each standard foundation shall be identical for standard towers, for extended towers and for leg extensions and shall comply with the requirements of the Specification on construction.

The soil investigation and foundation class selection carried out by the Contractor during survey shall be expected to provide sufficient data to permit the Contractor to design and install each foundation satisfactorily. In the rare case where further confirmatory investigations may be required to enable the type and size of a special foundation to be determined, the Engineer may require a 'specialist' soil investigation to be undertaken and a report and recommendation submitted. The report shall, as a minimum, include the results of in situ penetrometer or vane tests as well as providing values for soil cohesion and/or friction values obtained by means of quick, undrained triaxial compression tests to BS 1377 from undisturbed bore hole samples, together with other complementary laboratory test results.

Subject to the approval of the Engineer, where other towers adjacent to the bore hole are deemed to require special foundations, additional in situ tests shall be undertaken to extend and correlate the soils test data. These tests shall include, but not necessarily be confined to, use of the standard penetrometer, the shear vane, the penevane or the Dutch Cone (static penetration test) and bearing plate tests.

As an addition to the main quotation which shall be completed in full and shall be based on the foundation types specified, alternative types of foundation differing from those specified may be considered subject to the approval by the Engineer of design principles, parameters, and all relevant factors affecting the performance of the proposed foundations over the service life of the transmission line.

The designs for foundations for special towers shall consider the actual maximum loadings to which the particular tower under consideration will be subject in service due to its position on the transmission line profile. The specified unbalanced loadings and the assumptions of temperature and wind pressure shall otherwise apply together with the specified factor of safety.

Foundation designs for special towers shall conform to the conditions stated for foundations for standard towers and shall be developed following a comprehensive evaluation of the soil conditions prevailing at the tower site(s) under consideration.

The Contractor shall submit to the Engineer such drawings, stress diagrams and calculations as he may require for checking the design of any foundation.

A protective coating shall be applied to the surface interfaces of the foundation and tower legs to provide protection from the adverse effects of aggressive salt, soil and air. The coating shall be of

silicone or epoxy formulation, shall not be less than 200 microns thick, and shall be applied on exposed concrete surface to 50 mm below ground level of the foundation to 500 mm above. The type of coating shall be to approval of the Engineer.

7. STEELWORK DETAILING AND MANUFACTURE

7.1 Detailing and fabrication

All towers shall be of self-supporting construction.

The towers shall be of approved design and construction. Unless otherwise approved, tension members, such as crossarm ties, which are liable to be set in vibration, shall consist of rolled steel sections and not flats.

The material used for main leg angles and stubs shall not be less than 6 mm thick and the material used for all other tower steelwork shall have a minimum thickness of 4 mm.

Welding shall not be used in the fabrication of any component used to form the tower structure.

Stub steelwork used to connect the tower to the foundation shall be at least the same section and steel thickness used for the lower tower leg which is attached to the stub.
The stub is considered as part of the foundation, therefore the safety factor of the foundation shall apply to the stub and cleats calculation

Tension only members shall be detailed with a 1 mm ‘draw’ per metre length of member with an additional 1 mm for each joint in the member.

Horizontal members shall be detailed wherever possible, in such a way, as to place the horizontal flange on top.

No bolt hole shall, before galvanizing, be more than 1.5 mm larger than the corresponding bolt diameter. As far as possible, bolt heads, rather than nuts, shall be on the outer or upper faces of tower joints.

The distance between the centre line of any hole and the member end shall be in excess of 1.5 times the hole diameter. The distance between the centre line of any hole and the edge of the member shall be in excess of 1.25 times the hole diameter. Hole to hole distance shall not be less than 2.5 times the bolt diameter

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

The holes necessary for accommodating the specified earthing counterpoise connections shall be provided on each leg of every tower and extension and the earthwire peak.

Suspension insulator sets and earth conductor suspension assemblies shall be attached to the tower such that the point of transverse rotation is on a full bearing surface.
All attachments shall be of ‘hinge’ type. Ubolt/shackle attachment type shall not be allowed

Provision shall be made on all tower types for the attachment of stringing and maintenance equipment to the cross-arms.

Approved means shall be provided on all towers and extensions to avoid risk of livestock being caught and injured in the angles between tower members.

Towers shall be equipped with approved devices immediately above each suspension insulator attachment point to prevent birds perching above the insulators.

7.2 Material

All rolled steel sections, flats, plates and bolt and nut bars used shall consist of steel manufactured by an approved process and shall be to the requirements of BS EN 10025 for grades S235JR and S355JO steel or equivalent from other approved standards, the provisions of which in respect of tests and analyses shall be extended to include steel less than 6 mm thick. The steel shall be free from blisters, scales, laminations or other defects. Steel sections shall preferably be ISO Standard sections chosen with a view to avoiding delays in obtaining material.

High tensile steel when stored in the fabricator's stock-yard prior to fabrication and galvanising shall be marked continuously throughout its length with a light blue water paint line. In addition the grade of steel shall be painted on and ringed round with paint.

7.3 Bolts and nuts

All metal parts shall be secured by means of bolts and nuts and single washers. The minimum diameter shall be 12 mm.

All bolts and nuts shall comply with BS 4190, BS EN 20898 or other approved standard and screw threads shall be to metric standards. Bolts and nuts shall be of steel, with hexagonal heads. Screw threads shall not form part of the shearing plane between members, any thread in the bearing plane shall be to the approval of the Engineer. Bolts of any given diameter shall be of one grade of steel and marked for identification.

The nuts of all bolts for attaching to the tower, plates, brackets or angles supporting insulator sets or earth conductor fittings shall be locked by means of locknuts.

All bolts and screwed rods shall be galvanised, including the threaded portions; all nuts shall be galvanised with the exception of the threads, which shall be oiled. Galvanising shall be in accordance with Clause 8.1 of this Technical Specification.

When in position all bolts or screwed rods shall project through the corresponding nuts, for a minimum of two full turns but such projection shall not exceed 10 mm. Suitable bolt grip tables shall be provided to demonstrate compliance with the above requirements.

All bolts shall be supplied with nuts and flat washers.

7.4 Workmanship

All members shall be cut to jig and all holes shall be drilled or punched to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite to each other before being bolted up. Drifting of holes will not be allowed.

The drilling, punching, cutting and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulty in the erection of the towers on the Site.

All bends in high tensile steel shall be formed hot.

Built members shall, when finished, be true and free from all kinks, twists and open joints, and the material shall not be defective or strained in any way.

In order to check the workmanship, not less than 1 per cent of the members corresponding to each type of tower shall be selected at random and assembled to form complete towers in the presence of the Engineer at the Manufacturer's Works.

If the towers are fabricated or galvanized by Sub-contractors, the Contractor shall, if required by the Engineer, provide a resident inspector at the works of each Sub-Contractor during the time that the steelwork is being fabricated or galvanized.

7.5 Erection marks

Before leaving the Manufacturer's Works all tower members shall be hard stamped with distinguishing numbers and/or letters corresponding to distinguishing numbers and/or letters on approved drawings or material lists to be submitted by the Contractor. The erection marks shall be located on the member so that, after assembly and erection, all members can be individually identified.

The erection marks shall be stamped before galvanizing and shall be clearly legible after galvanizing. Care shall be taken to distinguish between various grades of steel.

The erection marks shall incorporate the standard tower nomenclature as given in Clause 5.2 of this Technical Specification.

8. GALVANIZING

8.1 General

Except where specified to the contrary, all iron and steel used in the construction of the Contract Works shall be galvanized after all sawing, shearing, drilling, punching, filing, bending and machining are completed.

Galvanizing of all material, except core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with BS EN ISO 1461 and BS 7371 Part 6 and shall be applied by the hot dip process to provide thickness of zinc coating of not less than 610 gm of zinc per square metre of surface on steel bars, plates, sections and fittings. Threaded work shall have a coating weight of 305 gm of zinc per square metre.

Galvanizing of steel core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with IEC 61089 and BS EN 10244-2 or other approved standard and shall be applied by either the hot dip or electrolytic process. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

All steel tower materials shall be treated with a sodium dichromate solution immediately after galvanizing.

The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. Tests shall be carried out in accordance with Clause 15 of this Technical Specification.

Sherardizing or other similar process shall not be used.

The Contractor shall keep available on site an instrument suitable to determine the thickness of galvanized coatings on steel members.

9. SURVEY AND SETTING OUT

9.1 General

The Contractor shall execute the works in accordance with the tower and material schedule and soil test data, provided that the works shall be subject to the modifications and variations due to the results of the survey.

9.2 Obtaining right of way and compensation

Subject to the requirements of landowners and their tenants, wayleaves and access facilities (but not necessarily the actual transport routes and access tracks themselves) will be provided by KETRACO to enable the Contractor to carry out the erection of the lines. KETRACO will, however, permit the Contractor to use the existing access tracks as provided for in Clause 9.4 of this Technical Specification.

For the purpose of preparing his construction programme the Contractor may assume that by the date for access to Site for each section of the Contract Works KETRACO will provide the following facilities for access to Site:

a. Over the whole length of the route, sufficient right of access as the Engineer agrees is essential for the Contractor's staff to carry out survey work and investigation of the general foundation conditions.

b. Unless otherwise agreed, over not less than three-quarters of the route as specified above, in not more than two continuous lengths there shall be:-

   i. such right of access for the Contractor's staff along the route as is necessary for the Contract Works;

   ii. the right to transport material on to the route at intervals approved by the Engineer;

   iii. the right to make a reasonable width of track for a direct visual survey and for the transport of stores and material and the carrying out of erection operations along the route except where the route crosses buildings, orchards, gardens or any other ground over which the Engineer decides that such a track is not reasonably practicable.

The facilities in sub clause b. above shall be extended to the complete line as soon as available.

9.3 Access

Where the facilities obtained under Clause 9.2 of this Technical Specification have been provided, no other access shall be used without the consent of the Engineer.

All manhandling of materials to the site which is rendered necessary by restricted access rights must be agreed with the Engineer and paid for at the time and material rates stated in the Price Schedules. The restricted access rights referred to in this Clause may arise as a result of specific wayleave

restrictions, but not as a result of difficult ground conditions. The costs arising because of difficult ground and terrain conditions making normal vehicular access difficult or impossible will be borne by the Contractor.

The Contractor shall make all necessary arrangements (other than questions of wayleaves and access) with the occupant of the site, but if any difficulty shall arise the Contractor shall inform the Engineer thereof. The Engineer will thereupon take such steps as may be necessary.

If KETRACO is unable to provide the above mentioned facilities for access to the Site until after the date stated in Section VIII, the construction programme shall be modified by agreement with the Engineer.

The arrangements for the removal where necessary, and the actual removal of obstructions such as cultivated trees, pipes, field drains, village houses or huts, telephone, telegraph and power lines, preventing the erection of the permanent works will be made by KETRACO or, if the Engineer so requires, by the Contractor at the expense of KETRACO at the time and material rates stated in the Price Schedules, except where such work shall be covered by the rates given in Section X covering unit rates.

When the Contractor is about to commence work on any property he shall be responsible for ascertaining from the Engineer that the wayleaves are in order and for giving the owner and occupier of such property adequate notice of the commencement of the work.

At least seven days before the commencement of construction works, the contractor shall provide KETRACO with lists of the towers which have been pegged and which tower sites are excavated and ready for inspection.

If the Contractor wishes to make a camp on any property he shall first obtain written permission to do so from the owner and occupier of such property. At all camps authorized persons shall be available to control the movements of labour, prevent trespass and to protect the interests of the owners and occupiers of the property.

In the event of any dispute or question of damage or of the adequacy of provisions made for permanent or temporary replacement or repair, the Contractor shall at once inform the Engineer.

When the Contractor is about to carry out erection of the conductors along or across public roads, telegraph or telephone lines, navigable water, or across power lines, he shall be responsible for giving adequate notice to the appropriate authorities of the date and time at which he proposed to perform the work. Where Local Authorities or other public undertakings affected deem it necessary for the protection of the public and the assistance of traffic to provide flagmen or watchmen or appropriate signalling apparatus, etc the cost of such provision shall be borne by the Contractor.

