REPUBLIC OF IRAQ

MINISTRY OF ELECTRICITY

STANDARD SPECIFICATION

The Iraq Power Alliance worked in close cooperation with the Ministry of Electricity to produce a comprehensive set of standard specifications for use in the Iraq Power Supply Industry.

The specifications were prepared between 2004 and 2006 for use by the Ministry in design, procurement, construction & commissioning and cover all major project types, areas of interest including, steam, gas turbine and diesel generating stations, high and medium voltage substations, overhead lines, together with ancillary transmission, distribution and control equipment.

The specifications are generic and therefore require the addition of project specific information such as: the site location, layout and line routing plans; the ratings and numbers of generators; the ratings and numbers of transformers and switchgear circuits; project specific communications and SCADA requirements and any non-standard requirements that are project specific. The specifications have been drafted on the basis that such data will be defined by the Ministry in a Project Scope of Works and, when appropriate, the Ministry will add to or modify the general specifications and schedules to reflect the needs of a particular project.

These standard specifications are based on the requirements of IEC and British Standards and were prepared in accordance with Ministry wishes and recommendations. The Iraq Power Alliance gratefully acknowledges the cooperation and guidance provided by the Ministry in the preparation of these specifications.

The Iraq Power Alliance is made up of Parsons Brinckerhoff and Worley Parson, both leading international engineering companies in the Power Supply Industry.

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MINISTRY
OF
ELECTRICITY

IRAQ SUPERGRID PROJECTS
132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

VOLUME 1
TECHNICAL SPECIFICATION

OCTOBER 2006

LIST OF REVISIONS

Current Rev.	Date	Page affected	Prepared by	Checked by (technical)	Checked by (quality assurance)	Approved by
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CONTENT SHEET

CONTENTS
VOLUME 1

DRAWINGS ATTACHED TO THE SPECIFICATION

PLATE NO 1	LOCATION MAP
PLATE NO 2	ROUTE OF PROPOSED TRANSMISSION LINE
PLATE NO 3	TOWER OUTLINES
PLATE NO 4	TOWER NOTICE PLATES
PLATE NO 5	CORRIDOR DIMENSIONS
PLATE NO 6	SUBDIVISION OF WORK AT SUBSTATIONS

VOLUME 2

TECHNICAL SCHEDULES

VOLUME 3

PRICES AND ESTIMATED QUANTITIES

VOLUME 1

TECHNICAL SPECIFICATION

132 KV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

1. SYSTEM PERFORMANCE

1.1 Topographical and meteorological site conditions

Altitude above sea level – maximum	m	1500
Air pressure yearly average	millibars	1011
Air temperatures		
Maximum peak	°C	50
Highest maximum for 6 hours a day	°C	55
Maximum daily average	°C	40
Maximum yearly average	°C	30
Minimum for design purposes	°C	-15
"Everyday" temperature (for design purposes)	°C	25
Highest one day variation	°C	30
Sun temperature in direct sunlight	°C	80
Humidity		
Maximum relative humidity at 30 degrees	%	92
Minimum relative humidity	%	8
Pollution level – IEC 60815		Class III – Heavy Class IV – V heavy
Dust storms	days/annum	30
Isoceraunic level	days/annum	25
Maximum gust wind speed	m/s	40
Ice loading, radial thickness	mm	10
Total rainfall per annum – maximum / minimum	mm	500 / 50
Assumed seismic acceleration (Unified Building Code)	Central/Southern Iraq Northern Iraq *	0.1 0.2

* Northern Iraq is defined as that territory north of latitude 35°N

1.2 Electrical design criteria

The following are the general particulars governing the design and working of the complete system of which the Works will form a part:

a. Electrical energy is generated at interconnected power stations as three-phase current at a frequency of 50 Hz, and transmitted therefrom by means of overhead lines.

b. The existing transmission in Iraq consists of overhead lines operating at 50 Hz.

c. The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons.

	400 kV	**132 kV**	**33 kV**	**11 kV**
Maximum system voltage (kV)	420	145	36	12
Nominal system voltage (kV)	400	132	33	11
System frequency (Hz)	50	50	50	50
Switching impulse withstand voltage (kV)	1050	-	-	-
Lightning impulse withstand voltage (kV)	1425	650	170	75

2. GENERAL

2.1 Definitions

In addition to the terms referred to in the Preamble and the General Conditions of Contract, the following, where used in this Specification, shall have the meanings listed below:

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

b. The expression “Commencement Date” hereafter used in connection with the time from which the various periods are to run shall mean the date specified in the Schedules.

2.2 Nature of work

The work covered by this Specification provides for the design, survey, supply and installation of a steel tower transmission line all as specified herein or in the attached Schedules.

The overhead transmission lines will form part of the Ministry of Electricity’s transmission system.

2.3 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:-

2.3.1 Definite work

The design, manufacture, supply, delivery to and off-loading at Site, erection, testing, starting to work, completion and the remedy of all defects during the Defect Notification Period 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, earthwires, insulators and fittings, towers and foundations, grounding (where required) and connections, and all other fittings at the total price for the estimated quantities stated under the Price Schedules (Volume 3). Estimated quantities are for tender 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 Volume 3, Schedule K, Labour and Equipment Rates for Extra Field Work.

2.3.2 Work at the option of the Engineer

2.3.2.1 Spare materials

This shall include but not be limited to:

The design, manufacture, supply, testing and delivery to such store or stores provided by the Engineer of such apparatus, spares and tools specified in the Technical Schedules, as the Engineer shall order from the Contractor at any time or times before the expiration of the Defect Notification Period of the Definite Work, at the total for quantities stated under the Price Schedules.

2.4 Terminal points

The slack span connections of conductors and earthwires from the terminal towers to the substation gantry structures and the down-droppers from the slack spans to the substation plant are included in this Specification.

Connection of the down-droppers to substation plant is not included in this Specification.

OPGW earthwire slack spans will be terminated in the junction boxes to be mounted on the substation gantry structures. Connections from the junction boxes towards the substations are not included.

Provision and installation of counterpoise from the terminal towers to the respective points of the substation grounding grids is included in this Specification. Connection of the counterpoise to the substation grounding grid is not included.

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

2.5 Standards and codes

Except where otherwise specified or implied, the works shall comply with the latest applicable Standards or Recommendations of the International Electrotechnical Commission (IEC) and ISO (International Standards Organisation). If relevant IEC and ISO standards and recommendations are not available in any case or cases then relevant British Standards or National Standards shall apply if available.

When IEC, ISO, BSI or National Standards are referred to the edition used shall be that current at the Date of Tender, together with any amendments issued to that date.

Further to that above, the standard order of preference is listed below,

IEC International Electrotechnical Commission
ISO International Standards Organisation
BSI British Standards Institution

NS National Standards (where available)
ANSI American National Standards Institute
IEEE Institute of Electrical and Electronic Engineers
ASCE American Society of Civil Engineers
NEMA National Electrical Manufacturers Association
ASTM American Society for Testing and Materials
UL Standards of the Underwriters Laboratories of USA
IPCEA Insulated Power Cable Engineers Association of USA
ASME American Society of Mechanical Engineers
AWS American Welding Society

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

Copies of any standards proposed in substitution for IEC, ISO or BS standards must be submitted with the Tender accompanied where necessary by English translations of the appropriate sections.

Notwithstanding any descriptions, drawings or illustrations which may have been submitted with the Tender, all details other than those shown in Schedule F, 'Deviations from the Technical Specification' and approved by the Engineer shall be deemed to be in accordance with the Specification and the standard specifications and codes referred to therein.

No departures from the Specification except those shown in the Schedule F, 'Deviations from the Technical Specification' and approved by the Engineer, are to be made without the written approval of the Engineer.

2.6 Abbreviations

The following abbreviations have been used in addition to those listed in Clause 2.5, Standards and Codes.

m	metre
nm	nanometre
mm	millimetre
km	kilometre
m^3	cubic metre
^{o}	degree
g	gram
kg	kilogram
kg/km	kilogram per kilometre
kg/m^3	kilogram per cubic metre
N	Newton

kN	kiloNewton
N/mm^2	Newton per square millimetre
KNm	kiloNewton x metre
s	second
µs	micro second
m/s	metre per second
kph	kilometre per hour
m^3/s	cubic metres per second
dc	direct current
A	ampere
kA	kilo ampere
V	volt
kV	kilovolt
kA^2s	kilo ampere squared x seconds
mW	milliwatt
kW	kilowatt
MW	megawatt
Mb/s	megabits per second
ºC	degrees centigrade
rh	relative humidity
Hz	hertz (cycles per second)
MHz	megahertz
rms	root mean square
ps/nm.km	pico second per nanometre x kilometre
dB	decibel
µV	micro volt
%	per cent

ACSR	aluminium conductor steel reinforced
Alum	aluminium
ATOL	air traffic obstruction lights
AWM	aircraft warning markers
BER	bit error rate
D	depth
DFB	distributed feedback
H	height
HF	high frequency
ICAO	International Civil Aviation Organization
LED	light emitting diode
LH	left hand
MFL	mechanical failure load
MOE	Ministry of Energy
MTBF	mean time between failures
MTTR	mean time to repair
No	number

NDT	non destructive testing
OPGW	optical fibre conductor
OTDR	optical time domain reflectometer
PDH	Plesiochronous digital hierarchy
RTS	rated tensile strength
RH	right hand
SI	International System of Units
SML	specified mechanical load
SMWT	specified maximum working tension
UTS	ultimate tensile strength
W	width

2.7 Details of transmission line routes

Where available details of the type of overhead line and its general routing, including some description of the terrain along the route, are given in the Solicitation, Offer and Award (SOW) documentation.

2.8 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 inquiries that the facilities available for unloading and bearing capacity of wharfs at the port of entry 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 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.

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.

2.9 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 which may be energized.

The Contractor and his representatives shall in all ways comply with the Ministry of Electricity'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 the Ministry of Electricity'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 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.

2.10 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 Iraq as are applicable to the Contract Works and with other applicable Regulations to which the Ministry of Electricity is subject.

2.11 General particulars and guarantees

The Works shall comply with the general particulars and guarantees stated in the 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 such particulars and guarantees have been approved by the Engineer or not.

2.12 Variations from Conditions of Contract

In the event of there being any inconsistency between the provisions of this Specification and the Conditions of Contract, the provisions of the Conditions of Contract shall prevail.

2.13 Places of manufacture

The manufacturers and the places of manufacture, testing and inspection of the various portions of the Works shall be as stated in Schedule C.

2.14 Subcontracted plant, materials and labour

Triplicate copies of all subcontracted plant and material orders shall be submitted to the Engineer for review at the time any such order is placed. Copies submitted shall be clearly marked on the first page with the Project title and a statement that the plant and material are to be inspected by the Engineer. The Contractor shall ensure that sufficient information is to be given on each sub-order to identify the material or equipment to which the sub-order applies and to notify the sub-contractor that the conditions of the Specification apply.

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

2.15 Dates for completion

The dates of readiness for design, manufacture, inspection and testing, delivery and completion of the various sections of the Works shall be as stated in Schedule B which also states the dates by which the Contractor will require access to the Site.

2.16 Access to manufacturers' works

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

2.17 Planning and progress reports

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.

Reporting requirements shall be as specified from time to time by the party that has entered into the Contract with the Contractor or shall be otherwise, as follows.

The Contractor shall submit to the Engineer 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 monthly 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.

2.18 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 which 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.