KETRACO will pay for unavoidable damage to crops, but the Contractor shall, at his own expense, make good to the reasonable satisfaction of the Engineer, authorities, owners and tenants concerned, all land, property, roads, tracks, bridges, drains, fences, walls, hedges, gates and the like which are damaged or disturbed during the execution of the Works and shall remove all surplus construction material after erection. Temporary provisions shall be made by the Contractor to prevent straying of, or damage to, livestock during the execution of the Works and until the permanent reinstatement of

fences, walls, hedges, gates and the like is completed. The Contractor shall be held responsible for any damage to livestock due to failure to comply with the above requirements.

Individual trees, groups of trees, and other vegetation shall be thoroughly protected from damage incidental to construction operations by the erection of barriers or by such other approved means as the circumstances may require.

The Contractor shall, if required, provide at his temporary offices on the Site or Construction Camp, reasonable office accommodation for the Engineer's supervising staff.

9.4 Access tracks

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

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

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

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

9.5 Survey

The Contractor shall be responsible for the complete survey of the transmission line. However KETRACO will make available LIDAR data to the Contractor to assist with route surveys and profiling.

Angle points are to be agreed with KETRACO and tied to Kenya National Local Grid (coordinates and elevations of points). The contractor will be required to assist KETRACO in the establishment of these angle points

The LIDAR data shall be used by the contractor who shall undertake a check survey to confirm the accuracy and efficacy of the data provided. The check survey shall include the identification and labelling of all features including, but not limited to those listed below.

Should it be determined that the LIDAR data cannot be used for justifiable reasons then the contractor will be required to undertake the survey works by traditional methods. The survey shall include all necessary clearing of trees and vegetation and the setting out of the bearing for each section of line, the measuring and levelling and production of all necessary plans, profiles, route maps and tower schedules; the location of positions on the profiles in accordance with the Specification and all necessary setting out support for construction, all to the approval of the Engineer. All surveying measurements, both linear and vertical, made on the line route shall be closed on standard reference points, or, where such points are not available the measurements shall be closed by alternative reciprocal measurements, the degree of closing error to be approved by the Engineer.

The levels along the surveyed centre lines shall be taken as follows:

1. On flat ground, at intervals not longer than 20 m.

2. At each depression, ditch or rise when the ditch is deeper than 400 mm or the rise is 200 mm high or higher.

3. On sloping ground, at points where changes of slope occur and at intervening points not more than 30 m apart.

4. On steeply sloping ground, at intervals of 20 m, if practicable.

5. At each canal crossing to the water level at each side and determined maximum water level.

6. At the centre point of each tower.

The Contractor shall survey all roads, major canals, pipelines, power lines and telecommunication lines wherever they cross the route of the proposed line and shall indicate the following:

a. Roads:

   i. Surface and class of road, eg first, second, paved,

   ii. Names of adjacent towns,

   iii. Angle of crossing,

   iv. Chainage of centre and both sides of the road,

   v. Elevation of pavement and shoulders and ditches,

   vi. If the road is curving additional data to define the curve of the road,

   vii. The location of any mile post or sign board with their description, if located within 100 m of the crossing point.

b. Pipelines:

i. Crossing chainage,

ii. Crossing angle,

iii. Number and size of pipes, if exposed,

iv. Trench width, if buried,

v. Location of any identifiable mark on the pipeline route.

c. Power and telecommunication lines:

i. Type of line,

ii. Voltage,

iii. Crossing angle,

iv. Crossing chainage,

v. distance to the nearest support on either side of crossing, and if one is within 50m of crossing, the support beyond it,

vi. The ground level and the level of the highest conductor at each of the support position above and the crossing point,

vii. A pole or a structure number and the line name.

If a road, a pipeline or a power line lies within 100 m of the survey centre line, chainage data and offset measurements shall be made to establish the proximity of the feature.

If a route is located along a street, full details of the street cross section at intervals of not more than 200 m and/or at places of varying street width shall be taken. Such details shall be agreed with KETRACO.

Where KETRACO or the consultant has commissioned a preliminary survey of the line route, either by aerial photography or by land based methods, the resulting data shall be made available to the Contractor. Tower sites determined by this survey shall be incorporated in the Contractor's survey and line profiles. It shall remain the responsibility of the Contractor to satisfy himself as to the accuracy and suitability of any preliminary profile so provided.

Where the line route has been established by KETRACO, the Contractor may expect that at the time of Award of Contract KETRACO will be in a position to indicate to the Contractor sufficient firm details of the location of terminal and angle positions for the Contractor to commence his survey with reasonable continuity of operation in the major sections of the lines.

After approval of the line route, the contractor shall clearly mark the points of angle points by concrete beacons with the round steel bar in the centre. The concrete mixture shall be 1:1:4, beacon minimum sizes 200 x 200 x 600 mm and the steel bar 10 mm diameter and 500 mm long.

Intermediate beacons, of the same design, shall be embedded at the intervals of approximately 1 km between angle points.

The Contractor shall be responsible for marking in an approved manner any special trees which, in his opinion, require to be felled or lopped in order to carry out a survey.

Where the route of the line is parallel to an existing line adequate falling clearance is to be provided between adjacent supports and conductors to the approval of the Engineer. The nominal spacing between the centres of the adjacent parallel transmission lines shall be as given on the bid drawings.

9.6 Profiles

The contractor shall use the LIDAR data for developing the line profiles and shall re-confirm the accuracy of the LIDAR data during the tower spotting process.

The ground profiles (longitudinal and strip plan) are to be prepared by the Contractor for the complete route length. Unless otherwise approved, the scale shall be 1:200 vertical and 1:2000 horizontal.

In addition to showing the line route ground line and tower (centre point) location, the following features, where applicable, shall be shown;

a. continuous longitudinal chainage

b. ground line

c. line of lowest conductor at the maximum still air sag specified in the Technical Schedules.

d. clearance curve or clearance line

e. indication of side slopes where these affect clearances (account being taken of conductor under 45^{o} swing angle conditions)

f. all the numbered pegs identifying the survey points and the towers locations. For each peg the plan will show partial and progressive distances and elevation

g. buildings, rivers, roads, power and telecommunication lines, and other obstacles to be crossed. (buildings to be shown on the strip plan only until such time as these have been removed. Profiles to then be revised.)

h. sections unsuitable for tower locations

i. vegetation and nature of ground

j. tower locations, tower number and type of tower with type of extension if necessary

k. angles of deviation, spans, equivalent spans.

l. sag templates used.

The Contractor shall be responsible for checking the minimum weight condition on suspension and tension structures under assumed conditions of still air for any conductor temperature between the specified minimum ambient and maximum conductor operating temperature. The mass of conductors carried by any suspension insulator set shall not be less than 35 per cent of the total mass of the corresponding line conductors included in the two adjacent spans. Similarly the mass of conductors or magnitude of the uplift supported by any tower shall not exceed the specified design limitations. For supports that carry both dead weight and uplift from adjacent spans special consideration shall be given to ensure that the vertical loadings are within the support design limitations. The Contractor shall be responsible for any alternations to the Works that may be required in order to comply with requirements or to give the specified minimum clearances.

The Contractor will be expected to prepare the line route profiles and to optimize the position of the towers by means of a computer program and plotter which shall be compatible with the LIDAR data provided. For particular conditions it may be necessary for the Engineer to restrict the employment of maximum support extensions and also to include provision in the computer program for restricting costly special foundations. The software used shall be freely accessible to KETRACO for checking the line design and profiles. A copy of the software shall be handed over to KETRACO on completion of the project.

For final records, profiles shall be provided on A0 sheets and each sheet shall represent approximately 4 km of line.

The Contractor shall provide suitable diagonal profiles to enable accurate determination of foundation setting levels, tower leg extensions and, where required, foundation chimney extensions wherever there are side slopes that require such consideration. The diagonal profiles shall be to a scale not less than 1 to 200 and shall extend beyond the limits of the assumed foundation uplift frustum. Support setting levels shall be reflected in the longitudinal profile and be selected to preclude the requirement for structural members to be encased with concrete.

The overhead line route will maintain the following minimum horizontal clearances:

50 m:	National Road, Railway track
30 m:	Other road
100 m:	to parallel pipelines subject to discussion with pipes owners
30 m:	any area classified as hazardous.

No structure will be positioned so that any excavation or erection work will be closer than 30 m to a pipeline or major road.

9.7 Line schedule

As soon as the final tower locations are agreed and approved by engineer of KETRACO, the Contractor shall submit a line schedule. The line schedule shall indicate tower numbers, tower types, body and leg extensions, angles of deviation, insulator types, insulators string types, spans, equivalent spans, section lengths, accumulated spans, sags, foundation details, accumulated

chainage and a “remarks” column in which details of crossings, etc can be entered. At the completion of foundation works, the foundation types for each tower shall be added to the line schedule.

9.8 Route map

During the progress of the work, the Contractor shall record on profiles and on a set of map transparencies to 1:50 000 or other approved scale, such particulars as will allow an accurate reference to be made during construction and afterwards in case of any fault or projected modification to the line. The plans shall show the exact positions of every tower with approved reference marks so that, in conjunction with line schedules, the types of tower, foundations, insulators, counterpoise and the location of mid-span joints, repair sleeves, etc can be ascertained quickly. The data included on the plans and schedules shall be to the approval of the Engineer, to whom facilities shall be given for examining the plans during the progress of the work. The plans and not less than four copies of the schedules shall be the property of KETRACO but will be in the charge of the Contractor until the completion of the particular section of the work to which they refer.

Important note: Any pertaining information regarding airports or landing strips subject to Kenyan Civil Aviation requirements shall be shown on these maps.

9.9 Sag templates

The Contractor shall provide three complete sets of sag templates on Perspex or similar material based on a maximum for each construction of three equivalent spans that encompass the range of spans encountered. The spans selected shall be to approval.

The templates shall show the line conductor sag in still air at the maximum temperature of line conductor specified in the Technical Schedules and the ground clearance line. An additional curve shall be marked on the template showing the conductor sag at minimum temperature in still air condition. Each template shall be clearly endorsed with the design loading conditions, type of conductor, basis of calculations, equivalent span and the scale appropriate to the scale of the relevant profile. The templates shall include a vertical scale showing the heights of the conductor attachment on the standard and extended towers.

The scales of the sag templates shall be 1:200 vertically and 1:2000 horizontally or other approved scales to match those used for the profile.

10. CIVIL WORKS

10.1 Sub-surface investigation and foundation class selection

The Contractor shall be responsible at his own cost for ascertaining that the foundations to be employed are suitable for the sub-surface conditions encountered at each tower site. For this purpose he will be responsible for classifying these conditions at each tower site at an early stage of the Contract. Results of any geotechnical investigations already carried out for KETRACO will be provided as reference.

Once the overhead line route has been agreed and angle tower positions established the contractor shall undertake geotechnical investigations in sufficient detail to permit the Contractor to design and install each foundation satisfactorily at every tower location.

Geotechnical investigations shall be in accordance with BS 5930 and generally incorporate field assessments, ground investigations, sampling, and laboratory testing. Sufficient ground investigation data shall be made available to confirm foundation suitability and constructability.

The Contractor shall obtain information on ground properties of the various underground strata in which to provide sufficient soil, rock, and groundwater data for use in the uplift and compression design and checking of each foundation. In this respect a sufficient number of angle positions and intermediate tower sites shall be investigated by borehole in soil, or rotary drilling and coring in rock, to confirm or adjust the parameters for standard foundations given for bid purposes in the Schedules. The number and frequency of boreholes taken may vary along the route, will be determined by the variability or suitability of the soils encountered and will be subject to approval by the Engineer.

In-situ testing in boreholes shall include either Standard Penetration Testing (SPT) or Shear Vane Testing (SVT) as a minimum. SPT shall be carried out in accordance with ISO 22476.

Laboratory testing shall be carried out on retrieved soil samples in accordance with BS 1377 and shall include one or more of the following methods of testing:-

- Triaxial shear strength testing (cohesive soils)
- Direct shear strength testing (granular soils)
- Soil density
- Particle Size Distribution (sieve analysis)
- Moisture content
- Atterberg limits (plasticity, liquidity, and expansion indices)

Laboratory testing shall be carried out on retrieved rock samples in accordance with ISRM procedures and shall include one or more of the following methods of testing:-

- Unconfined Compressive Strength (UCS)
- Point Load Test (PLT)
- Rock density

Where foundation excavations are to be of the open-cut type, the properties of compacted backfill are also to be examined and tested and related to undisturbed soil properties in accordance with the schedule on foundation tests.

On completion of profiling and tower spotting, in order to provide adequate correlation where boreholes or rotary holes have not been undertaken, the main sites and every tower position shall also be investigated by one or more of the following methods:-

- Dynamic Cone Penetration Testing (DCPT)
- Static or Dutch Cone Penetration Testing (CPT)
- In-situ Plate Bearing Testing (PBT)

DCPT shall be carried out in accordance with ISO 22476. Soil and/or rock engineering descriptions shall be provided on a log at each probe site. Rock Quality Designation (RQD) shall also be provided where rock cores are taken.

Ground investigation, in-situ testing, and sampling at each tower site will be by use of an approved type of penetrometer or borer. The Contractor shall be responsible for any subsidence or failure due, in the opinion of the Engineer, to insufficient care having been taken in his examination of ground conditions or in installation of the foundations.

The ground investigation carried out by the Contractor during survey shall be expected to provide sufficient data to permit the Contractor to design and install each foundation satisfactorily. Where towers are deemed to require special foundations but do not fall on a scheduled main investigation site, additional ground investigation should be undertaken, subject to the approval of the Engineer, to extend and correlate data.

In the rare case where additional investigations may be required to enable the type and size of a special foundation to be determined, the Engineer may instruct a 'specialist' ground investigation to be carried out with a report and recommendation submitted. Proposals shall initially be submitted for approval. The report shall, as a minimum, include details of the field work undertaken, field logs, the results of in situ and laboratory testing, interpretation of the results, and recommendations for design and construction.

Additional probe tests, as well as any other tests the Contractor deems necessary, should be carried out in areas of variable ground condition where the Contractor may wish to propose selective movement of some foundation locations. Where soil probing indicates the possibility of rock due to 'refusal' of the probe test, the Contractor shall confirm by carrying out further probe tests at an adjacent location or by drilling that rock, to confirm that an isolated boulder has not been encountered. Further tests subject to the approval of the Engineer may be required to determine the rock quality. Sites with additional tests approved by the Engineer will be paid at the rates stated in the Section X.

Subject to the approval of the Engineer, the parameters obtained from the bore holes and sub-surface probe tests shall be classified into typical groups and employed in the designs of all foundations. The results of all soil and rock tests shall be submitted to the Engineer, together with any proposals that the Contractor may consider necessary, to ascertain the parameters and dimensions for the standard foundations given in the Schedules or the need for special designs.

Prior to construction the Contractor shall submit for approval his proposals for correlating the results of the detailed ground investigations and the soil and rock tests undertaken at each site with the parameters employed for the foundation design. These proposals shall also consider visual and manual checks and tests to be made after excavation and will be to the Engineer's approval.

The Contractor shall prepare and update the Line Schedule for construction purposes that clearly indicates the class of foundation to be installed at each site and records the soil investigation data on which the choice has been made. The schedule will be subject to approval of the Engineer prior to commencement of foundation construction.

When required by the Engineer, the Contractor will be required to make arrangements for a special comprehensive ground investigation to be carried out at any specified tower site, including deep borings and laboratory analysis of undisturbed soil samples, and for a report and recommendation to be submitted. The Engineer may require that this work shall be carried out by an approved subcontractor at rates to be agreed.

10.2 Route clearance

The Contractor shall clear a strip of land through those sections of the route that pass through vegetation. Clearance shall consist of felling or trimming trees and other vegetation to obtain a clearance of not less than 8 m from the nearest conductors. All limbs and branches required to be trimmed shall be neatly cut close to the trunk of the trees or to main branches, and cuts more than 40 mm in diameter shall be painted with an approved paint. In determining the clearance and in estimating the mean height of the vegetation due allowance shall be made for seasonal growth.

Trees, scrub and undergrowth shall be cleared by felling not more than 150 mm above ground. Tree stumps are to be burned to prevent regrowth. All timber and brush shall be removed to the outer limits of the cleared strip and care shall be taken to avoid unnecessary removal of topsoil when clearing the strip. Before any burning of timber or tree stumps the permission of the police authorities shall be obtained. The Contractor shall be responsible for compliance with all military and local laws and regulations relative to open fires.

The extent of the land clearance during the construction period shall be determined by the requirements for safe construction and the strip of land to be cleared shall be in a cleared condition at the agreed handing over date for the whole transmission line.

Clearing operations shall be undertaken in such a way as to prevent damage to existing structures and installations, and to those under construction, as well as to provide for the safety of employees and the public.

Disposal of timber, brush, etc other than as stated above, or any land drainage or bridging or prevention of soil erosion or other special work arising out of the route clearance shall be done by the Contractor at his own cost.

10.3 Installation of foundations

a. **General**. Foundation construction shall always be carried out with all due regard to the mitigation of any damage to the environment and in accordance with the

findings of any Environmental Impact Assessments and Management or Monitoring Plans.

b. **Site levelling**. From consideration of the impact on the environment it is normally preferable not to level sites, but to build the structures into the land form basically as it exists, using suitable steel leg extensions on the towers or concrete extensions on the foundations. However in exceptional cases, where tower leg foundations are located on the side of a hill or on a slope and it is decided that terracing, or cut and fill, is an option, full proposals for earthworks shall be submitted to the Engineer for approval before any excavation or filling takes place. Proposals shall show:

   i. how rainwater run-off from the hillside is to be allowed for and diverted around the foundation;

   ii. how the exposed surfaces are to be protected against weathering and the possibility of erosion;

   iii. the full depth and details of the foundation, with particular note of the presence of fill material;

   iv. that the Contractor is aware of the possibility of slippage taking place and has taken precautions to avoid it.

   Preference will be given to proposals that minimize the amount of disturbance to the terrain environment. Material that is excavated in terracing shall be spread in an appropriate manner in an area near the tower but in such a manner that no instability is caused to the terrain and the spreading causes no environmental distress.

c. **Foundations**. A record shall be kept of each foundation installed including details of the strata of the ground throughout the depth of excavation, the presence or not of water during construction and liability to seasonal flooding, together with results of tests carried out and all other relevant information.

   Where ground conditions necessitate, the foundation dimensions shall be increased and concrete added and/or reinforced as may be approved by the Engineer.

   Where ground conditions are unsuitable for the installation of any standard or modified standard class of foundation the Contractor will be required to make arrangements to provide a piled or other special foundation as may be approved. The Engineer may require that such specialist foundation work shall be carried out by an approved subcontractor.

   In ground which may be flooded at any time of the year and where the soil is such that enlarged pad or raft foundations may be employed economically the excavated subsoil remaining after backfilling shall be formed into a flat topped mound approximately 0.75 m high extending approximately 1 m beyond all sides of the tower base. The sides of the mound shall be battered to minimize the

effects of erosion. The mass of the mound shall not be considered in the uplift capacity of the foundations. The foundation stubs shall be extended to allow for the change in ground level such that the encasing concrete extends to 300 mm above the level of the top of the mound. The cost of forming the mounds will be included in the total cost of the foundations.

In areas where black cotton is encountered the contractor shall make provision for importing backfill material.

d. **Excavation.** During excavation, the Contractor shall take adequate precautions to prevent earth disturbances that might affect the safety of personnel, property and the Site Works.

Before excavations are commenced the Contractor shall submit his proposals with regard thereto for the Engineer's approval. Excavations shall be close timbered or sheeted, planked and strutted as and when necessary and kept free of water by pumping or other means during the course of the work and shall ensure the safety of personnel working within them. The sides of excavations shall normally be vertical unless otherwise specifically agreed with the Engineer.

Should dewatering be necessary during excavation and concreting works due consideration shall be taken to ensure there will be no adverse influence on adjacent structures as a result of the lowered ground water table.

Written approval shall be obtained from the Engineer before explosives are used for excavating foundations in rock. The Contractor shall be responsible for complying with local regulations concerning the use of explosives and for the safekeeping and handling of explosives. Proper warning shall be given of all blasting operations. During operations involving the handling or use of explosives, the Contractor shall be responsible for the safety of personnel, Site Works and people or properties in the vicinity of the Site. The Contractor shall make good at his own expense any damage caused by the use or mishandling of explosives. No blasting is permitted near permanent work or dwellings.

Blinding concrete shall be provided under all concrete foundations at the base of the excavation for a thickness of at least 75 mm and shall be deemed to be included in the price of the foundations. In cohesive material the final 150 mm of ground above formation level shall only be removed immediately prior to placing the blinding concrete.

e. **Stub setting**. Stubs for tower foundations shall be carefully adjusted to an approved template and shall be held in the correct position while the concrete for the foundation structure is placed. The templates shall not be struck until at least 24 hours after foundations have been completed nor before the completion of backfilling activities. The spacing and levels of the stubs after the templates have been struck shall be such as to ensure correct alignment of the towers without forcing of members during erection and shall comply with the construction tolerances stated under subclause j.

f. **Formworks**. Formers shall normally be employed to produce the correct foundation shape and ensure no loss of aggregate or cement. All formers shall be sufficiently strong to withstand the pressure arising from the concrete during compaction and shall be capable of removal without undue disturbance to the concrete.

Formers may consist either of steel, timber or plywood elements.

The faces of the formers that are in contact with the concrete shall be cleaned and oiled or coated to prevent any concrete adherence to them and to facilitate their removal.

Formers shall not be removed before sufficient hardening of the cast-in concrete has taken place and in no case less than 24 hours after the concrete has been placed. Any concrete that has been damaged during formwork removal or is honeycombed must be removed by chipping to sound concrete and then repaired at the Contractor's expense and to the Engineer's approval.

g. **Reinforcement**. All steel rod reinforcement shall be clean and free from loose mill scale, loose rust, oil and grease or other harmful matter and except at bends shall be truly straight before being surrounded with concrete. Evidence of steel quality, which shall be to an approved Standard such as BS 4449, shall be provided. The numbers, lengths, diameters, forms and positions of all reinforcing bars shall be in accordance with approved drawings.

The steel reinforcement shall be so connected as to form a rigid cage or mat. To prevent displacement before or during concreting, the bars shall be secured one to the other with 18-gauge soft iron wire. Sufficient precast rings or distance blocks shall be used between the reinforcement and the bottom and sides of the excavations to ensure the correct cover of concrete around the bars. The distance blocks shall be made of concrete of not less strength than that of the concrete in which they occur. The foundation reinforcement shall be bonded to the tower stub with 7/4 mm galvanized steel wire strand before concreting.

Steel rod reinforcement shall be bent cold in a manner that will not injure the material. Bending hot at a cherry red heat (ie not exceeding 840°C) may be allowed except for bars that depend for their strength on cold working. Bars bent hot shall not be cooled by quenching.

Bends, cranks or other operations on reinforcing bars shall be in accordance with approved drawings. Where splices or overlapping in reinforcement are required the bars shall unless otherwise approved have an overlap as specified in BS 8110.

h. **Concrete**. Unless otherwise approved, concrete for foundations and for encasing concrete shall be to Design Mix Grade C25 to BS 5328 (BS EN 206-1 AND BS 8500) with minimum cement content of 300 kg/m^3 concrete, maximum water cement ratio of 0.6 and maximum slump of 75 mm.

The concrete mix is to be designed by the Contractor and submitted to the Engineer for approval in sufficient time to permit the necessary tests on compressive strength to be carried out prior to construction commencing.

All cement used shall be of Portland or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS 12 (BS EN 197-1). Where Portland cement concrete may be liable to chemical attack sulphate resistant cement to BS 4027 may be used where approved. Cement shall be stored in an approved manner.

All aggregates shall be obtained from sources approved by the Engineer and shall be clean and free of clay, earth, organic matter, salt or other impurities. The aggregate shall comply generally with the requirements of BS 882.

Coarse aggregate shall be gravel or broken stone of angular or rounded shape, of approved grading and shall pass a mesh not more than 40 mm square for foundation concrete or 20 mm square for encasing concrete.

Fine aggregate shall, unless otherwise approved by the Engineer, be sand, well graded from 4 mm gauge downwards. No seashore sand shall be used, and. unwashed pit or river sand shall not be used unless approved by the Engineer.

Water shall be obtained only from sources approved by the Engineer. It shall be clean, free from deleterious materials and chemically neutral.

Cement shall be measured by weight, either by use of one or more complete bags or by weighing on site. Other ingredients shall be measured by weight or by volume, and concrete shall be mixed in batches using one or more complete bags of cement. Only in exceptional circumstances shall a bag of cement be divided. When mixing by volume is adopted, suitable batch boxes of approved dimensions shall be made and used for the measurement of coarse and fine aggregates. A calibrated container for the measurement of water shall also be used.