2.18.1 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, "Model for quality assurance in design, development, production, installation and servicing".

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.

2.18.2 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.

2.18.3 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.

2.18.4 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.

2.18.5 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.

2.18.6 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 which are to be subcontracted, identifying all items for which inspection and test plans will be submitted.

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

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

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

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

b. indicate where subcontract services will be employed (e.g. subcontractor NDT or heat treatment),

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

d. indicate mandatory hold points established by the Engineer which 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 3 weeks prior to a notification point 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 tests 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 relieve the Contractor of any responsibility whatever regarding defects or other failures which may be found before the end of the defects liability period.

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

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

2.18.7 Construction/installation phase

Within 30 days of mobilization of works, inspection and test plan(s), similar in form and content to that described in 2.18.6 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.

2.18.8 Non-conformances

All items or services not in accordance with the Contract 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.

2.18.9 Records

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

2.18.10 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.

2.19 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 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.

2.20 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 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.

2.21 Language, weights and measures

The English language shall be used in all written communications between 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).

2.22 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 the Engineer when equipment and materials are available for inspection.

The Contractor shall carry out the tests stated in Clause 13 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 3 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 5 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.

2.23 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 the Ministry of Electricity is to be made good at the Contractor's expense.

2.24 Drawings, models and samples

A list of the drawings attached to the Specification is given in Schedule E – 'Drawings, Documentation and Samples'.

A list of the drawings which are to be submitted by the Contractor with his Tender and a list of drawings to be submitted after the Commencement Date are also given in Schedule E. 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. The time allowed for the Engineer to review and comment on drawings, samples and models shall be agreed.

If the Contractor requires early review of any drawing in order to avoid delay in the completion of the Contract Works, he shall advise the Engineer to such effect when submitting the drawing.

Four copies of each drawing and four copies of any subsequent revision shall be submitted to the Engineer for review. Following final review, four further copies of the reviewed drawing shall be marked "Issued for Construction" and shall be supplied to the Engineer for distribution and to Site.

Drawings for review shall be submitted as paper prints or electronic copies as shall be agreed and shall bear the authorized Contract reference.

All drawings shall be drawn to one of the preferred scales quoted in Table 7 of BS Publication PD6031 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 therefrom. 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 have the following particulars in the lower right hand corner in addition to the Contractor's name, date, scale, number and title of the drawing, contract number, overhead line title and equipment description.

Ministry of Electricity

Baghdad

Iraq

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, as detailed in Schedule E, 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 provisions in the Schedules and shall become the property of the Ministry of Electricity.

The requirements for Final Record drawings are given in Clause 2.29 of this Specification.

2.25 Spares

All spare material shall comply with the requirements of this Specification including compliance with the specified tests and interchangeability. Spares ordered within 6 months of placing of the Contract shall be available at the time of completion of the Works.

All spare apparatus or materials containing electrical insulation shall be delivered in approved cases suitable for storing such parts or material over a period of years without deterioration. The cases will remain the property of the Ministry of Electricity.

The Contractor shall ensure that sufficient spare parts and consumable items are available for his own use during construction and commissioning of the works. Spares ordered by the Engineer shall not be used by the Contractor without the written consent of the Engineer.

2.26 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 sections of the Works, whether under construction, during tests or in use by the Ministry of Electricity.

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 which 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 which 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 Specification and Works described in the 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 Specification.

2.27 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.

2.28 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.

A further 6 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 the Ministry of Electricity shall be inscribed upon the spine.

The finished books are to be handed to the Engineer not later than 1 month before the Taking-Over Certificate is issued.

2.29 Final records

After completion of work on Site all Contract drawings shall be revised where necessary to show the equipment as installed and two copies of revised drawings 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 the Ministry of Electricity's number allocated to the item.

After final review of the “As Constructed” record drawings the Contractor shall submit two complete sets of records on compact discs, one of which is for the Ministry of Electricity. Electronic copies of the drawings shall be in CADD vector format suitable for reproduction on paper using the Engineer’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, complete with unique title and drawing number, 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.

The list of drawings required for final record purposes is given in Schedule E.

Final record copies shall be handed over before the issue of the Taking Over Certificate.

2.30 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 corrosion, physical damage, contamination or damage from water or dust or from any other source in all climatic conditions experienced in transit and during 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.

The Contractor shall prepare a method statement covering all aspects of packaging, marking, colour coding, documentation, lifting, transporting and stacking of etc., that will be used by all manufacturers, suppliers and shippers and will be applicable for all stages from manufacture/supply via transport and storage to use. This method statement shall be subject to the approval of the Engineer and it is a requirement that this approval is received before any materials are packed.

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 weight limit for the bundles should be approximately 500 kg. . Strap bundles of steelwork with extra heavy duty galvanised steel straps, ensuring that all members in a bundle are alike, that they are packed in an interlocking fashion and that the strapping pressure is sufficient to prevent slippage of members within the bundle. The members within each bundle shall be secured with wire passing through member holes at each end of the bundle.

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 wet storage stain. Full details of the proposed method of protection, (for instance, dipping in Sodium Dichromate solution) shall be submitted to the Engineer for approval prior to fabrication of the steel.

For short members (1 m long or less), the size of each bundle shall be limited to approximately 300mm in width and 300mm in height. Extra straps shall be used as necessary to prevent slippage between members within bundles. It is preferable if the bundles are secured to pallets, which are then double strapped in both directions. The weight of each pallet shall be limited to approximately 500 kg.

Small members such as gusset plates, clip angles, etc., shall be wired together in small bundles and shall be packed in heavy gauge drums or strong boxes with totally closed–in sides, bottom and top. The drums shall be packed no more than two-thirds full and the contents shall have a strongly braced solid cover fixed directly above the items. Lifting holes or lugs shall be provided on all drums and the weight contained in each drum shall be no greater than 50% of the drum capacity.

Bolts and nuts shall be crated for shipment. Together with washers and similar accessories they shall be packed in boxes or in small steel pails. Where pails are used, the lids shall be securely wired to the pails, which shall be placed on a pallet, with a second pallet placed on top pf the pails so that it touches and secures all the pail lids. The pallets shall be double strapped in both directions.

Bundles of steelwork shall be handled and stored horizontally; they shall not be placed 'on end'. Metallic lifting lugs and chains shall only be used if adequate rubber sheathing is provided to the steel. The preferred method for lifting bundles of steel is to use manilla rope slings. The lifting surfaces shall be protected with strips of wood or rubber. All steelwork shall be held above ground, truck beds, warehouse floors, wharfs, etc., by the use of suitable blocks, which shall also be used between layers and bundles when these are stored or piled. Sufficient blocking shall be provided to ensure that members are not subject to bending and to provide easy access for slings and fork lifts.

Conductors and cables shall be packed on non-returnable wooden drums with wooden battens, constructed from seasoned softwoods with suitable anti-termite and anti-fungal treatment, that shall not react with aluminium, applied prior to any painting. The drums shall be 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. All drums shall be provided with steel hubs with a through hole of minimum diameter 75 mm. Waterproof paper shall be used between conductor, drum and battens, which shall be securely and correctly nailed to the drum flanges. Nails shall not damage the conductor. The drum construction must be proved adequate to transport the conductor weight. Drums shall be marked with an arrow showing the correct direction of rotation for rolling and shall have attached a metallic label showing a serial number, the conductor type, size and length and also the gross and tare weight of the drum and its cubic measure.

Drums shall be lifted be means of a bar through the hub to which are attached slings or chains, which shall have a spreader bar above the drum if a single lift point is used. Where a drum is moved by fork lift trucks, the drum shall be set with the hub axis parallel to the direction of travel; care shall be taken to ensure that the drum battens are not damaged by the lifting forks. Drums shall not be lifted by threading a chain through the hubs or by slinging around the drum battens. Drums shall remain upright on their flanges during handling and storage. Drums shall not be stored or rolled on rough surfaces. Drums shall be rolled as little as possible and always the rotation of the drum shall be in the direction of the arrow on the drum. Drums shall be stored only in single or in double rows and there must be sufficient loading space between each single or double row. Drums shall be rotated by a quarter revolution each six months while they are in storage. Suitable blocks shall be used to keep drums off the ground during site storage.

Insulators shall be packed in strong wooden crates with side members a minimum of 12 mm thick and end members a minimum of 25 mm thick. Side members shall be a minimum of 100 mm wide with a smooth outer surface. The crates shall be packed onto pallets and shall be secured with double straps in both directions

Hardware, accessories and small members shall be packed in wooden boxes, made of timber a minimum of 25 mm thick, with reinforced edges, corners and ends. Nails that are ringed or spiralled shall be used for the box construction. The boxes shall be lined with waterproof paper and shall be double strapped in both directions. The weight of the boxes shall be limited to approximately 100 kg. Suppliers' standard cardboard boxes shall be left intact and shall be over-packed using wooden boxes designed to suit.

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

Crating together of components of dissimilar metals is not acceptable.

All parts shall be clearly marked to facilitate easy sorting and erection.

Particular attention shall be given to strutting before packing crates 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.

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 shall be marked with the contract number and port of destination. They shall also bear an identification mark relating to the appropriate shipping documents. Material intended for different locations in Iraq shall be packed separately and packages shall clearly identify the destination.

The Engineer may require 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.

All arrangements shall be made for all forms of transport used, to ensure that all items are transported safely and on time to their destination.

Only reputable carriers, which have regular schedules to the required destination shall be used. All the facilities, reliability and record of carriers, ports and other depots shall be investigated and arrangements shall be made to supplement any deficiencies in handling equipment and other facilities. The number of carriers shall be kept to a minimum and double handling at ports and depots shall be avoided as far as possible. The contractor shall ensure that all warehouses used en route, are suitable and that all items can be stored without any deterioration or damage from water, sunlight dust or any other cause. When possible the sending of partial consignments is to be avoided. If such are required, items such as steel towers shall be shipped in complete units.

The Contractor shall make all the necessary arrangements for customs clearance in Iraq, the country of origin, and any countries through which goods pass.

Law of Iraq No. 157 has been passed to facilitate the entry into and transit within Iraq of goods, plant, materials and equipment necessary for the construction of major projects, including this project.

The Contractor shall obtain all the necessary export and import permits and any other documents required for the transport of goods. Copies of all forms and documents relating to customs, permits, packing lists, bills of lading and insurance, etc. shall be forwarded to the Engineer.

Packing cases and packing material shall remain the property of the Contractor.

All labels, markings and colour codings on crates, packages, conductor drums, etc., shall be legible, waterproof, not affected by sunlight and are securely fixed or painted on the item. The standard project shipping mark shall be applied to all items and shall be visible at a distance from different viewpoints. In addition to a packing list included in a waterproof envelope, each item shall be marked on the outside providing details of contents, order number, shipper, shipping contract numbers case numbers, etc. Packages contained within a larger crate shall be marked with full details of their contents and any other relevant information. Oil, paint and other hazardous or inflammable materials are to be marked accordingly, including the wording “Flash Point °C” and the recommended storage temperature.

2.31 Site storage and accommodation

Storage facilities. The Contractor shall make his own arrangements for storage areas and camp sites. The Contractor shall in all instances 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. As a minimum the Contractor shall provide a security fence 2 m high, topped with barbed wire, all round the area, with suitable gates and with provision for floodlighting the area at night. The handling and storage of any equipment at the site or storage areas is to be at the risk of the Contractor and without responsibility to the Ministry of Electricity. The Contractor is to arrange, to the satisfaction of the Engineer, for the protection 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 hardstanding for the orderly delivery, storage and subsequent removal of conductor drums, tower steel, insulators and fittings so that the material will not be damaged by the effects of adverse weather during storage. The areas shall be graded to provide an even, firm surface, sloped to permit drainage, All items shall be blocked clear of the ground at all times. Covered areas within the security compound shall be provided for storage of all items that have to be protected against rain, dust, sand and strong sunlight. 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.