All concrete shall be thoroughly mixed by machine, with only sufficient water to ensure a workable mix. Consistency tests shall be made when required by the Engineer by checking the maximum slump in a truncated cone 300 mm high and of standard dimensions. No concrete shall be mixed or placed when the temperature of the air or the ingredients is less than 2°C nor shall concrete be placed when its temperature is greater than 32°C. In hot conditions the initial temperature of the mix should be kept as low as possible, by shading the materials against the sun. Retarding admixtures may be used subject to the Engineer's approval. Freshly placed concrete shall be properly protected against the weather.

Test cubes of 150 mm face in accordance with BS 1881 shall be made during the progress of the works, comprising a minimum of one set of four cubes per tower or per day, or one set of four cubes for each 6 m^3 of concrete placed if greater.

Cubes shall be tested in accordance with BS 1881 and Clause 16 of this Technical Specification.

Contractors shall submit plans showing where the concrete will be mixed for each tower site and how they propose to transport the concrete to the foundation location. If the concrete is being made “off-site” and transported in “ready-mix” trucks, then the journey time must be noted and approved by the Engineer. Transportation shall be such as to avoid segregation of the concrete constituents.

The concrete shall be vibrated or thoroughly rammed during placing to ensure that it is homogeneous and free from voids. Excessive vibration shall be avoided.

The upper surface of the concrete for all types of foundations shall be made by a continuous pour of foundation concrete and shall be sloped in an approved manner to prevent accumulation of water.

Unless otherwise approved, there shall be no joints in the concrete foundation. Where the construction of the foundation is such that joints are unavoidable adequate bond between the old and new concrete shall be ensured by chipping the old concrete to a rough, clean surface free from loose particles. Immediately before placing the new concrete, this cleaned surface shall be primed with a layer approximately 15 mm thick of a wet mix of cement and fine sand in equal proportions.

Particular attention shall be paid to the need to ensure complete curing of all concrete and the Contractor shall supply information in his method statement relating to his proposed methods for curing and for protecting the concrete. Curing and protection shall start immediately after the compaction of the concrete and shall ensure adequate protection from:

- premature drying out, particularly by solar radiation and wind
- leaching out by rain and flowing water
- rapid cooling during the first few days after placing
- high internal thermal gradients
- low temperature or frost
- vibration and impact which could disrupt the concrete and interfere with its bond to the reinforcement.

i. **Backfill**. Proper precautions shall be taken to ensure that all backfilling and compaction of earth is done thoroughly and evenly round all parts of each separate foundation block or structure. The backfill shall be placed in layers not exceeding 200 mm in thickness and shall be compacted to achieve the bulk density assumed in the design using a method of compaction included in the Contractor’s method statement and approved by the Engineer. Backfilling only from one side or corner of an excavation hole shall not be allowed. In wet or

flooded situations adequate provision shall be made to ensure the excavation is kept free from water whilst work is carried out. Stub setting templates shall not be removed before completion of backfilling.

Organic matter and silt shall not be used as backfill material. All temporary timbering, shuttering, etc and all decomposable or perishable material shall be removed from the excavations prior to backfilling.

Black cotton soil or peat soil shall not be used for backfilling and it is categorised as unsuitable material. Contractor shall import suitable soil for backfilling.

j. **Construction tolerances**. Foundation setting tolerances shall be in accordance with the requirements stated below.

The difference in elevation between the tops of any two stub angles shall not exceed 1/1000 of the horizontal distance between the stubs. The actual elevation of any stub angle shall not differ from the computed elevation by more than 1/100 of the foundation depth.

Stub rake shall be within 1 per cent of the required hip or face rake.

Back-to-back dimensions at top of stubs shall be within 10 mm on the face or within 15 mm on the diagonal.

The twist of any stub in plan shall be less than 1° about the longitudinal axis.

Tolerances for the position of the tower and excavations in relation to the tower position given on the profile shall be:

	Out of alignment	**From centre line of route**	**From transverse centre line of tower**
Suspension tower	0.25°	±25 mm	±250 mm
Tension tower	0.25°	±25 mm	±25 mm

k. **Site clearance**. As soon as practicable at each tower site, backfilling shall be completed, surplus soil removed and the site cleared. Final site clearance will normally be carried out at the same time as fitting of anti-climbing devices and tower plates, and shall be undertaken without delay.

l. **Protection of tower footings**. At locations where water due to flood or tidal water may affect the foundations or cause erosion of the ground near the tower foundations, protection to the foundations and to the ground surrounding them shall be provided by the Contractor. Methods include stone revetment, concrete placement, gabion structures or reinforcement of ground surfaces as well as drainage schemes as necessary. Other methods, where more suitable, are not precluded and the Contractor shall furnish recommendations for the provision of protection at such locations.

11. ERECTION

11.1 Storage and erection of steelwork

a. **General**. All transmission tower steelwork stored at site shall be kept clear of the ground. Contact with brackish water or other substances likely to attack galvanizing shall be avoided and all tower members shall be kept in a clean and tidy condition.

b. **Assembly and erection**. The Contractor shall erect the towers for the transmission line in accordance with the erection diagrams, construction lists and other drawings and instructions.

Unless otherwise approved, towers with concrete foundations shall not be erected until the concrete has had 14 days in which to cure, or such longer or shorter time as may be approved, depending on the type of cement used and on local conditions.

The method of assembling and erecting a tower shall be such that during erection no member shall be subjected to any stress in excess of that for which it was designed.

Misalignment or misfit of adjacent sections or members attributable to the adopted method of erection shall be corrected by changing erection methods as necessary to eliminate the trouble.

All members shall have their joints cleaned when bolted up. As far as possible bolt heads, rather than nuts, shall be on the outer or upper faces of tower joints.

All towers assembled on the ground shall be kept off the ground with wood so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure.

If erected by assembling in sections, the initial tightening of bolts shall be adequate for dead load, live load and direction stresses, but shall not be so strong as to prevent aligning and fitting adjacent sections or members. The assembled sections shall be adequately supported during erection.

Spanners used during erection shall be well shaped and shall fit closely onto the hexagon to avoid damage to nut and bolt heads. The use of any wrench that may deform the nut or cut or flake the galvanizing will not be allowed. During assembly, punching, reaming or drilling for correction of mismatched holes shall not be permitted without the authorization of the Engineer in writing.

Proper precautions shall be taken to ensure that towers are not strained or damaged in any way during erection. Suitable ladders shall be used, whenever necessary, during erection of towers. All ladders and removable step bolts shall be removed when erection work is not in progress.

If any shop errors in the steel are discovered, the Contractor shall notify the Engineer who will decide whether the error shall be corrected on site or the members shall be replaced.

All exposed steel surfaces around the holes or on cuts on which such corrective work is permitted shall be given sufficient coats of a zinc rich paint to provide sufficient protection to the steel and shall be to the approval of the Engineer.

All towers shall be vertical under the stresses set up by the overhead line after conductor erection. A tolerance of 25 mm for every 10 m height may be allowed.

After erection each tower shall be thoroughly inspected by a special crew to check the condition of the section surfaces and the correct tightness of the nuts on the bolts. The final tightening of the nuts shall be carried out using torque wrenches and the nuts shall be torqued to the values proposed by the Contractor and approved by the Engineer.

On each tower the Contractor shall install the relevant danger and identification plates as indicated in the erection drawing.

In order to prevent pilfering, all bolts and nuts from ground to two metres above of the anti-climbing device shall be secured by means of specifically designed anti-theft type bolts and nuts to the approval of the engineer on each tower.

All foreign matter and surplus materials shall be removed from the towers and from the site upon completion of erection.

c. **Tower earthing and resistance measurements**. The Contractor shall install and test the structure grounding in accordance with Clause 11.2 of this Technical Specification.

11.2 Earthing

The Contractor shall undertake preliminary soil resistivity measurements along each line route as soon as possible after Award of the Contract. The number and location of test points as well as method of testing shall be agreed with the Engineer.

In the presence of the Engineer, the Contractor shall measure the electrical footing resistance to earth of each tower before the earth conductors are erected. These measurements shall be recorded by the Contractor in the form of a tower footing earth resistance profile of an approved type.

The following materials or their equivalents shall be used:

- Earthing rods shall be made of galvanised steel, with a minimum diameter of 20mm and minimum length of 3m. There shall be provision for coupling rods to extend their length if necessary. A bronze or brass bolted clamp shall be provided for connection of earthing cables to the earthing rods;
- Earthing cables (counterpoise) shall be of galvanised steel wire with 11.5mm diameter.

- Connection of the counterpoise to the tower steelwork shall be by means of a compressed lug and two galvanized bolts and nuts, washers and spring washer on the tower stub at least 500 mm above the foundation surface. The minimum diameter of the bolts shall be 12 mm. The holes in the leg/stub steelwork shall be factory drilled prior to galvanizing.
- The earthing counterpoise shall pass through the concrete chimney via an encased, flexible PVC pipe and exit from the chimney at the required depth. On completion of the earthing installation the PVC pipe shall be filled with a cement mortar mix.

The depths of the upper ends of earthing rods and the depth of burial of earthing cables shall not be less than the following values:

- Cultivated (soft) soil 800 mm
- Normal soil 500 mm
- Rocky ground 150 mm
- Where required drilling or augering methods shall be used for installing the earth rods. The holes shall be filled with bentonite and the earthing rod pushed into the prepared holes.

Type A: Every tower shall be fitted with compulsory earthing on two diagonally opposed legs. The earthing rods, one per leg, shall be driven vertically into the ground to a depth of 3m at a distance of 5m from the footing and shall be connected to the tower legs by earthing counterpoise cable.

Where the measured tower footing resistance is greater than 10 ohms the earthing shall be enhanced using one of the systems detailed below.

Type B: Installation of earthing rods as described in type A above but with one 3m rod and earthing counterpoise cable connected to each tower leg.

This type of earthing system shall be used in cultivated (soft) soil where type A earthing does not provide adequate earthing.

Type C: Installation of earthing rods as described in type B but with each rod being extended to 6m long and earthing counterpoise cable connected to each tower leg.

This earthing system shall generally be used where the ground conditions are not favourable, but not rocky.

Alternatively, an additional 3m earthing rod shall be connected to each previously installed rod via an additional 5m of counterpoise cable.

Type D: Any special measures and methods (deep grounding, counterpoise connection to the adjacent tower, earth conductivity improving chemicals etc.), subject to approval of the Engineer, which shall be used in specific soils where type C earthing cannot provide sufficient reduction in resistance.

For all types of earthing system, each section of earthing cable shall be separately bolted to the tower in order that it can, if required, be disconnected for the purpose of earth resistance measurements.

At each tower connected to an earthing system the Contractor shall measure the electrical footing resistance to earth with the system connected. The measurements shall also be recorded by the Contractor on the tower footing earth resistance profile to be provided as a final record.

The terminal towers shall be connected to the substation earthing grid.

Type and thickness of galvanizing shall provide sufficient protection of steel for 20 years service and shall not be less than 610g/mm^2.

Metal roofs of existing buildings constructed within 30 m of the centre of the transmission line shall be securely earthed. A minimum of two earth connections shall be made to opposite sides of the roofs by means of earthing (counterpoise) cable, which shall be led down the sides of the building to earth. The earthing cable shall be securely fixed in cleats to the sides of the buildings and not less than 2 m of the cable shall be buried in the ground at a depth of at least 800 mm.

All metallic fences both new and existing, which cross under, or which are located near and parallel to the transmission line shall be earthed as follows:

- One earthing rod shall be used to ground each 100 m of fence that is parallel to and within 50 m of the centre line of the transmission line. One earthing rod shall be used on each side of the right of way to earth fences crossing under the line.

- Earthing rods, to which the fence wires shall be bonded, shall be driven to a depth of not less than 1.5 m. All metallic fence gates within the right of way shall be electrically bonded to the fences.

11.3 Erection of insulators

Insulators and insulator fittings shall be assembled and installed by the Contractor as shown on the drawings, and in accordance with the recommendations of the manufacturers.

All insulators shall be handled carefully during transportation, assembly and installation on the tower to avoid damage and shall be cleaned when installed using techniques which cause no damage to the surface of the insulator.

Proper precautions shall be taken to ensure that insulators and fittings are not strained or damaged during erection of the insulator sets, and during the pulling out and erection of conductors.

The Contractor shall take adequate precautions to ensure that dust and dirt is excluded from insulator ball and socket joints.

11.4 Crossing of public services

At crossings of roads, buildings, waterways, telegraph and telephone lines, over or under other power lines, the provisions of any Regulations to which KETRACO is subject shall be complied with. No additional payment will be made for any temporary guarding or scaffolding required for erection of the conductors at crossings.

When the Contractor is about to carry out erection of the conductors along or across power lines or telecommunication circuits, public roads, waterways, he shall be responsible for giving advance notice to the appropriate authorities of the date and time at which he proposes to carry out the work. Where authorities, or public undertakings deem it necessary for the protection of their employees or property, or of the public, or for the regulation of traffic, to provide flagmen or watchmen, the cost of such provision shall be borne by the Contractor.

11.5 Erection sags and tensions

The line and earth conductors shall be erected so that the tensions at “everyday temperature” in still air shall be the figures stated in the Technical Schedules and shall be equal in all spans, excepting for sections with spans differing considerably from the basic span where compliance with the specified tensions under the assumed maximum loading conditions may necessitate a lower figure for the “everyday temperature” still air tension.

At “everyday temperature” in still air, in any span, the earth conductor sag shall be approximately 10 per cent less than the line conductor sag.

In calculating the initial sags and tensions allowance shall be made for the elasticity and coefficient of expansion of the conductor materials.

The "equivalent span" method shall be used, in which the tension in any section length is that which would apply to a single span equal to the square root of the figure arrived at by dividing the sum of the cubes of the individual span lengths, in the section considered, by their sum. Unless otherwise approved, the sag of any one conductor should not differ from the correct sag by more than 3 per cent and, in any one span, the maximum permissible difference in sag between conductors of different phases shall not exceed 150 mm.

The sag of the subconductors of any one phase shall not differ by more than 50 mm.

Employing the approved design sags and tensions as the basis the Contractor shall submit, for approval, calculations for the initial sags and tensions to be employed during stringing activities. These calculations shall take into consideration the effects of creep for each of the phase and earth conductors and also that, for instance, Aircraft Warning Markers will not be installed at the time of sagging. For sections where Aircraft Warning Markers are to be installed additional initial sag and tension data shall be provided.

11.6 Erection of line and Aluminium Steel Clad earth conductors

At least 3 months prior to the commencement of stringing activities the Contractor shall submit his stringing schedule identifying the stringing sections, locations of tensioner and puller, the proposed position of mid-span joints, drum identification numbers, sagging spans and, where appropriate, check sagging spans. The sagging span shall normally be the longest span within the section but consideration shall be given to establishing a line-of-sight to the puller station. In addition, details of temporary staying of towers, joints of control and other relevant information shall be submitted.

The fullest use possible shall be made of the maximum lengths of line and earth conductor in order to reduce to a minimum the number of joints. The number and span location of tension joints shall be

approved. The number and span location of tension joints shall be approved. Unless otherwise approved there shall be no tension joints in adjacent spans or in sections, between tension towers, of less than three spans; there shall be no joints in spans crossing roads, navigable waterways or buildings or in the spans immediately adjacent thereto. All joints shall be at least 30 m away from structures.

The conductors, joints and clamps shall be assembled using the approved tools and shall be erected in such a manner that no bird-caging, over-tensioning of individual wires or layers, or other deformation or damage to the conductors shall occur. Running out blocks shall be of an appropriate diameter to avoid the formation of permanent "sets" in the conductor and shall be to approval. The use of midspan compression joints for the purpose of pulling out conductors during erection and the use of insulators and line materials in general for erection purposes will not be allowed. Auxiliary erection clamps, or hauling devices shall be of approved design, and shall under erection conditions, allow no relative movement of strands or layers of the conductors. If required by the Engineer, this property shall be demonstrated by actual test. Cutting of layers of ASCR or ASC conductors shall be carried out with tools designed not to damage underlying strands. Cropping or shearing of complete conductors shall not be permitted. The cut ends of the conductors and the joints, clamps and fittings attached to the conductor themselves shall be treated in an approved manner to prevent ingress of moisture.

The Contractor shall measure by means of approved micro-ohm meter equipment in accordance with the Tests section of this Technical Specification the electrical resistance of all joints after completion and before erection. The resistance of the joint shall be in accordance with the requirements of the Specification and shall in no case be greater than 75 per cent of the resistance of the equivalent length of conductor. The values of resistance measured shall be recorded on a schedule that shall be submitted to the Engineer as part of the final records. Any faulty joint shall be cut out and replaced at the Contractor’s expense.

All current carrying surfaces of bolted connections shall be coated, prior to erection, with an approved conducting compound in an approved manner.

In case of local damage to isolated strands of a conductor during erection the use of repair sleeves of approved type may, in exceptional circumstances, be permitted upon application to and at the discretion of the Engineer who will regard repair sleeves as joints in respect of permitted locations. Any use of repair sleeves shall not incur additional cost to KETRACO.

The Contractor shall at his own expense make suitable arrangements for temporary guying of towers, where necessary. Suitable plates (detachable or otherwise) shall be provided on the towers for the attachment of any temporary guys. The additional loads imposed on specific towers during erection by the use of temporary guys shall be calculated and approved. Attachment of the guys to the tower shall be accomplished so as not to damage to steelwork or the galvanized coating.

The line and earth conductors shall be erected employing tension stringing methods and equipment and shall not at any time during erection come into contact with the ground or any obstacle, such as walls, fences or buildings, except when the conductors are at rest. Approved means shall be provided to prevent any damage to conductors where these are run over temporary supports.

Conductor running-out blocks shall be free running and of approved materials and dimensions.

Conductors shall be clamped in, vibration dampers and spacers shall be erected, as soon as practicable but in any case within 72 hours after having been tensioned to the correct sag.

The Contractor shall make any necessary special arrangements for running out and sagging the conductors where the route crosses buildings, orchards, plantations, gardens, or other ground over which erection cannot be carried out in the normal manner. No extra charge for man-handling of material or for any special precautions or methods necessary at such positions shall be allowed.

The Contractor shall also make such special arrangements as the Engineer may approve where power lines are to be crossed. Where the conductors have to be erected whilst the power line to be crossed is energized, no additional payment to the prices stated in Price Schedules shall be made for any special scaffolding or equipment required.

Where required by the Engineer, prior to the issue of the taking-over certificate, the Contractor shall be responsible for checking that the relative sags of the conductors are within the specified tolerance. Such checks shall be carried out at selected points along the route as required by the Engineer.

At the end of the maintenance period stated in the Conditions of Contract, the line conductor sag adjusting devices for bundled subconductors shall be finally not more than 50 mm plus or minus, from their median position, unless otherwise approved.

The Contractor shall provide suitable dynamometers, thermometers, sighting rods and other approved apparatus necessary for the proper checking of the work. Dynamometers, if used, shall read in kilograms or Newtons and, where required by the Engineer, shall be tested and, if necessary, recalibrated.

The Contractor shall keep a record of the particulars of the sagging of conductors in each section of the route showing the mean actual sag of the line conductors and date of stringing as well as the ambient and conductor temperature. The data shall be handed to the Engineer at the conclusion of erection work.

Clearances between phase conductors and ground and between jumpers and structures shall be checked during erection and before handing over the line.

The Contractor shall submit his proposals for a test regime to the Engineer for approval prior to fieldwork commencing.

11.7 Erection of optical fibre (OPGW) earth conductors

The fullest use shall be made of the maximum lengths of conductor to reduce the number of joints to a minimum. The locations for joints shall be approved by the Engineer.

The conductors and clamps shall be assembled using approved tools and shall be erected in such a manner that no bird-caging, over-tensioning of individual wires or layers, over-tensioning or stressing of optical fibre elements, or any other deformation or damage to the conductors shall occur.

The conductors shall not at any time during erection come into contact with the ground or with any obstacle, including walls, fences and buildings.

The relevant clauses related to erection of line conductors shall apply also for OPGW earth conductors.

The erection of OPGW is to be effected in such a manner that neither torsion nor bending stresses on the conductor during erection, sagging, jointing or landing shall cause any damage or deterioration to the optical fibre system. Suitable precautions shall be taken, using for example torsionally stable pulling ropes, suitable running-boards, counterweights and running blocks. Special attention shall be paid to ensure that the conductor at no time is subjected to bending in excess of that permitted by the minimum bending radius specified by the manufacturer. Running-out blocks shall be sized to conform to the minimum bending radius specified by the OPGW manufacturer.

The Contractor shall carry out tests to confirm the satisfactory condition of optical fibres prior to erection.

Once installation of OPGW earth conductor is complete a series of tests to be agreed with the Engineer shall be carried out to ensure the satisfactory operation of the cable. The tests shall be carried out in both directions.

The tests shall include but not be limited to:

1. Optical attenuation on OPGW earth conductor terminated with connectors carried out in both directions at 1550 nm.

2. Loss distribution to measure the uniformity of loss in the optical fibres and joint losses in the OPGW earth conductor using an optical time domain reflectometer (OTDR).

On completion of the tests three copies of the test report shall be supplied to the Engineer.

Optical attenuation of the OPGW earth conductor terminated with connectors shall be measured and recorded at the end of the guarantee period and it shall not be more than 102 per cent of the reading at commissioning.

The contractor shall submit his proposals for erection and test regimes to the Engineer for approval prior to fieldwork commencing.

11.8 Work in detail

The diversions/terminations of the Isinya-Suswa Transmission line into Kimuka substation is included in the scope of works. Provisions shall be made to ensure that the overhead line modification works

are conducted under single circuit outage conditions. A double circuit outage will not normally be given. Allowances shall be made by the contractor for any temporary structures that may be required to complete the works under single circuit outages.

The location and orientation of all towers at the ends of the lines are to be studied with extreme care. Method statements and drawings with sufficient detail are to be provided prior to outages being granted. Outage dates and outage durations are to be requested well in advance to allow KETRACO sufficient time to arrange these outages.

11.9 Final inspection

Upon the notification by the Contractor that the work is finished on a completed section of line, the Engineer, prior to issuing the taking over certificate, will inspect the completed Works, in order to ascertain that they have all been carried out in accordance with the Specification and to the Engineer's satisfaction.

In particular it will be ascertained that at least:

1. **At tower positions**, backfilling of the excavations, ramming, levelling around foundations, draining of higher footings on sloping ground, dispersal of excess earth etc, is complete.

   Concrete protruding above ground is correctly shaped, finished and sealed. Counterpoise earthing is installed where required.

   Silicone, epoxy or other approved painting has been correctly applied. Steel sections are straight and not damaged. Bolts and nuts are correctly fitted with washers and are properly tightened and locked.

   The line and earth conductor fittings are erected in accordance with the drawings and are complete. The line and earth conductors are correctly clamped. Electrical clearances from jumpers to tower steelwork are adequate.

   All tower steelwork, bolts, nuts, lock nuts, cotter pins, washers and split pins on all fittings are properly fitted. The tower steelwork is free of all foreign matter.

   Anti-climbing devices, danger and identification plates are complete and correctly fitted.

2. **Along the transmission line**. The conductors and earthwires are clean, without strand damage and free of mud, foliage, loose wires, etc. The sags of all conductors and earthwires are in accordance with sagging documents and clearances are correct.

   All packing and surplus materials have been removed from the site. The cutting and removal of trees and all route clearing is in accordance with the Specification.

   All access and inspection tracks are completed and in good condition.

12. SPECIAL TOOLS AND EQUIPMENT

General requirements for mandatory and recommended special tools and equipment are stated in Section III.

13. SPARE PARTS

NOT APPLICABLE.

14. REMEASURED WORK

14.1 Measurements of work

All measurements of length for the purpose of payments shall be to the nearest metre, and shall be made, after erection, along the centre line of the transmission line without allowance for sag or slope.

All measurements of mass for the purpose of payments shall be to the nearest kilogramme, and shall be calculated from the approved working drawings, steel being assumed to have a density of 7850 kg/m^3.

All measurement of the cleared strip shall be based on the prices stated in the Price Schedules which shall be deemed to be the average for the total line route irrespective of the varying density of the vegetation or the nature of the terrain.

All measurements for the purpose of payments shall be made jointly by representatives of the Contractor and the Engineer.