The stores compound shall be efficiently laid out and shall be maintained in an efficient manner so that when required the Engineer may check the contents of the store. Store records such as bin cards shall be kept up to date to show incoming and outgoing material and present stocks.

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.

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. Temporary construction camps shall be provided with proper sanitation and other necessary facilities. All accommodation shall 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 the Engineer 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.

Office accommodation. The Contractor shall provide such temporary buildings as may be necessary for office accommodation for his site staff during the erection of the works and the cost of these shall be deemed to be included in the Contract Price. The Contractor shall also provide at his own cost and in his site office, two rooms with office furniture and fittings for use by representatives of the Engineer.

3. LINE CONDUCTOR

3.1 General

The line conductor shall consist of Aluminium Conductor Steel Reinforced (ACSR) having the characteristics stated in Schedule D and shall be manufactured to Code Name “Teal” in ASTM B232.

The conductor characteristics (see also Schedule D 4) comprise the following: -

Stranding details	Aluminium	30 x 3.61 diameter
	Steel	19 x 2.16 diameter
Conductor diameter		25.24 mm
Total cross-sectional area		376.7 mm^2
Mass of conductor without grease		1398 kg/km
Rated ultimate tensile strength		133.06 kN
DC Resistance		0.09426 ohm/km at 20 °C
Final modulus of elasticity		78 460 N/mm^2
Coefficient of linear expansion		1.80 x 10^{-5} / degC

The conductor shall comply in all respects with the requirements of IEC 61089 or other approved standard. The outer layer wires and the steel core wires shall be pre-formed so that they remain inert when the conductor is cut.

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 Schedule D. 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. 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 Schedule D. It shall exhibit adequate resistance to oxidation and shall conform to the test requirements stated in BS EN 50326 and as given in Clauses 13.3.1 and 13.3.2.

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.

The aluminium shall be of the highest purity commercially obtainable, but the aluminium content shall not be less than 99.5 %, and the Contractor shall submit certificates of analyses giving the percentage and nature of any impurities in the metal of which the wires are made. Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper or other materials which 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.

Empty conductor drums, where not returnable to the Manufacturer's Works, shall be deemed after use to be the property of the Contractor who shall be responsible for their disposal.

The type, size and number of conductors to be installed for each phase of the transmission line shall be as stated in Schedule D. 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.

3.2 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. Before compression the overall length of the joint shall not be less than 680 mm with the outside diameter of the joint not less than 42 mm. 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 Schedule D and when tested in accordance with the test conditions specified in Clause 13.5 of this Specification.

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. 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.

3.3 Vibration dampers, spacers and spacer-dampers

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 spacers or by means of spacer dampers.

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 efficiency of the proposed system for damping aeolian vibrations shall be demonstrated by calculation, as detailed below.

The Stockbridge type vibration dampers shall be designed to:

a. 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,

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

The number of dampers per span of individual conductor shall be as stated in Schedule D.

The approval of vibration dampers shall be conditional on the provision of evidence in respect of fatigue resistance, clamp to conductor grip, damping of aeolian vibration with disposition along the span as recommended by the manufacturers. An adequate clamping surface with a radius at the clamping mouth shall be provided. The grip of the conductor clamp to conductor strands and the satisfactory properties related to the damping of aeolian vibrations shall be demonstrated. All bolts shall be locked in an approved manner.

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 spacers and dampers.

Spacers (or spacer dampers) shall be provided in each span and installed in accordance with the manufacturer's recommendations, subject to the approval by the Engineer. Notwithstanding these recommendations the distance between spacers shall not exceed 75 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 Schedule D.

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 (e.g. 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 spacing of sub conductors in the bundle and to restoring their torsional stability after unfavourable conditions, to:

i. introduce an additional damping effect to that of the conductor and to control Aeolian vibration and sub span 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,

ii. prevent damage to each sub conductor from vertical and horizontal vibration and oscillation,

iii. prevent physical contact between sub conductors arising from wind and electro-magnetic forces (except short-circuit current),

iv. guarantee that conductor bending strain at suspension and tension clamps shall not exceed the limit of 150 micro strain,

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

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 sub span 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.

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 clamp and bolt arrangements 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.

The elastic material (elastomer) used for the damping component of the spacer dampers shall withstand a temperature range between -40°C to +90°C with a semi-conductive property.

Each jumper connection shall be provided with at least two spacers (spacing as specified in Schedule D), 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.

Slack spans shall be fitted with rigid spacers at a maximum distance apart of 30 m. The spacers shall provide the spacing of the sub conductors in the bundle as specified in Schedule D.

Spacers, spacer-dampers and vibration dampers shall satisfy the requirements specified in Clause 13 of this Specification and in IEC 61284, 61854 and 61897 as relevant.

3.4 Armour rods

Approved pre-formed helical armour rods shall be fitted to the line conductor, or each subconductor, at all tangent towers, in accordance with the Schedule D.

Armour rods shall be fabricated from aluminium alloy, shall be 'ball-ended' and shall comprise 11 rods each of 7.62 mm diameter with an overall length of 2337 mm.

The armour rods shall be of a material that is compatible with the material of the line conductor or subconductor to which they are 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 material and diameter range of the conductor on which the rods are to be fitted. 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.

4. EARTHWIRES

4.1 General

Where a single earthwire is used this may be either optical fibre (OPGW) conductor or aluminium conductor steel reinforced (ACSR) as specified in Schedules A and D.

OPGW. OPGW earthwire shall consist of at least two layers of wires surrounding an optical fibre communication cable enclosed in an aluminium alloy or stainless steel tube, which shall preferably be the central core of the OPGW earthwire. Aluminium-clad steel wires may be incorporated into the OPGW 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 proposed design shall be to the approval of the Engineer.

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).

The OPGW earthwire shall have the characteristics stated in Schedule D 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 in the inner layers of the OPGW they shall be to IEC 61232 class 20SA type A or higher.

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 Schedule D. 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 at the centre of the OPGW earthwire. This tube shall be of aluminium alloy or stainless steel material. The central aluminium alloy tube may be cold formed with a longitudinal seam or be formed from segmental aluminium alloy wire strands. If an open seamed tube or segmental construction is used a supplementary plastic sheath shall be used inside the metallic tube to provide a waterproof sleeve to the optical fibres. A central stainless steel tube may be seamed or seamless. If seamed this shall also require the use of an inner plastic sheath, as described above. The optical fibres shall be protected from water ingress by the application of a waterproof gel, applied, during manufacture, between the buffer tubes and the plastic sheath or seamless metallic tube.

To protect the earthwires from corrosion each layer 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 Schedule D. 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 earthwire is between the wires of the penultimate layer. The grease shall conform to the requirements of BS EN 50326 and shall not corrode the aluminium, aluminium alloy wires or steel used in the OPGW. 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 Schedule D. It shall exhibit adequate resistance to oxidation and shall conform to the test requirements stated in BS EN 50326 and as given in the Clauses 13.3.1 and 13.3.2.

The OPGW shall be designed to withstand the lightning stroke current, short-circuit current, ambient and extreme temperatures and loadings specified in the Schedules with no effect on the attenuation of the optical fibres and no permanent damage to the optical 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 earthwire.

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 Schedule D. The fibres shall be single mode type, suitable for operation at wavelengths of both 1310 nm and 1550 nm and shall conform to ITU-T recommendation G.652 with transmission of information at data rates up to 622 Mbit/s. The OPGW shall conform to existing installations where applicable.

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

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 less than or equal to 0.4 dB/km at 1310 nm and 0.25 dB/km at 1550 nm.

The optical fibres shall be able to withstand temperature cycling in the range –5°C to +80°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 for a time period of 3 seconds without any degradation of performance.

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

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

2. Installation methods and materials.

3. Jointing methods, materials and mounting arrangements.

4. Physical protection against the ingress and transmission of moisture.

5. Identification marking and fibre coding.

ACSR. The earthwire shall consist of Aluminium Conductor Steel Reinforced (ACSR) having the characteristics stated in Schedule D and shall be manufactured to Code Name Dorking in ASTM B 2.32 or to Code 97-AL1/56-ST1A in EN 50182

The conductor characteristics (see also Schedule D 4) comprise the following: -

Stranding details	Aluminium	12 x 3.20 diameter
	Aluminium Clad Steel	7 x 3.20 diameter
Conductor diameter		16.0 mm
Total cross-sectional area		152.8 mm^2
Mass of conductor without grease		707 kg/km
Rated ultimate tensile strength		83.04 kN

DC Resistance	0.2992 ohm/km at 20 °C
Final modulus of elasticity	105 000 N/mm^2
Coefficient of linear expansion	1.53×10^{-5} / degC

The conductor shall comply in all respects with the requirements of IEC 61089 or other approved standard. The outer layer wires and the steel core wires shall be pre-formed so that they remain inert when the conductor is cut. 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 Schedule D. 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. 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 Schedule D. It shall exhibit adequate resistance to oxidation and shall conform to the test requirements stated in BS EN 50326 and as given in Clauses 13.3.1 and 13.3.2.

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.

The aluminium shall be of the highest purity commercially obtainable, but the aluminium content shall not be less than 99.5 %, and the Contractor shall submit certificates of analyses giving the percentage and nature of any impurities in the metal of which the wires are made. Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper or other materials which may adversely affect the aluminium.

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

At tension towers the earthwire clamps shall each be securely bonded to the tower steelwork by means of suitable lengths of polymer covered multistrand aluminium flexible bond wires of suitable form and cross section.

Tangent 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 earthwire drums.

4.2 Joints

Joints for connecting earthwires shall be of approved types.

OPGW. There shall be no connecting joints in OPGW earthwire. Optical fibres shall only be jointed at approved joint boxes, in accordance with the requirements given in Clause 4.5 of this Specification.

ACSR. Tension joints for ACSR earthwire 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. Before compression the overall length of the joint shall not be less than 570 mm with the outside diameter of the joint not less than 34 mm. 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 Schedule D and when tested in accordance with the test conditions specified in Clause 13 of this Specification.

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. 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.

4.3 Vibration dampers

Vibration dampers shall be fitted to all overhead earthwires, both OPGW and ACSR.

The earthwire vibration dampers shall be designed to:

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

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

OPGW. The optical fibre earthwire (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.

ACSR. The ACSR earthwire shall be fitted with approved Stockbridge vibration dampers.

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 earthwire shall be as recommended by the manufacturer and approved by the Engineer.

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 earthwire 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 earthwires with and without vibration dampers.

Stockbridge type vibration dampers shall satisfy the requirements specified in Clause 3.3 of this Specification and in IEC 61897.

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

4.4 Armour rods

The provisions of the Specification in relation to armour rods for line conductor shall also apply to armour rods for OPGW and ACSR earthwires.

Armour rods shall be fabricated from aluminium alloy, shall be ‘ball-ended’ and shall comprise, for Dorking ACSR earth wire, 12 rods each of 4.47 mm diameter with an overall length of 1626 mm.

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 and vibration damper for OPGW, and shall be to the approval of the Engineer.