14.2 Towers and foundations

The rates given in the Price Schedules for the standard types of towers, standard foundations, and earthing and for excavation, concrete, steelwork and reinforcement for foundations of special towers shall include all work which the Contractor may have to do when installing the standard towers, foundations, special foundations and earthing, regardless of the nature of the ground, the presence of water, the slope or irregularity of the ground surface or other local conditions, except that where sloping ground necessitates the use of individual tower leg extensions, these extensions will be paid for at the appropriate rates given in the Price Schedules. The foundation rates are deemed to include for any additional work that may be required to secure foundations against the effects of soil erosion.

Single leg extensions for standard and extended towers shall be paid for at the rate stated in the Price Schedules.

Payment for minor modifications to parts of standard towers which do not involve modifications to the main structure, such as modifications to crossarms, etc shall be calculated by deducting from the price of the standard tower the cost of the omitted steelwork calculated at 75 per cent of the special steelwork rate stated in the Section X, and adding the cost of the modified steelwork calculated at the whole of that special steelwork rate. Steelwork additional to an otherwise standard tower, such as additional brackets, etc shall be paid for at the special steelwork rate stated in Section X. Where a standard tower is erected on special foundations or on a special extension the standard tower shall be paid for at the rate stated in Section X and the special extension and the foundations shall be paid for at the appropriate rates stated in Section X. Special towers, or standard towers with radical modifications to the main structure, and the special foundations shall be paid for at the appropriate rates stated in Section X.

Where specialist soil investigation (not routine soil testing) or specialist foundation work including design and construction is carried out by an approved subcontractor, this shall be paid for at agreed cost plus 5 per cent.

14.3 Tests

The Employers/Engineer has the right to inspect materials and equipment, and witness factory tests of any plant and equipment included in this Contract. The cost of a satisfactory and approved type test shall be paid for at the rates stated in the Price Schedules. Prices for tests shall include manufacture, supply, erection and dismantling of all materials and provision of all test facilities. The Contractor shall also include in the price for the attendance by the Engineer and KETRACO staff to witness the tests, that is, 3 Engineers for each trip.

The price shall include food, accommodation, daily allowance, round trip air fare between Nairobi and/or the Engineer's home office and any other countries where equipment are to tested and any internal transportation within the country of the test.

Each consignment of material shall be inspected and tested in the presence or representatives of the Employers and the Engineer.

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

1. Economy class returns air ticket (from Nairobi or the Engineer's home office to Places of Test and/or Inspection).

2. Visa expenses, airport taxes and other incidental travel expenses as required.

3. Hotel accommodation, including full board plus daily allowances of US$ 120/day for incidental expenses for a minimum of 5 days for each trip. (US$120/day for KETRACO staff only)

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

Prior to the tests, the Contractor shall submit an outline of the procedures and tests in its plans to demonstrate fulfilment of the requirements specified in the subsequent sections of the detailed technical specifications.

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

Type tests necessary for proving compliance with the Specification and not specifically mentioned in the Schedules shall be undertaken at no extra cost to KETRACO.

Uplift and compression tests on special foundations, including tests on piles, or other additional tests including bore holes and specialist soil tests, when instructed by the Engineer, shall be paid for at the rates stated in Section X or, if not defined in Section X as may be agreed by the Engineer at cost plus 5 per cent.

The cost of all routine or sample tests on materials and/or analyses shall be borne by the Contractor.

The cost of additional tests and/or analyses required by the Engineer and effected elsewhere than at the works of the Contractor or a subcontractor or on the Site will be borne by KETRACO should such tests prove satisfactory, but the Contractor will be called upon to pay all expenses incurred by KETRACO and/or Engineer in respect of any work or material found to be defective, of inferior quality, adulterated or otherwise unacceptable.

15. TESTS

15.1 General

The following tests shall be carried out in order to determine whether the materials and apparatus comply with the Specification.

Not less than four weeks notice of all tests shall be given to the Engineer. As many tests as in the opinion of the Engineer are possible shall be arranged together. Four copies of the records of all tests shall be furnished to the Engineer for review and approval. All instruments shall be approved and shall, if required by the Engineer, be calibrated at the expense of the Contractor by an approved authority.

With the exception of the manufacturers' routine and sample tests all type tests may, at the option of the Engineer, be waived providing satisfactory previous type testing records, issued by an approved internationally acknowledged reputable independent testing laboratory, are available and are approved by the Engineer.

For tests to be carried out at the manufacturer’s works, the Contractor shall cater for all the FAT related expenses as follows:

1. One economy class return air ticket however for flights over 5 hours business class return air tickets shall apply.

2. Visa application fee, airport taxes and other incidental travel expenses as required.

3. Local transportation in contractor’s country, Accommodation in a minimum 4 star international hotel including food, hotel laundry services, international telephone services and high speed internet connection.

4. The Contractor shall in addition provide a USD 250/day stipend allowance for each employer’s representative for the entire training period.

15.2 Summary of tests

The following tests shall be carried out in accordance with the details as specified.

Tests to be carried out at the manufacturer's works (unless otherwise specified or approved):-

1. Line and earth conductors – type, routine and sample tests.

2. OPGW earth conductors –qualification, field routine acceptance, sample tests.

3. Tension and suspension clamps and joints - type and sample tests.

4. Insulators, insulator fittings and conductor mechanical protective fittings - type, routine and sample tests.

5. Towers and metal fittings for towers - type and sample tests.
6. Zinc coating - sample tests.

Tests to be carried out on the Site:-

7. Tests on cement and concrete - type and sample tests.
8. Tests on foundations - type tests.
9. Tower footing resistances - routine tests.
10. OPGW earth conductors - routine tests.

11. Tests on conductor joints and clamps - routine tests.

12. Line insulation and conductivity - routine tests.

13. Such tests as are required by the Engineer to prove compliance with the Specification independently of any tests that may have already been carried out at the Manufacturer's Works, or elsewhere.

15.3 Details of tests

15.3.1 Line and earth conductors

15.3.1.1 Type tests

Conductor or earthwire shall be type tested in accordance with IEC 61089. Used grease shall be tested in accordance with Table 1 of BS EN 50326 to determine the characteristics of the grease, including the drop point as stated in the Technical Schedules and to confirm the absence of corrosive substances. Type test records and certificates for identical type of conductor may be accepted provided that those records and certificates are not older then five years and tests were carried in accredited laboratory.

15.3.1.2 Sample tests

Sample from 10% of lengths of finished line or earth conductor shall be taken and subjected to the tests stated in IEC 61089. In the event of the sample from any length not passing these tests a second and third sample shall be taken from the same length and if one of these also fails under test the length from which it has been taken shall be rejected.

15.3.1.3 Routine tests

Routine tests in accordance with IEC 61089 shall be carried out during the production on the complete conductor to prove compliance with the details in the Technical Schedules.

15.3.2 OPGW earth conductors

15.3.2.1 Qualification tests

Tests on complete composite fibre optic earth conductor shall be carried out in general accordance with the IEEE 1138/2009 and referenced standards. Lightning arc test shall be carried out for Class 2. Any deviation from these methods or any alternative methods proposed must have prior approval from the Engineer.

15.3.2.2 Field routine acceptance tests

The Contractor shall carry out attenuation tests to confirm the satisfactory condition of the optical fibres prior to erection. These will be compared against the values obtained prior to shipment.

Once installation of the fibre optic cable is complete a series of tests to be agreed with the Engineer shall be carried out to ensure the satisfactory operation of the cable. The tests shall be carried out in both directions.

The tests, using an optical time domain reflectometer (OTDR), shall include but not be limited to:

a. Optical attenuation on the terminated cable in both directions carried out at the wavelengths given in Clause 3.1 of this specification.

b. Loss distribution to measure the uniformity of loss in the fibre and joint losses.

c. End to end attenuation tests including connectors at terminal stations prior to commissioning.

d. Bit Error Rate (BER) test shall be carried out and the error rate shall not exceed 10^{-9}.

On completion of the tests three copies of the test reports shall be supplied to the Engineer.

At the end of the guarantee period the optical attenuation of the cable between terminal stations complete with end connectors shall be remeasured and recorded and it shall not be more than 102 per cent of the readings obtained at commissioning. BER tests shall also be repeated.

15.3.2.3 Sample tests

Sample from 10% of lengths of finished OPGW shall be taken, metallic fibres subjected to tests stated in IEC 61089 and optical fibres subjected to attenuation and disperse tests in accordance with IEC. In the event of the sample from any length not passing these tests a second and third sample shall be taken from the same length and if one of these also fails under test the length from which it has been taken shall be rejected.

15.3.3 Tension and suspension clamps and joints

Testing shall be in accordance with IEC 61284. Tests on fittings for OPGW shall in addition comply with the recommendations given in the CIGRE Report 'Guide to fittings for optical cables on transmission lines: Part 2A Testing procedures - optical groundwire fittings and optical phase conductor fittings' ELECTRA No.188 February 2000. The following additions shall apply.

15.3.3.1 Type tests

All joints and clamps shall be submitted for examination before test and all assembly, cutting off of conductor, compound filling (where applicable) and insertion of a plug in a centralizing hole and any other work whatsoever necessary for the assembly of the clamps and joints shall be carried out in the presence of the Engineer with the erection methods and tools proposed for field use.

Approval of such methods and tools will be subject to inspection at the time of the tests. The Contractor shall ensure that a reasonable number of his supervising staff shall be present at the type tests or, alternatively, ensure the correct jointing techniques are demonstrated to his linesmen in the presence of the Engineer.

15.3.3.1.1 Mechanical type tests

The following tensile tests shall be carried out on tension clamps and tension joints:-

a. Two tension clamps shall be fitted to the ends of a length of conductor not less than 6 m long.

b. A tension joint shall be fitted in the centre of a 6 m length of conductor, each end of which shall be held in an anchor clamp.

For both tests a. and b. a tensile load of about 50 per cent of the ultimate strength of the conductor calculated in accordance with IEC 61089 shall be applied and the conductor shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95 per cent of the ultimate strength and then reduced to 90 per cent of the ultimate strength and maintained for one minute. There shall be no movement of the conductor relative to the fitting due to slip during this one-minute period and no failure of the fitting.

Non-tension joints and clamps and non-tension parts of tension clamps shall be similarly tested to show compliance with the provisions of the Specification.

Slip tests shall be carried out on suspension clamps to demonstrate compliance with the Specification and to establish the torque to be applied to the clamp bolt nuts.

15.3.3.1.2 Electrical type test

Electrical type tests, including resistance and heating-cycle tests on tension joints and heating-cycle tests on non-tension joints, shall be made on one sample of each type of midspan joint, dead-end jumper lug and repair sleeve. The tests shall be carried out in accordance with IEC 61284 and the samples shall meet the requirements of the Standard with the following exceptions. For the heating cycle test the ambient temperature shall not be greater than 25°C and the test current shall be that current which raises the conductor to the maximum operating temperature specified. In addition the heating cycle test shall be carried out with a tensile load equal to approximately 20 per cent of the breaking load of the conductor and shall be recorded.

The corona type test specified under "Insulator units, insulator sets, insulator fittings and conductor mechanical protective devices", shall be applied to all conductor fittings, including dampers and these tests may be carried out simultaneously with the insulator set tests if this is found to be convenient.

15.3.3.2 Sample tests

Sample clamps and joints shall be submitted to such tests as the Engineer may require in order to demonstrate compliance with this Specification.

15.4 Insulator units, insulator sets, insulator fittings and conductor mechanical protective devices

Testing shall be in accordance with the relevant clauses of the latest editions of IEC 60383-1, IEC 60383-2, IEC 60437, IEC 60797, BS 5049:Part 2, IEC 61109, IEC 61284, IEC 61466, IEC 61854 and IEC 61897, ANSI C29-11, ANSI/IEEE Std 989 and CIGRE Report ELECTRA No.188 February 2000 for OPGW fittings, with the following additions.

15.4.1 Insulator Units

15.4.1.1 Type tests of insulator units

The type tests are as follows:

- verification of the dimensions
- dry lightning impulse withstand and flashover voltage test
- wet power frequency withstand voltage and flashover tests
- electromechanical failing load test or mechanical failing load test, as applicable
- thermal-mechanical performance test.
- all other composite insulator type tests as required by IEC 61109

15.4.1.2 Routine tests of insulator units

Routine tests shall be carried out in accordance with IEC 60383-1.

15.4.1.3 Sample tests of insulator units

Sample tests shall be carried out in accordance with IEC 60383-1.

15.4.2 Insulator sets

15.4.2.1 Type test of complete insulator set

- 50 per cent dry lightning impulse flashover voltage test
- wet power frequency withstand voltage test
- wet switching impulse withstand voltage test
- corona test
- radio interference test.

15.4.2.2 Routine test of insulator set fittings

All castings and fittings in which a weld is subject to a tensile load in service (including arcing horns) shall comply with the routine load test requirements of 50% of the specified minimum failing load to IEC 61284 “Overhead lines – Requirements and tests for fittings”.

15.4.2.3 Fault current tests on spacers

Each type of spacer or spacer-damper must be tested to examine the effects of short duration fault currents on the mechanical strength of the spacers. For the tests the spacers must be clamped to the centre of an 80 m span of conductor that will be supported under the 'everyday' still air tension given in the Technical Schedules. The spacers must withstand without damage or distortion the forces

developed on the spacers by the conductors when the fault current is carried by the conductors. The spacers must withstand the effects of 5 fault currents of 40 kA symmetrical current, with a first peak of 100 kA and of a total duration of 5 cycles.

15.4.2.4 Mechanical tests on spacers

To supplement the claimed performance of spacers and spacer-dampers, the engineer may require certain mechanical and fatigue tests to be carried out to substantiate the claimed service performance data.

15.5 Towers and metal fittings for towers

15.5.1 Material Sample Tests

Samples of the material for the towers and fittings shall be tested in accordance with BS EN 10025 as modified by this Specification. Bolts and nuts shall be tested in accordance with the requirements of BS 4190 and EN 20898-1.

15.5.2 Assembly test

In order to check the workmanship (detailing and fabrication) one tower of each standard type and any special tower, inclusive of all body and leg extensions shall be subject to a check assembly. The members employed for the check assembly shall be selected at random by the Engineer, and assembled to form complete towers, in the presence of the Engineer, at the manufacturer's works.

Check assembly should include anti-climbing devices, bird guards and anti-theft bolts to check the suitability.

15.5.3 Type test

As required by the Engineer, one tower of each standard type shall be assembled at the Manufacturer's Works or other approved place and shall be tested on a rigid foundation.

If the Contractor, in carrying out erection of steel towers on the site, proposes to assemble the towers on the ground subsequently raising them to the vertical position, the sample towers submitted for test shall be so assembled and raised to the vertical position on the test foundation in the presence of the Engineer.

Each tower shall then be tested in accordance with IEC 60652 and subjected to such test loads as the Engineer may specify in order to prove compliance with the ultimate loading conditions including the overload factor stated in the Technical Schedules, applied in an approved manner without showing signs of failure or permanent distortion in any part.

Tests to destruction shall then be carried out in an approved manner on suspension type towers only. No tower or parts of any tower submitted for destruction test shall be used on the contract Works, and steel members shall be destroyed or marked in an approved manner.

Tests to ultimate loading shall be carried out in an approved manner on tension tower types. Where tower tests are satisfactorily completed (and not taken to destruction), the tower shall be carefully

inspected after dismantling to ensure that no parts are damaged. The tower may be re-used on the contract at an approved position (of light loading) provided any members showing signs of deformation are replaced. Before delivery to site all parts of the tower shall be clearly marked to enable identification from routine deliveries. New bolts are to be provided for erection of tested towers at site.

Steel towers submitted for test shall be galvanized unless specific approval is obtained. All tower tests for which the results are approved will be paid for at the rates stated in the price schedule. Towers shall be provided with anti-climbing devices on at least 1 leg to facilitate inspection of the proposed devices.

15.5.4 Zinc coatings

15.5.4.1 Sample tests

Samples, selected by the Engineer, of all zinc coated material shall, unless otherwise approved, be subject to the following tests:-

For material other than wires, the tests specified in BS EN 1461 and BS 7371 Pt 6.

For wires, the tests specified in BS EN 10244 Part 2.

15.5.5 Tests on foundations

15.5.5.1 General

Type testing and proof testing of foundations shall be carried out in accordance with IEC 61773. The total number of each type of test may vary but it is generally considered that where foundation designs are more conservative less testing will be required and where foundation designs are more efficient greater testing will be required.

The location for each test and choice of foundation to be subjected to test shall be to the Engineer's approval. Method Statements, Testing Proposals, and Calibration Certificates, shall be submitted in advance to the Engineer for approval and shall include details of the following:-

- Relevant ground investigation data
- Foundation type and installation procedure
- Proposed type and set-up of testing equipment
- Unique reference numbers of calibrated instruments and equipment
- Foundation testing procedure and test record sheets to be completed on site (record sheets should clearly include proposed loading/unloading targets and minimum monitoring periods)
- Proposed testing schedule and programme for contract

Additional foundation testing may be requested by the Engineer at his discretion. Any foundation tests requested by the Engineer for which the results are approved will be paid for at the rates stated in Section X.

15.5.5.2 Type tests (Design)

Type tests, or design tests, shall consist of site trials of sacrificial foundations installed to the same methodology as that intended for the working foundations. Design tests shall involve uplift and compression tests to ultimate design loadings or to destruction and shall be carried out on each class of standard foundation given in the Technical Schedules, or to the approval of the Engineer. Standard foundation classes shall include each soil and rock type expected along the line route. Tests will be such to verify that the selected design parameters for foundations are suitable for the relevant range of ground conditions.

The results of each foundation test are to be correlated to soil properties at the same location to establish a routine procedure for ground testing and correlation of ground parameters to the foundation class for each tower site on the line route. The soil properties at each test site shall be determined primarily by Standard Penetration Tests (SPT) and triaxial compression tests on undisturbed samples taken from at least three different depths within the sphere of influence of the foundation. Special consideration shall be given to the correlation of disturbed backfill soil properties with the cohesion and/or internal friction of surrounding undisturbed soil.

Each foundation shall be subjected to test loads in order to prove compliance with the ultimate loading conditions stated in the Technical Schedules. Test loads may be specified by the Engineer. The maximum displacements for settlement and uplift shall be consistent with the type of structure to be supported and comply with the maximum allowable differential movement under simultaneous ultimate loadings given in the Technical Schedules.

The type testing schedule of any foundation design shall be completed in advance of any permanent works utilising that design and shall be used in the verification process of the Contractor's design. For this purpose he will be responsible for carrying out type testing or design testing in the most common ground conditions at an early stage of the Contract.

15.5.5.3 Proof tests

Proof tests shall be conducted on working foundations and individual rock anchors to verify performance for in-service working conditions and as a quality control check on construction. Test loads for proof testing shall be 60 % of the design load (approximately equivalent to 150 % of working load). Routine proof testing will not generally be carried out in compression or on gravity based foundation designs.

15.5.6 Tests on cement and concrete

15.5.6.1 Type tests

Samples from the cement to be used on site are to be taken to a laboratory or testing station approved by the Engineer to demonstrate compliance with BS 12 (BS EN 197-1) or BS 915 or BS 4027 as applicable.

Mix design for the concrete shall be proved by carrying out standard 28 day compressive strength testing to confirm the required characteristic strength of concrete can be obtained. When required by the Engineer, test results to confirm both the cement content and the dry density of the concrete shall be presented.

15.5.6.2 Sample tests

Tests on the concrete shall be made during the construction of foundations, to demonstrate compliance with this Specification, as required by the Engineer. Such tests shall include sampling the concrete and preparation and handling of specimens. The Contractor shall provide cube moulds and slump cones as necessary. Curing of test cubes shall be made under laboratory conditions and tests shall be performed 28 days after sampling. The Engineer may specify tests at 7 days after sampling if the relation between these tests and the 28 day tests has been established.

15.5.7 Tower footing resistances

15.5.7.1 Routine tests

The resistance to earth of each tower shall be measured and recorded in an approved manner. Following the installation of an earthing system to any tower the new resistance to earth of the tower shall be measured, all prior to the erection of the earth conductors.

15.5.8 Tests on conductor joints and clamps

15.5.8.1 Routine tests

The electrical resistance of all joints and clamps shall be measured accurately by the Contractor. Measurements shall normally be made before erection of the conductors but where the joint consists of several parts bolted together, such as a dead-end anchor with a jumper terminal, the resistance to be measured is that of the complete assembly. The resistance of all joints shall be recorded and compared to the resistance of an equivalent length of conductor measured adjacent to the fitting. Joints with unacceptable resistances greater than 75 per cent of the resistances of the equivalent length of conductor shall be cut out and remade.

The Contractor shall provide a micro ohmmeter, preferably a digital model for making the above tests, and shall submit details of the proposed instruments to the Engineer for approval. Suitable clamps are to be supplied for connecting the current leads of the measuring instrument to the test sample to provide adequate surface contract at the interfaces. Test probes as used for potential contacts are unsuitable for current connections. Stringing of line and earth conductors shall not commence until the instruments are on site and ready for use.

15.5.9 Line insulation and conductivity

15.5.9.1 Routine tests

Tests shall be made on all lines after erection to establish continuity and absence of accidental earth connections.

16. DRAWINGS, DOCUMENTATION AND SAMPLES

16.1 Drawings and documentation

16.1.1 General

All drawings shall be to scale and comply in full with the Technical Specification and be fully detailed. Drawings shall not exceed 1189 x 841 mm (ISO A0 size) and shall bear approved Contract references.

16.1.2 Submittals to be attached to the Bid

16.1.2.1 Drawings

The following are the drawings to be submitted with the Bid.

a. Tower outlines with clearance diagrams for all the tower types listed in the Technical Schedules.
   Each tower outline drawing shall show a route for the step bolts, position of anti-climbing guard, bird guards and notice plates for all standard towers and extensions.

b. Diagram of external loads:
   - Suspension towers
   - Tension towers

c. General arrangement of:
   - Suspension insulator sets and fittings
   - Tension insulator sets and fittings

d. Detailed drawings of:-
   - Insulator unit
   - Line conductor tension anchor clamp and midspan joint
   - Line conductor suspension clamp
   - Cross-section of the complete OPGW including the aluminium tube and fibre cable indicating the dimensions of each element, the design and make-up of the cable.
   - Earth conductor tension clamps and midspan joints
   - Earth conductor suspension clamps
   - Line conductor non-tension joint
   - Line conductor vibration damper
   - Line conductor spacer
   - Earth conductor vibration dampers

e. Foundation outlines for all standard designs.

f. Shoring design for all class of foundation
g. Testing arrangements (foundation test, pile test, tower test etc)
h. Layouts with proposals of line entries at Kimuka and Komarock substations

16.1.2.2 Documentation with bid

The following is a list of documentation to be submitted with the Bid.

a. Programme of anticipated works, to conform with completion times required in the Special Conditions of Contract.

b. Details of the method of working to demonstrate that the specified Quality Assurance requirements will be complied with.

c. Copies of any standards proposed in substitution for International Electro-technical Commission Standards or Recommendations or British Standards accompanied where necessary by English translations of the appropriate sections.

d. Record of previous service experience of the fibre-optic earth wire offered.

e. Documentary evidence of the successful service history of the proposed damping system for line and earth conductors in environments at least as hostile as that for the present project.

f. Documentary evidence of satisfactory service history of the polymeric insulators.

g. Other supporting documentation considered appropriate by the Bidder.

16.1.3 Submittals during contract period

16.1.3.1 Programme of submittals

The Contractor shall arrange his design and drawing programme so that the works can be properly co-ordinated by the Engineer. He shall provide the documentation as specified below within 4 weeks of the award of Contract, together with any drawings and information considered necessary by the Contractor or Engineer.

a. Confirmation of contract documentation

b. A detailed schedule of all plant to be supplied under the Contract. This schedule shall have space for the following information as a minimum requirement in respect of each item:-

i Manufacturer

ii Country of origin

iii Planned FOB delivery date

iv Planned date of arrival on site

v Sub-order number (as applicable)

vi Allocated drawing numbers

c. A preliminary schedule of drawings to be submitted to the Engineer for approval in respect of all items of equipment to be supplied under the Contract. The schedule shall include a programme for submittal of all drawings required by the Specification. The schedule shall have space for at least the following information to be added at a later date:-

i Drawing number

ii Drawing title

iii Proposed date of submission

iv Actual date of submission

v Resubmissions

vi Revision numbers

vii Date of approval

viii Release as a working drawing

ix Date to site

x Date to Engineer

xi Date of as-built drawing

16.1.3.2 Drawing numbers

The Contractor will apply drawing numbers to all drawings, including those from sub-contractors and those issued for information before they are submitted to the Engineer. The Contractor's drawing office will be expected to issue the numbers in batches that will cover broad subject areas. For instance the Contractor might propose batches for towers, foundations, insulators, conductors, profiles, etc. The Contractor shall submit to the Engineer for approval the subject areas he proposes to use prior to the issue of any drawing. The Contractor shall each month issue an up-to-date drawing list to the Engineer.