4.5 Optical joints and joint boxes

The Contractor shall design, supply and install optical fibre cable joints for the OPGW earthwire. 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. Where required by the Client joint boxes may be located at higher positions on towers, up to lower crossarm level. Joint towers may be either tension or tangent 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 and/or aluminium alloy and shall provide protection to Class IP 65 of IEC 60529. Access on the bottom edge of the box shall be by means of weathertight glands sized for the incoming and exiting OPGW earthwire. 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 earthwire.

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 the Arabic and English languages. The conductors or cables and integral optical cables shall be brought into the box.

The OPGW earthwire 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 suitable lengths of OPGW earthwire, minimum 3 m, are to be coiled and supported on a suitable frame fixed to the structure as specified before entering the joint box. Where the joint box is placed at a higher location on the tower the length of the coiled OPGW shall be increased sufficiently to permit jointing to take place at ground level, or at any other level to be agreed between the Ministry of Electricity and the supplier of the jointing team.

All required materials for fixing the OPGW earthwire 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 earthwire, as shall the costs for carrying out all the necessary jointing and splicing.

4.6 Optical regenerative repeaters

It is desirable that no intermediate repeaters are employed in the OPGW earthwire. However, if the distance involved so requires, the Contractor shall provide all necessary optical regenerative repeaters and associated plant together with detailed calculations justifying the need to have intermediate repeaters. The locations for repeaters shall be determined by the Contractor and details of equipment locations shall be submitted by the Contractor for the approval of the Engineer. All necessary costs shall be deemed to be included in the cost of the optical fibre conductor.

Optical regenerative repeaters, where required, shall be connected to the fibres of the OPGW earthwire at the repeater sites by means of detachable optical connectors. Each spare fibre shall be equipped with an optical connector.

Each two-way repeater shall comprise an optical receiver, a regenerator circuit, and an optical transmitter. The optical output level shall be maintained relatively constant with variation in the optical input level due to fibre length, and with variation in power supply voltage and/or ambient temperature.

Each optical regenerative repeater shall be totally compatible with other optical repeaters and optical line system described in this Specification. Except for minor level adjustments, each optical line repeater shall be mechanically, electrically and optically interchangeable.

The repeater shall be equipped with facilities for sending alarm signals to the optical line system to indicate a fault condition. Proper operation of the repeaters shall be continuously monitored during service.

The following alarms shall be provided on the optical regenerative repeater equipment:

a. loss of incoming signal or loss of frame alignment,

b. optical transmit power low,

c. laser current high,

d. Bit error rate (BER) threshold high (for both directions of transmission),

e. optical receive level low,

f. switchover to standby transmitter,

g. fault in supervision channel,

h. power supply fail or out of limits.

The alarms from the repeater shall be transmitted to the terminal ends. At the terminal ends, the repeater alarms shall be monitored and displayed on the alarm monitoring system. The alarm monitoring system of the repeaters shall also form an integral part of the network management system.

The optical repeaters shall be housed in a weatherproof enclosure. The enclosure shall be one of two types:

i. The first type shall be suitable for mounting on overhead line towers. The container shall be weather and vandal resistant and equipped with all accessories necessary for securing to the tower and for grounding any metal parts. Due account shall be taken over the weight and wind area of the enclosure and its effect on the design of the towers.

ii. The second type shall be suitable for use underground. These containers shall be weatherproof and suitable for installing in a manhole. If the container is metal, cathodic protection shall be incorporated where corrosion would otherwise occur. The optical repeater housings shall provide the required degree of protection for equipment without the need for pressurizing the container.

Both types of container shall be of sufficient size to meet minimum bending radius requirements of the OPGW earthwire and to accommodate duplex repeaters and shall accommodate any necessary ancillary equipment including storage for sufficient length of fibre for at least ten future splices.

At intermediate repeater sites where a 48 V dc power supply is not made available by others, the Contractor shall provide a self-contained power supply system comprising solar cells, batteries, control equipment, remote supervision and alarm monitoring units, cables and accessories required for each repeater installation. The photovoltaic solar cells shall be mounted on the south facing side of the transmission tower and be provided with adequate protection against vandalism. High efficiency solar cells shall be used. The solar cells shall be designed so as to float charge the battery and the system shall be sized to meet the continuous standing load and any applicable short term loads arising during normal operation under all the local climatic conditions throughout the year including periods of continuous cloud and the effect of dust on the solar panels. The solar cell panels shall be used to deliver at last 1.5 times the repeater equipment maximum electrical loading at 65 °C with full light intensity. Solar arrays and batteries shall form two parallel systems each of which can feed the load.

The batteries shall preferably be maintenance-free nickel cadmium prismatic rechargeable type complying with the requirements of IEC 60623, and shall be enclosed in a weatherproof cabinet adjacent to the solar array or may be housed in the manhole if the optical repeater is underground. The batteries shall be sized to power all equipment provided at the repeater. A period of 4 days without sun (i.e. no battery recharging) shall be taken into consideration as a safety factor. Sealed lead-acid, long life batteries may also be offered as an alternative option. Full constructional, operational and maintenance details and battery type test results showing suitability of the battery for operation in the proposed environment shall be included in the Tender.

A control unit regulator shall be provided to control optimum charging conditions for the batteries, prevent overcharging or deep discharge. Blocking diode(s) shall be provided to prevent battery discharge through the solar cell panel.

An alarm unit shall be provided to monitor and report the status of the solar power supply system. Voltage free contacts shall be provided to enable remote indication of each alarm. An alarm shall be activated at least in the following fault conditions:

1. charger fail

2. low voltage

3. high voltage.

Low and high voltage cut-outs shall be provided to protect the batteries from overcharge and equipment from overvoltage. The cut-out shall be reset automatically when the fault condition is cleared.

Due account shall be taken of the weight and wind area of any equipment mounted on to a tower and its effect on the design of the tower.

5. INSULATORS AND FITTINGS

5.1 Insulator sets and earthwire sets

Unless otherwise stated in the Specification, insulator units of the cap and pin type together with their metal fittings shall comply in all aspects with the requirements of IEC 60120, IEC 60305, IEC 60383-1, IEC 60383-2, IEC 60437, IEC 60797 and IEC 61284.

The address of the high voltage laboratory at which the type tests will be made shall be stated in Schedule C The laboratory must be fully equipped and of proper physical dimensions to allow the tests to be carried out in accordance with the requirements of Clause 13 of this Specification, in particular Clauses 13.1, 13.2, 13.6, 13.6.1, 13.6.2, 13.6.3, 13.6.4 and 13.6.5..

5.2 Types of insulator

Insulators shall be of the cap and pin, fog type, made of toughened glass or aluminous porcelain.

Alternatively, aerodynamic units may be proposed. Special aerodynamically shaped insulators (also known as open profile insulators) designed to minimize the adherence of dust and other solids, shall be fitted to those sections of the line where heavy dust deposition coupled with periodic or daily dew formation is considered likely to occur. The insulators shall otherwise comply with Schedule D and the complete insulator set shall be of approximately the same overall length and be interchangeable with insulator strings of standard units.

Phase conductors shall be supported on suspension and tension sets of types specified in Schedule D. Yoke plates of a suitable design shall be used to support bundled conductors.

Cap and pin insulators shall be provided with ball and socket fittings in accordance with IEC 60120 and split-pin locking devices for the insulator units themselves, in accordance with IEC 60372.

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.

Cap and pin insulators shall be provided with a pure zinc anti-corrosion sleeve, bonded to the surface of the pin and extending at least 12 mm on either side of the interface between pin and internal cement. The material of the sleeve shall be pure zinc, with impurities not exceeding 0.3 per cent. The zinc sleeve shall not be porous. A suitable metallurgical bond is required between sleeve and pin; the fused area between them shall be in excess of 80 per cent of the total interfacial area between the sleeve and the pin.

5.3 Arcing devices

Arcing horns, formed from galvanized mild steel and of approved types, shall be attached in an approved manner to both the live and the earthed end on all suspension and tension insulator sets. The horns shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the arcing horns shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and arcing horns themselves under all flashover conditions. The general shape and method of attachment of the live end arcing horn shall also not restrict the replacement of insulators under live line conditions. The mechanical strength of arcing horns at the live end of the suspension insulator sets shall be such as safely to withstand a force of 1000 N (assumed to be the weight of a man and tools) applied at the tip.

5.4 Electrical design

All insulators and insulator sets shall comply with the technical requirements of Schedule D and satisfy the test requirements stated in Clause 13 of this Specification.

5.5 Mechanical design

The mechanical strength of the insulators shall be as stated in Schedule D.

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. Where cement is used as a fixing medium, cement thicknesses shall be as small and even as possible and proper care shall be taken to correctly centre and locate the individual parts during cementing.

5.6 Marking

Each insulator unit shall be legibly and indelibly marked with the manufacturer's name and trade mark, the insulator type or catalogue number, the date of manufacture, the minimum failing load and such other marks to assist in the representative selection of batches for the purpose of the sample tests stated in Clause 13.6.1 of this Specification. For porcelain insulators these marks shall be printed, not impressed, and shall be applied before firing and shall be clearly legible after firing the glazing. For glass insulators these marks may be applied by sand blasting.

5.7 Clamps and fittings

The suspension clamps and insulator fittings for line conductors shall be suitable for “I” suspension insulator sets. Single strings shall be used for the general run of the line but double string suspension sets shall be provided on towers immediately on each side of main road, river, railway, telephone or pipeline crossings or on each side of a long span. Single or twin string tension insulator sets as stated in schedule D shall be provided for tension towers and single string tension insulator sets for light duty use, the latter being for slack span connections to substations. Double string tension sets

shall be provided with a double attachment at the tower crossarm. Single string auxiliary (jumper) insulator sets may be used where approved.

Suspension and tension clamps for line conductors and earthwires 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 which are subject to a tensile load in service shall comply with IEC 61284, except that the nut of each fixing bolt shall be secured by a split pin. A backing washer is not required. The unthreaded shank of the fixing bolt 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. The mechanical strength of the fittings shall be as stated in Schedule D and the minimum failure load of each fitting shall be stated on the drawings.

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.

Tension insulator sets shall be equipped with sag-adjusting 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.

Parallel tension insulator strings shall be provided with links of a length necessary to ensure insulators lie opposite each other when erected.

Suspension clamps for line conductors and ACSR earthwires shall be free to pivot in the vertical plane about a horizontal axis passing through and transverse to the centre line of the conductor. The overall length of the suspension clamp for ACSR line conductor shall not be less than 320 mm and for ACSR earthwire shall not be less than 240 mm. Suspension clamps shall permit the complete conductor to slip at approximately twice the still air tension at the everyday temperature stated in Schedule D, but the conductor shall be mechanically clamped in an approved manner. Unless otherwise approved, the outermost point of clamping pressure shall not be less than two conductor diameters inside the outermost point of contact between the conductor and its supporting groove (the conductor being assumed to be horizontal). (Where armour rods are used, the design shall consider the diameter of the armour rods over the conductor.) The supporting groove beyond the latter point

shall be curved in the vertical plane to a minimum radius of 150 mm and for a sufficient distance 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 to a minimum radius of 25 mm for a distance of 12.5 mm, unless otherwise approved. 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 earthwire shall be designed for attachment of the required flexible earthing bond which is to be bolted between each suspension clamp and the tower steelwork.

Ferrous suspension clamps for line conductors and earthwires, if used, shall be provided with soft pure aluminium liners to protect the conductor.

Bundled line conductors shall be supported on suspension sets with a yoke plate which provides a conductor centre to centre separation as specified in Schedule D. 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 60° 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 suspension counterweights.

Suspension clamps for optical fibre (OPGW) earthwires, 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 7 to 15 kN. 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 suitable positive metallic ‘stops’ or elastomeric clamp liners in the suspension clamp body. Suspension clamps for OPGW earthwire shall be designed for attachment of the required flexible earthing bond which is to be bolted between each suspension clamp and the tower steelwork.

Tension clamps for ACSR line conductors and ACSR earthwires shall be of the compression type and shall comply in all respects with the provision of the Specification for line conductor joints. The design of the clamps for ACSR conductors shall be such as to make it impossible to position the steel sleeve incorrectly. Before compression the overall length of the clamp shall not be less than 500 mm, with the outside diameter of the clamp not less than 43 mm, for the ACSR Teal and the overall length shall not be less than 405 mm, with the outside diameter of the clamp not less than 34 mm, for the ACSR Dorking. 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.

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 down-dropper 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 down-dropper connections to substation equipment require conductors of different configuration to that for slack spans, 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.

Tension clamps for OPGW earthwire shall be of the pre-formed helical or other approved type. They shall comply with the provision of the Specification for line conductor clamps, but shall also support the OPGW earthwire 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 earthwire 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.

Adjustable extension links are to be provided at the lower end of slack spans and fitted at the earth end of the light duty tension sets.

Conductor fittings shall not employ screw threads loaded in tension. Hooks shall not be used for attaching insulator sets to tower crossarms.

6. STEEL TOWER DESIGN

6.1 General

Towers shall be of the self-supporting type in single or double circuit configuration as specified in Schedule D.

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

For single circuit towers the line conductors shall be arranged in triangular formation with one overrunning earthwire disposed above the line conductors to provide the shielding angle specified in Schedule D8. Horizontal spacing between phase conductors and vertical spacing between phase and earthwire shall be as specified in Schedule D11.

Double circuit towers shall have extended middle cross arms with the phase conductors of each circuit vertically disposed and with one over running earthwire disposed above the phase conductors.

The methods of attachment of the earthwire to the towers shall be by means of suspension clamps at the tangent towers and by means of tension anchor clamps at tension towers. Tangent towers shall be capable of accommodating OPGW joints.

6.2 Types of tower

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

Single circuit towers

Type	Position of use	Angle of deviation or entry	Type of insulator
1S2	Tangent	0° - 2°	Suspension
1R2	Long span tangent	0°	Suspension
1M2	Medium angle 30°	0° - 30°	Tension
1T2	Medium angle 60°	30° - 60°	Tension
1E2	Large angle and	60° - 90°	Tension
	Full dead end	0° - 30°	Tension
1K2	Under-crossing tower	0° - 30°	Tension
1SP2	Tee-off/Special purpose	90°	Tension

Double circuit towers

Type	Position of use	Angle of deviation or entry	Type of insulator
2S2	Tangent	0° - 2°	Suspension
2R2	Long span tangent	0°	Suspension
2M2	Medium angle 30°	0° - 30°	Tension
2T2	Medium angle 60°	30° - 60°	Tension
2E2	Large angle and	60° - 90°	Tension
	Full dead end	0° - 30°	Tension
2K2	Under crossing Tower	0° - 30°	Tension
2SP2	Tee-off/Special Purpose	90°	Tension

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

The standard height of towers shall be based on the sag of the conductor specified in Schedule D at the maximum temperature specified in Schedule D 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 Schedule D. An extended tower shall be designated by the addition to its standard designation of the symbol '+' followed by the height of the body extensions in metres. Variations in height from the standard height tower are to be achieved without any change to the common portion of the tower.

Standard and extended towers, except towers type 2K2 and 2SP2 shall be designed for and provided, where necessary, with 3 m and 6m body extensions.

Tangent towers shall employ pointed crossarms. For deviation angles exceeding 30°, tension towers shall use rectangular crossarms on the outer side of the deviation angle.

Tower type 1R2 and 2R2 shall be designed for and provided, where necessary with body extensions in multiples of 3 m, from 3 m to 15 m.

The extensions 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 if 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.

6.3 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 or makes any deviation not exceeding 2°, the Type 1S2 or 2S2 tower with suspension insulator sets shall normally be used subject to the sum of adjacent spans limitation, swing clearances being maintained and with the approval of the Engineer. Where there is a requirement, such as at a river crossing, for a tower at a straight line position but with a longer span than that permitted by the 1S2 or 2S2 towers, Type 1R2 or 2R2 towers shall be used with suspension insulator sets.

Where the route makes any deviation exceeding 2°, angle towers, with tension insulator sets shall normally 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 earthwires, Type 1M2 or 2M2 towers shall be provided at approved positions. Section lengths shall not normally exceed 5 km.

The transmission lines shall be terminated on a Type 1E2 or 2E2 tower with tension insulator sets. The maximum angle of entry of the line to the dead-end tower is 45°. The Type 1E2 or 2E2 tower shall be designed to withstand all specified loadings with and without slack spans erected. The slack spans shall be assumed to exit from the Type E2 tower at any horizontal angle up to but not exceeding ±45° from the tower centre line and at any vertical angle to the horizontal between 0° and 45°. The slack span conductors between the dead-end tower and the substation gantry shall be erected with substantially reduced tensions, as given in Schedule D, and shall normally be supported at both ends on light duty tension insulator sets. Earthwires shall be included in slack span spans.

Where it is necessary to provide a double circuit tee-off connection, 2SP2 towers shall be used and employed at straight line positions or at an angles up to 30°. The 2SP2 tower shall be designed to accommodate 12 crossarms.

6.4 Final sags and tensions

The line and earthwires shall be erected so that the final tensions at the “everyday temperature” in still air shall be the figures stated in Schedule D 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 earthwire sag shall be at least 25 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 earthwire will be designed and the standard tower heights determined. The calculations shall consider the tension limitations specified in Schedule D together with the mass of grease and spacers or spacer-dampers and the mass of aircraft warning markers (AWM) where appropriate. The requirements for differential sagging of the earthwire 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 earthwires at various temperatures and spans, the former making allowance for such permanent stretch as may take place in service.

6.5 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 Schedule D and their respective meanings are as follows:

a. **Basic span** shall mean the horizontal distance between the centres of adjacent supports on level ground 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.

b. **Wind span** shall mean half the sum of adjacent horizontal span lengths supported on any tower. The wind span for all tower types shall be 1.1 times the basic span.

c. **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 tangent 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 Schedule D. No single span shall normally exceed the maximum single span length stated in Schedule D, except on special towers.

All standard towers, except tangent 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.

At road and railway crossings the crossing span length shall not exceed the basic span or the length specified in Schedule D without the approval of the Engineer.

6.6 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 Schedule D.

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),

Tangent towers 0° to +20°

Tension towers -10° to +20°

It shall be assumed for tower design purposes that, under wind loading, jumper loops will swing transversely and the swing angle of the jumper loops shall be calculated assuming 50 per cent of the specified ultimate wind pressure. 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 Schedule D. Designs to determine the swing of the jumper loops and the required mass, if any, of weights shall be provided. 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 jumper sets 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 (m) 132 kV line
Normal ground, uninhabited areas	6.0
Normal ground, residential areas	7.0
* Main Roads – road level	8.8
# Rail crossings – rail level	11.5
Any wall, building or other structure on which a man may stand, or on which a ladder may be placed	5.0
Power transmission line crossings	3.0
Navigable rivers to high water	12.5
Oil pipelines	8.8
# Telecommunications lines	3.0
Main canal	14.0

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

\# Where a line erected under this Contract crosses over telecommunication lines and railways, clearances as laid down in Regulations shall take preference.

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

To account for minor variations in ground topography and foundation installation, the transmission line profile shall be plotted with an additional clearance of 0.5 m over those specified in the above table.

The following minimum horizontal distances from tower locations shall be maintained.

Situation	Minimum distance (m) from tower
To centre line of rail tracks	50
To centre line of roads, bridges and pipelines	100
To centre line of power and communication circuits	50

6.7 Applied loads

6.7.1 Normal loading conditions

Wind: The maximum design gust speed shall be 40 m/s acting at an elevation of 10 m above the surface of the ground. The gust speed shall vary with height in accordance with the following expression:

$V = 40 \times (H/10)^{1/7}$, where V = gust speed, m/s, at an elevation of H m.

Gust pressures on the earthwires, phase conductors and towers are calculated in accordance with the following expressions:

$P_s = 0.613 \times V_s^2 \times a$

$P_c = 0.613 V_c^2 \times a$

$P_t = V_t^2$

Where: P_s = gust pressure, N/m^2, at mean earthwire elevation,

P_c = gust pressure, N/m^2, at mean conductor elevation,

P_t = gust pressure, N/m^2, at elevation of 15 m, 30 m, 45 m, etc, on tower

V_s = gust speed, m/s, at mean earthwire elevation,

V_c = gust speed, m/s, at mean conductor elevation,

V_t = gust speed, m/s, at elevation of 15 m, 30 m, 45 m, etc, on tower

a = gust factor = 0.6

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 Schedules, shall be as follows:

a. **Transverse loads**

a.1 **Wind**: The transverse load shall be the wind pressure calculated as above (or as stated in Schedule D) acting at right angles to the following line components:

a.1.1 the whole projected area of the line and earthwires when coated with the radial thickness of ice as applicable given in Schedule D, appropriate to the loading condition, over the specified wind span stated in Schedule D, and the transverse horizontal resultant of the maximum line and earthwire tensions, stated in Schedule D,

a.1.2 1.0 times the projected area of the insulators,

a.1.3 2.0 times projected area of 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 any Aircraft Warning Marker (AWM). The full wind span shall be taken regardless of the angle of line deviation. The transverse components of line and earthwire tensions shall be computed for the full range of specified angles of deviation.

a.2 Wind at 45°: As a.1, 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.

b. **Vertical loads**

b.1 **Normal**. For normal load conditions the mass of the line and earthwires when coated with the radial thickness of ice as applicable and of the density given in Schedule D, appropriate to the loading condition, the mass of the insulators, insulator fittings, earthwire 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 Schedule D.

b.2 **Minimum**. For the minimum load condition for tangent towers the mass of line and earthwires shall be considered to be zero. The mass of the insulators shall be ignored.

b.3 **Uplift**. The uplift force acting on the towers shall be assumed to be equivalent to the mass of line and earthwires contained in the uplift span specified in Schedule D

c. **Longitudinal loads**

c.1 **Normal**. The longitudinal components of the line and earthwire tensions stated in Schedule D (checked at all angles of entry) (terminal towers only).

c.2 **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 earthwire tensions stated in Schedule D.

At load attachment points of tension towers, other than those on the tower transverse centre line (e.g. at pointed crossarms), the normal vertical load as defined in b.1. and the uplift load defined in b.3 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 the following table.

NORMAL LOADING CONDITIONS

Loads to be applied at each line conductor phase attachment and at each earthwire attachment, factor of safety 1.5 to be applied.