16.1.3.3 Drawings to be submitted during the contract period.

The following is a list of drawings and documents to be submitted by the Contractor, for approval, within two months from the Commencement Date or such later date as may be approved.

a. **Detailed project programme**:

To cover all aspects of the Contract: design, procurement, manufacture, testing, shipment and transport, delivery to site, all site operations related to construction,

erection and installation, testing at site, commissioning and completion of the transmission line project.

b. **Design drawings and documents detailing**:

Calculations giving the design basis to be employed for the sags and tensions for the line and earth conductors for both final and erection conditions and calculations providing data for the manufacture of the sag templates.

Derivation of applied loads for all towers including wind on structure.

Detailed live metal or wire clearance diagrams for each type of tower.

Basis to be employed for the design of structures.

Analysis of maximum member and connection loads and capacities for all members in standard towers, body and leg extensions.

Structure foundation loads for all loading cases demonstrating that the critical condition for any combination of body and leg extension has been considered.

Foundation designs for all standard classes, including stub and cleat designs.

Concrete mix design.

c. **Arrangement drawings of**:

Each type of standard tower, body and leg extension showing connection to foundations, insulator and earth conductor attachments and complete with all necessary erection information and part list including weight.

Stubs, foundations (including details of reinforcement, excavation, stub setting).

Special towers, extensions and foundations (as required).

d. **Detail drawings of**:

Suspension and tension insulator sets, with all fittings and securing devices.

Insulator units, showing cross section and details of securing device.

Line conductor tension clamps and joints.

Tension make-offs and suspension clamps for earth conductors.

Vibration dampers for line and earth conductors including calculations to demonstrate the efficacy of the proposed system.

All OPGW ancillary equipment.

Tower earthing arrangements.

Tower obstruction lighting and marking.

Proposed live-line maintenance equipment.

Danger and property, route and tower number, circuit colour, phase and aerial number plates.

Curves showing the initial and final sags and tensions of the line and earth conductors at different spans and temperatures, all in accordance with the Specification.

Route plans, schedules and profile drawings all in accordance with the Specification.

16.1.4 Final records

After completion of work on Site all Contract drawings shall be revised where necessary to show the equipment as installed and the number of copies of revised drawings as specified in Section X shall be submitted for review. A complete set of reviewed records shall be provided comprising, one full size reproducible copy and one full size print. Record drawings shall be endorsed “As Constructed” and shall be correctly titled and carry the Engineer’s review number, Contractor’s drawing number and where appropriate KETRACO’s number allocated to the item.

After final review of the “As Constructed” record drawings the Contractor shall submit complete sets of records on compact discs, one of which is for KETRACO as detailed in Section X. Electronic copies of the drawings shall be in electronic format suitable for reproduction on paper using KETRACO’s preferred software packages. Each disc shall provide a comprehensive drawing list containing the drawing number, sheet, revision and title of every drawing. Each single file drawing record shall be self-supporting without referencing other files. Non-standard items such as fonts, line types, etc should not be used. If compression techniques are applied to files then any software necessary to decompress the files shall be included on the discs. The Contractor shall ensure that all information contained on the discs has been checked for virus contamination. Each compact disc shall be supplied suitably encased and accompanied with printed documentation describing the contents of the compact discs, the formats and software used to compile the discs and the print hardware required to reproduce the record drawings.

Final record copies shall be handed over before the issue of the Taking Over Certificate.

The list of drawings required for final record purposes is given below.

After completion of work on site all Contract Record drawings, as required by the Specification.

a. Tower and foundation designs and calculations

b. Tower and foundation details including all types of extensions

c. Insulator sets plus component parts

d. Earth conductor suspension and tension sets plus component parts

e. All types of connectors, dampers and joints

f. Earthing details

g. Line conductor and earth conductor initial/final sag-tension charts

h. Sag templates

i. Wire clearance diagrams

j. Material lists for each tower

k. Stub setting templates

l. Foundation installation details

m. Foundation setting level diagrams

n. Profiles and strip plans

o. Route maps

p. Line schedules

q. Tower footing resistance chart

r. Tower notice plates and accessories.

16.1.5 Installation and maintenance instructions

The Contract Price shall be deemed to include illustrated installation and maintenance instructions written in English.

Before commencement of conductor stringing the Contractor shall submit to the Engineer for review fully detailed operating and maintenance instructions for compressors and any other working equipment. Also to be included are instructions on the method of making compression joints and the methods to be used for the erection of all fittings on the line together with the necessary tests and checks to ensure fitting has been successfully effected. The instructions are to be as simple and clear as possible, fully illustrated with drawings and diagrams as necessary and detailed with part numbers for ordering of replacements. Two copies are required for use of the Engineer during erection work.

Further copies are to be reproduced as a book or books of approximately A4 size and bound into strong black durable imitation leather covers inscribed upon the front generally in the form of the title page to this document except that the references to Specification, Conditions of Contract, drawings, etc, will be replaced by “Installation and Maintenance Instructions”.

The name of the main Contractor, but not that of any subcontractor, may also be inscribed upon the cover after the description of the plant. The name of KETRACO shall be inscribed upon the spine.

The finished books are to be handed to the KETRACO not later than 1 month before the Taking-Over Certificate is issued.

16.2 SAMPLES

16.2.1 General

The Contractor shall submit samples of material as required from time to time by the Engineer.

17. TRAINING

The Contractor shall provide on site training to KETRACO staff during all stages of the installation works.

In addition the Contractor shall provide specific training to two members of KETRACO staff in their main design offices. Training shall be specific to the Nairobi Ring Project and shall include, but not limited to, foundation design, tower design and detailing, the use of PLS Tower or similar tower design software and the use of the PLS CADD or similar profiling software, both of which shall be provided as part of the Contract. Each KETRACO Engineer will be required to spend a minimum of 2 months at the Contractors design offices for training purposes.

The Contractor shall provide for each KETRACO Engineer, one economy class return air ticket.

APPENDIX A - LOADING CONDITIONS

Working loads to be applied at each phase attachment and at each earth conductor attachment, (factors of safety to be applied: see the Technical Schedules).

Tower type	Load case	Transverse (as defined in Clause 5.7a)	Vertical (as defined in Clause 5.7b)	Longitudinal (as defined in Clause 5.7c)
Straight line	1	Normal	Normal	-
(suspension	2	Wind at 45°	Normal	-
insulators)	3	Normal	Minimum	-
	4	Wind at 45°	Minimum	-
Angle	1	Normal	Normal	Section
(tension insulators)	2	Wind at 45°	Normal	Section
	3	Wind perpendicular	Normal	Section
	4	90° Reversed wind	Normal	Section
	5	Normal	Uplift	Section
	6	Wind at 45°	Uplift	Section
	7	Wind perpendicular	Uplift	Section
	8	90° Reversed wind	Uplift	Section
Terminal	1	Normal	Normal	Normal
(tension insulators)	2	Wind at 45°	Normal	Normal
	3	Wind perpendicular	Normal	Normal
	4	90° Reversed wind	Normal	Normal
	5	Normal	Uplift	Normal
	6	Wind at 45°	Uplift	Normal
	7	Wind perpendicular	Uplift	Normal
	8	90° Reversed wind	Uplift	Normal

APPENDIX B - SIMULTANEOUS UNBALANCED LOADING CONDITIONS

(Factors of safety to be applied: see the Technical Schedules).

TOWER TYPE Unbalanced conditions in any one span (ie in same direction)	**TRANSVERSE (as percentage of conditions specified in Clause 5.7)**		**VERTICAL (as percentage of conditions specified in Clause 5.7)**	**LONGITUDINAL**
	Due to wind	**Due to angle of deviation**		
Straight line(suspension insulators) at any one attachment,				
phase:	75%	-	75%	70% of EDT
earth:	75%	-	75%	EDT
Cascade collapse conditions at all attachments,				
phase:	15%	-	66.7%	70% of EDT
earth:	15%	-	66.7%	EDT
Angle (tension insulators) at any two attachments,				
either phase,	75%	50%	75%	EDT
or earth:	75%	50%	75%	EDT
Cascade collapse conditions at all attachments,				
phase:	15%	*	66.7%	EDT
earth :	15%	*	66.7%	EDT
Terminal (tension insulators) at any two attachments,				
phase	15%	0%	0%	EDT
earth	15%	0%	0%	EDT

EDT = Every Day Tension = 20% ultimate tensile strength (UTS)

* The transverse component of the longitudinal load at any line deviation between minimum and maximum.

APPENDIX C - APPLIED LOADS: CONSTRUCTION AND MAINTENANCE LOADING CONDITIONS

(Factors of safety to be applied).

Tower Type	**Loads at phase and earth conductor attachment points (Newton)**		
	Transverse	**Vertical**	**Longitudinal**
Straight line (suspension insulators)			
Maintenance condition			
Phase	**-**	2 x normal	-
Earth	**-**	2 x normal	-
Angle and terminal tower (tension insulators**)**			
Temporary terminal condition			
Phase	*****	Normal	EDT
Earth	*****	Normal	EDT
Maintenance condition			-
Phase	-	2 x normal	-
Earth	-	2 x normal	

* The transverse and longitudinal components of the conductor tension at any line deviation between minimum and maximum.

APPENDIX D - FOUNDATION DESIGN PARTICULARS

Foundation Class	**1**	**2**	**3**	**4**	**4W**	**5**	**5W**	**6**
Foundation types	Rock anchor	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Special: Piling, raft, enlarged concrete pad and chimney
Approximate soil description	Homogeneous rock	Fractured rock/hard clay/ very dense sand	Stiff clay/ dense sand	Firm clay/ medium dense sand	Firm clay/ medium dense sand	Soft clay/ silt/ loose sand	Soft clay/ silt/ loose sand	Subject to detailed soil investigation
Nett allowable design bearing capacity under ultimate load (kN/m^2)	>750	>400	>250	>150	>100	>50	>50	Subject to detailed soil investigation
Design uplift frustum angle	30°	25°	20°	15°	10°	10°	0°	As above
Approximate sub-soil investigation parameters:#								
Cohesive soil,N (blows/300mm)	-	>30	>19	>12	>8	>4	>4	As above
Cohesive soil, qc (kg/cm^2)	-	>80	>50	>30	>20	>10	>10	
Frictional soil, N (blows/300mm)	-	>40	>25	>17	>12	>7	>7	As above
Frictional soil, qc (kg/cm^2)	-	>160	>100	>60	>40	>20	>20	
Allowable lateral earth pressure # to (kN/m^2)								
Backfilled/disturbed soil:	Nil	Nil	Nil	Nil	Nil	Nil	Nil	As above
Undisturbed soil:	400	50 + 50H	50 + 25H	Nil	Nil	Nil	Nil	As above
Water table level	>0.5 m below Fdn level	>0.5 m below Fdn level	>0.5 m below Fdn level	>0.5 m below Fdn level	Grd level to <0.5 m below Fdn level	>0.5 m below Fdn level	Grd level to <0.5 m below Fdn level	As above
Concrete density kg/m^3	2240	2240	2240	2240	2240/1200*	2240	2240/1200*	As above
Undisturbed Soil density kg/m^3	>2000	>1800	>1600	>1500	>1500/1000*	>1400	>1400/960*	As above
Backfill Soil Density kg/m^3	>1600	>1600	>1500	>1400	>1400/960*	>1400	>1400/960*	As above

* Submerged density is subject to verification by foundation test

Notes:
1. The prices to be given in the Schedule of Prices are for standard foundations based on the assumed parameters listed above.
2. Allowable toe pressures for concrete monoblock foundations may be 25 per cent higher than the specified bearing pressures shown.
3. Sub-soil investigation limits based upon results of Standard Penetration Test or Dutch Cone penetrometer tests use correlations between N (blows/300mm) or cone resistance qc(kg/cm^2) and allowable bearing capacity generally accepted for most soils.
4. Lateral earth pressure to be considered ignoring first 1.0 m below ground level. H = depth below ground level.
5. Fdn : Foundation. Grd : Ground.
6. For augered shaft foundations the maximum ultimate friction/adhesion stress assumed between concrete and soil, averaged over the depth of the foundation, shall be 60 kN/m^2.