Tower type	Load case	Transverse (As defined in a. above)	Vertical (As defined in b. above)	Longitudinal (As defined in c. above)
TANGENT (suspension insulator sets)	1 2 3 4	Wind at 90° Wind at 45° Wind at 90° Wind at 45°	Normal Normal Minimum Minimum	- - - -
SMALL ANGLE (suspension insulator sets)	1 2 3 4	Wind at 90° Wind at 45° Wind at 90° Wind at 45°	Normal Normal Minimum Minimum	- - - -
ANGLE (tension insulator sets)	1 2 3 4 5 6	Wind at 90° Wind at 45° Wind at 90° Wind at 45° Wind at 90° Wind at 45°	Normal Normal Minimum Minimum Uplift Uplift	Section Section Section Section Section Section
DEAD-END (tension insulator sets)	1 2 3 4 5 6	Wind at 90° Wind at 45° Wind at 90° Wind at 45° Wind at 90° Wind at 45°	Normal Normal Minimum Minimum Normal Normal	Normal Normal Normal Normal Normal Normal

All towers shall be designed to accommodate AWM which may be located on the earthwire in accordance with the requirements of Clause 6.13 of this Specification. The Contractor shall give details of any reductions required to the lengths of spans due to the additional applied loadings where the AWM 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.

6.7.2 Broken wire and cascade collapse loading conditions

Wind: The average design wind speed (V_{av}) is 15 m/s acting at any elevation above the surface of the ground.

Average wind pressures shall be used during calculations concerning broken wire loading conditions. Still air conditions shall be assumed during cascade collapse loading conditions.

Average wind pressures on the shield wires, conductors and towers are calculated in accordance with the following expressions:

$P_{av}s = 0.613 \times V_{av}^2$

$P_{av}c = 0.613\ V_{av}^2$

$P_{av}t = V_{av}^2$

Where:

$P_{av}s$ = average wind pressure, N/m^2, on earthwire,

$P_{av}c$ = average wind pressure, N/m^2, on conductor,

$P_{av}t$ = average wind pressure, N/m^2, on tower,

V_{av} = average design wind speed, m/s, at all elevations.

All standard types of tower shall be designed for broken wire and cascade collapse loading conditions shown in the following tables.

For all loading cases referred to in Clause 6.7.1 of this Specification, at the conductor attachment points not affected by the broken wire loading conditions, transverse loads (due to wind or due to angle of deviation) shall be calculated using the average wind pressures and vertical loads shall be 100 per cent of the normal, minimum (or uplift) values for vertical loads specified in Clause 6.7.1.

During cascade collapse loading conditions it is assumed that all phase conductors and the earthwire are broken on one side of the tower. The specified cascade collapse condition loads shall be applied at the respective attachment points on the opposite face of the tower.

The longitudinal unbalanced loads shall be assumed to act in the direction(s) parallel to the centre line when one or more than one attachment point is assumed to carry unbalanced loads.

BROKEN WIRE LOADING CONDITIONS

Factor of safety of 1.5 to be applied.

Tower type (loading conditions in any one span i.e. in same direction)	**Transverse due to wind**	**Transverse due to angle of deviation**	**Percentage of loads specified in Clause6.7.1.b (Vertical)**	**Longitudinal (N)**
TANGENT/TRANSPOSITION, broken wire conditions at any one attachment:				
Phase OR Earth	Calculated using average wind pressures	Calculated using average wind pressures	100% 100%	Loads are given in Schedule D9
SINGLE CIRCUIT ANGLE, broken wire conditions at two attachments:				
Any one phase AND Any one earth	Calculated using average wind pressures	Calculated using average wind pressures	100% 100%	Loads are given in Schedule D9
DOUBLE CIRCUIT ANGLE, broken wire conditions at any two attachments:				
Phase OR Earth	Calculated using average wind pressures	Calculated using average wind pressures	100% 100%	Loads are given in Schedule D9
SINGLE CIRCUIT TERMINAL, broken wire conditions at two attachments on the line side:				
Any one phase : AND Any one earth	0 0	0 0	0 0	Loads are given in Schedule D9
DOUBLE CIRCUIT TERMINAL, broken wire conditions at any two attachments on the line side:				
Phase OR Earth	0 0	0 0	0 0	Loads are given in Schedule D9

CASCADE COLLAPSE LOADING CONDITIONS
Factor of safety of 1.5 to be applied.

	Percentage of loads specified in Clause			
Tower type (loading conditions in any one span i.e. in same direction)	**6.7.1.a (Transverse) Due t**		**6.7.1.b (Vertical)**	**Longitudinal (N)**
	Wind	**Angle of deviation**		
TANGENT, cascade collapse conditions at all attachments:				
Phase conductor:	0	0	100%	Loads are given in Schedule D9
Earthwire:	0	0	100%	
ANGLE, cascade collapse conditions at all attachments				
Phase conductor:	0	*	100%	Loads are given in Schedule D9
Earthwire:	0	*	100%	

* The transverse component of the longitudinal load at any line deviation between minimum and maximum.

6.7.3 Construction and maintenance loading conditions

Average wind pressures shall be used during calculations concerning construction and maintenance loading conditions.

Average wind pressures on the shield wires, conductors and towers are calculated in accordance with the expressions given previously in Clause 6.7.2.

In addition to the loadings specified in Clauses 6.7.1 and 6.7.2 towers shall be designed to withstand all the construction and maintenance loading conditions recommended in Clause 6.5 of IEC 60826.

All construction and maintenance loads shall be multiplied with the minimum factors of safety recommended by IEC 60826.

As a minimum, towers shall be designed to withstand the following construction and maintenance loading conditions. Respective line and earthwire loads shall act at all attachments simultaneously.

Tower type	Loads at phase and earthwire attachment points (Newton)			Conductor tension (Newton)
	Transverse	**Vertical**	**Longitudinal**	
TANGENT (suspension insulator sets)				
Maintenance condition				
Phase conductor: Earthwire:	- -	3 x normal 3 x normal	- -	Loads are given in Schedule D10
ANGLE AND TERMINATION TOWER (tension insulator sets)				
Maintenance condition				
Phase conductor: Earthwire:	- -	3 x normal 3 x normal	- -	Loads are given in Schedule D10
Temporary terminal condition				
Phase conductor: Earthwire:	* *	Normal Normal	* *	Loads are given in Schedule D10

* The transverse and longitudinal components of the conductor tension at any line deviation between minimum and maximum.

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

6.8 Tower design

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

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 Schedule D.

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.

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

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

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 30° to the horizontal) shall be capable of withstanding an ultimate point load of 1.8 kN at the centre point of the member.

The arrangement and methods of carrying out the tests stated in the 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. Graphical calculation of forces is not 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 for checking tower designs. A copy of the software shall be handed over to the Engineer on completion of the project.

Transmission line towers shall be designed as self supporting structures, conforming to the loadings and duties as specified and including all loadings resulting from the Contractor's erection and stringing methods, as well as for:

a. Simplicity and ease of erection,

b. Sub-assembly of panels on the ground,

c. Erection of panels by gin pole/derrick.

The minimum thickness of structural steel shall be as follows:

Main leg angles	8 mm
Crossarms	6 mm
Gusset plate	6 mm
Secondary angles	5 mm

Channels 5 mm

Any steel member 5 mm.

The minimum angle section permitted shall be 50 mm × 50 mm × 5 mm

The sections used in the design of the structures shall be readily available from standard sources of supply.

All structures and their components shall be designed to withstand without failure the stresses resulting from the design loading combinations, inclusive of the specified factors of safety.

All members shall be of such size, shape and length to preclude damage or failure from vibration or stress reversal. 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.

All crossarm and bridge chord members shall be capable of supporting an ultimate vertical ladder load at any position within 1 m of each phase centre line of 4450 N. The ladder load shall be applied as two 2225 N point loads 0.3 m apart.

The redundants shall be designed to carry 2.5 percent of the axial load of the members they restrain in addition to the vertical load of 1.8 kN described above.

The ultimate stress of any tower member shall be determined in accordance with ANSI/ASCE 10 “Design of Lattice Steel Transmission Structures” and with ASCE Manual 52,"Guide for Design of Steel Transmission Towers" (Second Edition, 1988).

The slenderness ratio, KL/r, shall not exceed the following values:

	Max. KL/r
Column or tower legs and beam chords	150
Compression bracings having calculated stress	200
Redundant, (bracings without calculated stress)	240
Tension members of tower cross-arm hangers	325
Other tension members	400

Where: L = the unsupported length of the member,
r = the radius of gyration of the member about the axis under consideration,
K= as defined in the ASCE Manual 52.

6.9 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. A schedule shall be presented summarizing the loading cases which are critical for each of the foundation classes, as appropriate.

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

6.10 Anti-climbing devices and steps

Each tower shall be fitted with an anti-climbing device of an approved adjustable barbed (razor) wire type design fixed at a height of between 3.5 and 5 m above ground. This anti-climbing device shall be of suitable construction to reasonably prevent unaided access up the tower. The position of the anti-climbing device on the tower shall preferably be such that a standard device is used regardless of the tower body and leg extensions which may be employed.

The anti-climbing devices shall be provided with hinged gates to allow access by authorized personnel for maintenance purposes. Gates shall be provided on each step bolt leg so as to provide individual access paths to each circuit. The gates shall be locked in the anti-climbing position by a padlock of the cylinder type with dustproof covers to key holes. Padlocks shall be of non-ferrous corrosion resistance material with stainless steel hasps. Dust covers shall be of the non-plastic type. The locks shall be unique to each circuit.

On each single circuit tower, one leg, and 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 earthwire peak. Where, for structural reasons, it is not possible to maintain the equal centres it shall be acceptable to change adjacent 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 Schedules.

6.11 Notice plates

Conspicuous danger and property plates, also circuit and tower number 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 Plate drawings. With the exception of danger and aerial number plates, all plates shall have black letters and/or numbers on a white background with the back of the plates coloured black. Danger and property plates shall have white letters on a red background.

Notice plates shall be fixed above the anti-climbing device.

Line code identification and tower number plates shall be attached centrally immediately below the danger plate.

Phase 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 and provided for each circuit on all double circuit towers. The plates are to be fixed to the tower legs fitted with step bolts, one plate at each crossarm level, and one plate immediately above the anti climbing device.

Aerial number plates shall be provided and fixed in approved positions on both transverse faces of the earthwire 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 Arabic and English language.

Flags are utilised during maintenance works to identify specific circuits. Flag fixing brackets are 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 and finished in vitreous enamel.

6.12 Bird guards

Towers shall be provided with saw like bird guards immediately above each conductor suspension assembly attachment point to prevent the perching and nesting of birds at these points.

6.13 Aircraft warning markers, obstruction lights and tower painting

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

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 earthwire 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 earthwire 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 m on the overall earthwire system.

The first and last spheres in any span shall be approximately 15 m from the towers defining the span.

Air traffic obstruction lights on towers. Where required, ATOL shall be installed on the towers defining the span, of International Standard red in colour, and having the following general features:

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

2. two lamps per each earthwire crossarm, of which only one may be lit at a time (by utilizing a switch-over relay)

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

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

5. all components shall be corrosion-proof for use during the varying atmospheric and climatic conditions occurring at all seasons.

The lighting system shall be designed to withstand the induced high voltage that can occur during earth fault conditions.

The lighting system shall be suitable for operation from a 230 V supply and shall be complete with all necessary equipment.

At tower locations where a 230 V supply is not made available by others, the Contractor shall provide a self-contained power supply system comprising solar cells, batteries, control equipment, remote supervision and alarm monitoring units, cable and accessories required for each set of air traffic obstruction lights. The provision shall be generally in accordance with the requirements for the power supply included in Clause 4.6 “Optical Regenerative Repeaters”. A battery maintenance interval of a minimum of 5 years shall be guaranteed, as shall the minimum luminous flux for the lights.

It shall be noted that the supply of equipment shall include the necessary spare parts as per manufacturer’s recommendations for a service period of 5 years, the cost of which is deemed to be included in the price quoted in the Schedules.

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

Air traffic obstruction lights on line conductors: Where required, ATOL shall be installed on the highest line conductor(s) in the span.

The obstruction lights shall be of the discharge type spaced at a minimum separation of 45 m. The lights on the two highest conductors shall be at the same separation on double circuit lines, while one of them could be dead.

The first and the last light in any span shall be approximately 20 m from the tower defining the span.

The Contractor shall supply and install a discharge lamp consisting of a set of capacity tappings and a set of accessories for suspension and insulation. The number of elements shall depend on the line voltage and shall be complete and in accordance with the manufacturer's instructions.

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

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.

7. FOUNDATION DESIGN

7.1 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. A schedule shall be presented summarizing the loading cases which are critical for each of the foundation classes, as appropriate.

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

7.2 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 Schedule D.

Concrete shall be reinforced and shall be designed, detailed and constructed, using design mixes to BS 5328, (BS EN 206-1 and BS 8500) in accordance with BS 8110 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 Schedule D, 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.

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 100 mm thick from a point at least 500 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 main foundation in an approved manner. Cover over the reinforcement bars shall not be less than 75 mm if the concrete is formed and shall not be less than 100 mm where concrete is placed against soil or blinding concrete.

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 class and 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 and type of tower foundation designed in accordance with the particulars given in Schedule D and any special foundations when instructed by the Engineer shall be tested in accordance with the requirements of Clause 13 of this Specification.

7.3 Foundation types

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

Self-supporting tangent and tension towers:

a. Concrete pyramid (or pad) and chimney foundation,

b. Concrete pile foundation,

c. Augered shaft foundation (tangent towers only),

d. Rock anchor array foundation,

e. Special 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**. Reinforced concrete design shall be used only. 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 Schedule D. 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 Schedule D. The depth of the foundation shall not exceed 1.5 times the foundation base width.

   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.

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 the walls of the rock for a minimum height of 600 mm. The walls shall be vertical and, where possible, shall also be undercut to provide greater bond between concrete and rock. Formed concrete pyramid foundations shall not be used in rock.

b. **Pile foundations:** Where the subsoil investigations have indicated soil of very low bearing capacity and/or high water table in granular soils, pile foundations comprising single or multiple reinforced concrete piles driven or bored in situ to a depth determined by the site soil investigation and joined to the stub in a reinforced concrete cap may be used.

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.

c. **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 1.5 times the diameter. Where ground conditions and installation technology permit, alternative proposals may be submitted for approval based on the use of two augered shafts per leg, with the shafts installed at a small angle to each other. 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 supporting 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 confirm continuity of the bearing stratum below the foundation.

Construction of reinforced concrete footings shall be carefully supervised at all times and excavations 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 to 0.5 metres 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.

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 separately tested.

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

d. **Rock anchor array foundation**. The rock anchor array foundation 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.

e. **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 or concrete raft.

   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.

f. **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.

g. **Raft foundations** are infrequently used 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.

h. **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 the Contractor, based on his investigations and experiments, shall propose the design parameters.

All types of foundations shall be designed to withstand uplift, settlement, overturning and sliding when subjected to the specified conditions of tower loading. Details on design requirements are included in Schedule D12. 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. Preference shall be given to foundation designs that enable the concrete to engage with undisturbed ground, if possible suitably undercut.

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.

Where a tower is situated in paddy or in areas subject to extended periods of flooding, the excavated soil remaining after the installation of an enlarged pad or raft foundation shall be placed around each leg to a height of 0.75 metres. The area of the mounds so raised may be extended over the complete tower site if the volume of surplus soil is adequate. The sides of the mounds shall be battered to minimise the effects of erosion. The stubs of towers situated in paddy shall be extended by 0.75 metres and encased with concrete to 500 mm above the top of the mound. The encasing concrete shall be adequately reinforced to resist the forces applied to the tower leg 0.75 metres above the normal ground line. Soil forming the mounds shall be considered not to contribute to the uplift resistance of the foundation. Piles used as foundations in paddy shall be capped with reinforced concrete and the cap shall extend upwards to 0.75 metres above the normal ground line. Soil forming the mounds shall be considered not to contribute to the uplift resistance of the foundation. Piles used as foundations in paddy shall be capped with reinforced concrete and the cap shall extend upwards to 0.75 metres above the normal ground line.

The cost of the extra work and materials arising from the provision of each 0.75 metres stub and foundation extensions but not including the raising of the soil mounds shall be paid for at the prices given in the Schedules.

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

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.

Where required, 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 for a height of 150 mm below the top surface of the foundation to 500 mm above. The type of coating shall be to approval of the Engineer. In all desert areas the coating shall be applied and extended to 1 m above the top surface of the foundation to counter the abrasion effects of wind blown sand.

8. STEELWORK DETAILING AND MANUFACTURE

8.1 Detailing and fabrication

All towers shall be of self-supporting construction.

The towers shall be of approved design and construction.

The Contractor shall supply raw material, fabricate, trial assemble, test and deliver galvanized steelwork for 132 kV transmission lines as shown in the drawings and Specifications.

Erection drawings showing the location of all members and the number and length of bolts required for each connection shall be submitted. 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.

Wherever possible, the horizontal members shall be placed so that the horizontal leg is on top.

Allowance shall be made in gauge dimensions on steel members for the thickness of subsequent galvanizing and the possible formation of spelter fillets inside the angles for adequate erection clearance after galvanizing.

The maximum length of members shall be restricted to 6.5 m for medium sections and 8 m for legs and heavy bracings.

The leg splices shall be located as near as possible and immediately above structure panel points.

The minimum size of bolt shall be 16 mm in diameter. Minimum nominal increase in the bolt diameters shall be 3 mm. Detailing practice shall not allow bolts in tension except where specifically called for in the design. The threaded portion of the bolt shall not encroach on bearing surfaces. The shank shall protrude beyond the nut a minimum of 4 mm.

Only one bolt diameter shall be used per tower type, unless otherwise agreed by the Engineer.

Minimum spacing of bolts and edge distances shall be as follows:

Bolt diameter	**Minimum bolt spacing**	**Minimum edge distance**		
		Rolled edge	**Sheared edge**	**Flame cut edge**
16	40	19	22	25
20	51	27	31	34
22	57	32	35	38

Stub steelwork used to connect the tower to the foundation shall be of the same section and steel thickness used for the lower tower leg which is attached to the stub.

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.

No bolt hole shall 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 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 grounding counterpoise connections shall be provided on each leg of every tower and extension and the earthwire peak.

Suspension insulator sets and earthwire suspension assemblies shall be attached to the tower such that the point of transverse rotation is on a full bearing surface of a shackle pin.

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

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.

8.2 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 S275JR 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.

8.3 Bolts and nuts

All metal parts shall be secured by means of bolts and nuts and single washers. The minimum diameter shall be 16 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 minimum grade of bolt shall be 5.8.

The nuts of all bolts for attaching to the tower, plates, brackets or angles supporting insulator sets or earthwire 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 9 of this 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.

On especially tall towers, nuts shall be locked, to the approval of the Engineer.

8.4 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.

The centre of any hole shall not vary more than 1.5 mm from its position shown on the drawing. The centre-to-centre distance of end holes in a group of holes shall not vary more than 1.5 mm from the dimension shown on the drawing.

Plugging or welding of incorrectly punched/drilled holes is not allowed. The punches and dies are to be sharp and true in order that all punched holes are round and free from ragged edges and burrs. The diameters of the finished holes are to be equal to the diameters of the bolts plus 1.5 mm.

Punching of material above 12 mm thickness is not allowed.

The cold bending of mild steel, in accordance with recognized practice and standards, shall be to approval. Any material showing signs of cracking will be rejected.

Bending of tower members shall be performed on a hydraulic press with a suitable die to prevent bucking of the legs. The bending shall be performed on a slow moving press. Use of quick impact press is not allowed.

All bends in high tensile steel shall be formed hot. Whenever hot bending is required, heating of bending area shall be performed in the oven, so that the member is uniformly heated to a distance of approximately 150 mm on either side of the bending point. Use of a torch is not allowed. The heat treatment procedure has to preserve the original characteristics of the material. Drilling of holes in the bending area can be performed after bending only.

All bends made by cutting and welding shall be to approval. Detailed welding procedures are to be submitted to the Engineer for approval when welded components are offered. Designs shall be provided for all welded connections.

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.

8.5 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 6.2 of this Specification.

9. GALVANIZING

9.1 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, earthwire 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 a minimum mean weight of zinc coating of not less than 610 g of zinc per square metre of surface on steel bars, plates, sections and fittings. Threaded work shall have a minimum mean coating weight of 305 g of zinc per square metre.

Galvanizing of steel core wires of line conductor, earthwire 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 13.8 of this Specification.

Sheradizing 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.

10. SURVEY AND SETTING OUT

10.1 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.

10.2 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 to enable the Contractor to carry out the erection of the lines. The Engineer will, however, permit the Contractor to use the existing access tracks as provided for in Clause 10.4 of this 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 stated in Schedule A the following facilities for access to Site will be provided:

a. Over the whole length of the route of such sections such 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 of such section in not more than two continuous lengths there shall be:

   i. such right of access for the Contractor's staff to and 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 subclause b. above shall be extended to the complete line as soon as available.

10.3 Access

Where the facilities obtained under Clause 10.2 of this 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 the above mentioned facilities for access to the Site can not be provided until after the date stated in the Schedules, 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 the Engineer or, if the Engineer so requires, by the Contractor at the labour and equipment rates stated in Volume 3, Schedule K, except where such work shall be covered by the rates given in Volume 3, Schedule H 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.

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 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, railways, tramways, navigable rivers, or canals, 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.

Unavoidable damage to crops will be paid for, 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.

10.4 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. The Engineer will, however, permit the Contractor to use any of the 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 the Ministry of Electricity’s maintenance vehicles and, for those originally belonging to the Ministry of Electricity, in no worse condition than originally recorded.

10.5 Survey

At an early stage of the Contract the Contractor shall mobilize on site to evaluate the line route shown in the drawings. The Contractor shall establish the optimum location of the line route considering minimal disturbance to landowners and property and ease of future line maintenance by the Ministry of Electricity.

The Contractor shall be responsible for the complete survey of the transmission line. 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, ground line profiles, route maps and record schedules; 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 shall be approved by the Engineer and not normally greater than 300 mm vertically and 0.1 per cent horizontally. All reference points are to be provided with GPS co-ordinates.

Where the Engineer 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. Control points and any 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 the Engineer, the Contractor may expect that at the time of Award of Contract the Engineer 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.

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

The Contractor shall survey all roads, major canals, pipelines and telecommunication lines wherever they cross the route of the proposed overhead line. 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.

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 Plate drawings.

10.6 Profiles

The ground profiles (longitudinal) 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 maximum still air sag specified in Schedule D,

d. clearance curve,

e. indication of side slopes where these affect clearances (account being taken of conductor under wind loaded 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, railways and other obstacles to be crossed,

h. sections unsuitable for tower locations,

i. vegetation and nature of ground,

j. tower locations including GPS co-ordinates, tower number and type of tower with type of extension if necessary ,

k. angles of deviation, spans, ruling spans.

l. sag templates used

The Contractor shall be responsible for checking the minimum weight condition on tangent and tension structures under assumed conditions of still air or ice 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 which 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 which may be required in order to comply with requirements or to give the specified minimum clearances.

If the Contractor proposes to prepare the line route profiles and to optimize the position of the towers by means of a computer program and plotter, the input data is to be first agreed with the Engineer. For particular conditions it may be necessary for the Engineer to restrict the employment of maximum tower extensions and also to include provision in the computer program for restricting costly special foundations.

For final records, profiles shall be provided on 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 which 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.

In addition to the clearances listed in Clause 6.6, the overhead line route will maintain the following minimum horizontal clearances:

100 m: to parallel pipelines

250 m: to pipelines parallel for more than 1 km

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.

10.7 Structure list

As soon as the final tower locations are agreed and approved by the Engineer, the Contractor shall submit a structure list. The structure list shall indicate tower construction and final numbers, tower types, body and leg extensions, angles of deviation, insulator types, insulators string types, spans, ruling spans, section lengths, 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 structure list.

10.8 Route map

During the progress of the work, the Contractor shall record on profiles and on a set of map transparencies to 1:100 000 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 structure lists, 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 the Ministry of Electricity but will be in the charge of the Contractor until the completion of the particular section of the work to which they refer.

10.9 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 ruling 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 the conductor specified in Schedule D 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, ruling 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 and shall be clearly marked to show the range of ruling spans for which the template is valid.

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.

11. CIVIL WORKS

11.1 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 the Engineer will be provided as reference.

After performing the tower spotting, the Contractor shall make a terrain reconnaissance, making probe or rock drilling tests at each tower location. 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.

Soil probe testing will be by means of an approved type of penetrometer or borer in order to give information on ground bearing properties of the various underground strata, to provide data which will aid in checking the compression and uplift design of the foundations and to provide data on underground water levels where they exist. Where the soil probing indicates the possibility of rock due to 'refusal' of the probe test the Contractor shall confirm by drilling that rock, rather than an isolated boulder, has been encountered. Further tests subject to the approval of the Engineer may be required to determine the rock quality.

Subject to the approval of the Engineer the parameters obtained from sub-surface tests shall be classified into typical groups and employed in the designs of all foundations.

In addition, to correlate the probe tests and to confirm or adjust the parameters for standard foundations given for tender purposes in the Schedules, one in five tower sites shall be investigated during the profile survey by bore hole and one or more of the following methods – Dutch static cone penetrometer, dynamic penetrometer, shear vane, rock drilling and coring, plate bearing tests, laboratory testing (including triaxial shear testing, sieve analysis, soil densities, moisture contents and plasticity and expansion indices, as well as chemical analysis of soil and water). 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. The one in five tests shall generally be performed at equal intervals along the line route but this may be varied where ground conditions are identified to differ significantly.

The costs of soil tests as detailed above will be included in the rate for profile survey.

Tests at additional sites approved by the Engineer will be paid at the rates stated in the Price Schedules.

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 results of all soils tests shall be submitted to the Engineer together with any proposals which the Contractor may consider necessary to ascertain the parameters and dimensions for 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 soil tests 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 a Schedule for construction purposes which 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 comprehensive soils 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.

11.2 Route clearance

The Contractor shall clear a parallel strip of land through those sections of the line route which pass through vegetation. The width of the strip, which shall be in accordance with the Plate drawings, may vary according to the mean height of the vegetation and shall be determined by ensuring that any standing tree would not cause flashover from a conductor deflected up to 45º from the vertical when a clearance of at least 5 m shall be maintained. In determining the flashover clearance and in estimating the mean height of the vegetation, due allowance shall be made for seasonal growth. In addition, any tree which may fall in the direction of the overhead line, shall be cleared unless located such that with the conductors hanging vertically, there would be clearance to the falling tree of at least 3 m.

Trees, scrub and undergrowth shall be cleared by felling not more than 150 mm above ground. 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 top soil when clearing the strip. Before any burning of timber or tree stumps, the permission of Authorities shall be obtained.

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.

11.3 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. **Method Statement.** The Contractor, within one month of being awarded the contract, shall submit to the Engineer a detailed method statement covering all aspects of work related to the installation of the foundations. Included shall be at least the sourcing, storage and protection (and shading from solar radiation) of materials, proposed plant and methods to be adopted for working in high temperatures, methods for concrete mix design, for concrete sampling and testing, for materials routine testing, the methods for work on site and details of risk analyses carried out and subsequent health and safety measures proposed during site activities. This is a **HOLD POINT.**

c. **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 leg extensions on the towers. 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.

   v. Preference will be given to proposals that minimize the amount of disturbance to the terrain environment. Material which 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.

d. **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 150 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.

e. **Excavation**. During excavation, the Contractor shall take adequate precautions to prevent earth disturbances which 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 safe-keeping 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 of at least 1:3:6 proportions 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. The blinding concrete shall be allowed to set for a period of 48 hours and shall then be covered with two layers of bituminous roofing felt prior to installation of the foundation concrete.

f. **Stub setting**. Stubs for tower foundations shall be carefully adjusted to an approved template (which may be the bottom section of the tower itself for grillage foundations only) 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 k.

g. **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 which 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.

h. **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 which will not injure the material. Bending hot at a cherry red heat (i.e. not exceeding 840°C) may be allowed except for bars which 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.

i. **Concrete**. Unless otherwise approved, concrete for foundations and for encasing concrete shall be to Design Mix Grade C30 to BS 5328 with minimum cement content of 375 kg/m^3 concrete, maximum water cement ratio of 0.45 and maximum slump of 50 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. As necessary, the Contractor should carry out trials to confirm the rate of loss of workability of the concrete with time and therefore to confirm the maximum permitted time between mixing, loading and placing of the concrete.

All cement used shall be Low Alkali Sulphate Resistant Portland composition obtained from an approved maker. Such cement shall conform in all respects to BS 4027 or to ASTM C-150 Type V. Cement shall be stored in an approved manner. All consignments of cement shall be accompanied with the manufacturer's serial number and the relevant test certificates. Additional tests on the cement shall be carried out when required by the Engineer.

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. It shall be obtained from sources known to produce aggregates satisfactory for concrete and that are chemically inert, hard and durable. Samples of the aggregates, details of tests to confirm conformance with requirements of the Standards and details of any changes to the sourcing of the aggregates shall be submitted to the Engineer at least six (6) weeks in advance of concreting. Any changes to grading of the aggregates will require the Contractor to provide new concrete design mixes, suitably tested and proved. The Contractor shall permit the Engineer to sample aggregates from site for testing. If such tests prove that an aggregate had not been supplied to the quality and grading originally submitted to the Engineer, the Contractor shall remove the aggregate and replace it with a suitable material.

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.

The content of sulphates and chlorides in the aggregates shall not be greater than the following values: -

Coarse aggregate	0.15 per cent by weight
Fine aggregate	0.35 per cent by weight

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. Mixing time for the concrete shall be kept to the minimum consistent with adequate quality and placing shall take place as soon as possible after mixing. Unless confirmed otherwise by trial, concrete should be placed and vibrated within 30 minutes of being discharged from the mixing plant. 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; every effort should be made to keep the concrete at a lower temperature. No concreting will be allowed when the ambient temperature exceeds 40°C and in practice it may be found desirable to restrict concrete working to night or early mornings during the periods of hotter weather. In hot conditions the initial temperature of the mix should be kept as low as possible, by correctly and efficiently shading the materials and equipment against the sun and, if necessary, by using chilled water. Retarding and plasticising 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 13.9 of this 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. Information shall be provided on the shading to be provided and other measures to be adopted to restrict the temperature rise on mixing and transportation equipment used for concreting purposes. 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 to confirm that it is within the 30 minute, or otherwise agreed, limit specified above. Transportation shall be such as to avoid segregation of the concrete constituents. Concrete shall not be poured from a height of more than 1.5 m also to avoid segregation.

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:

i. premature drying out, particularly by solar radiation and wind **for a period of at least seven days after placing**

ii. leaching out by rain and flowing water

iii. rapid cooling during the first few days after placing

iv. high internal thermal gradients

v. low temperature or frost

vi. vibration and impact which could disrupt the concrete and interfere with its bond to the reinforcement.

As soon as possible after the removal of formwork and when the concrete surface is suitable for the application, one of the following treatments shall be applied to all exposed concrete surfaces: -

- Two coats of emulsified asphalt
- Two coats of unfilled cut back asphalt
- Two coats of unfilled cut back tar

The materials used and the method of application shall be in conformance with acceptable national standards for damp proofing and water proofing concrete. Full details shall be provided by the Contractor in a Method Statement to be approved by the Engineer prior to work commencing.

j. **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.

k. **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**
Tangent tower	0.25°	±25 mm	±250 mm
Tension tower	0.25°	±25 mm	±25 mm

Meanings of the headings in the above table are as follows:

Out of alignment defines the permitted angle that the tower foundation setting may be instead of along line and transverse to line for a tangent tower or parallel to and normal to the bisector of the line directions at an angle tower.

From centre line of route defines the permitted lateral displacement of foundations from their design positions.

From transverse centre line of tower defines the permitted displacement along line of foundations from their design positions.

l. **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.

m. **Protection of tower footings**. At locations where water in rivers, wadis or from mountains or flood 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.

n. **Erosion protection in sand dune areas.** Where required at locations in sand dune areas and prior to construction tower positions shall be levelled for a distance of 4 m from around the base. After completion of all work the Contractor shall mound sand around tower locations for a depth of 0.5 m and width sufficient to prevent erosion of that ground materially affecting the foundation design. The widths will be agreed with the Engineer prior to commencement of work. After completion the mound and side slopes shall be covered with crude oil.

11.4 Crash barriers

Reinforced concrete crash barriers to approved designs shall be provided at the rates given in the Price Schedules as directed by the Engineer. The barriers shall be designed to afford protection to any part of the tower which are deemed to be vulnerable to collision by vehicular traffic. The barriers shall be purpose designed and sufficiently strong to deflect a vehicle away from the tower.

12. ERECTION

12.1 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 which 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 notice plates as indicated in the erection drawing.

In order to prevent pilfering, all bolts and nuts from ground to the top of the anti-climbing device shall be secured by means of punching the bolt threads three times at the emergence of the nut or by means of specifically designed and approved anti-pilfer nuts. If required by the Engineer all the bolts and nuts on each tower shall be secured by the same method at the rates stated in the price schedules.

After erection all exposed concrete, including capping concrete and all steelwork within 1 m of the ground or high water level shall be painted with two coats of bituminous or other approved paint. . In swamp areas the painting shall extend 1000 mm above the high water level.

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

c. **Tower grounding and resistance measurements**. The Contractor shall install and test the tower grounding in accordance with Clause 12.3 of the Specification.

12.2 Transposition

Transposition of phase conductors between substations is not required.

12.3 Grounding

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.

The Contractor shall measure the electrical footing resistance to earth of each tower before the earthwires are erected. These measurements shall be recorded by the Contractor in the form of a tower footing earth resistance profile of an approved type. Where the measured tower footing resistance is greater than 25 ohms or where required by the Engineer, towers shall be provided with one of the basic grounding systems (Types G2 to G7) described below.

Seven (7) basic grounding systems are included in this Specification and are described as follows: -

Type G1 Tower foundation with no grounding installed, but with provision for attachment of grounding if later required.

Type G2 Tower foundation with grounding installed consisting of one (1) ground rod or one (1) copper wire grounding grid per foundation.

Type G3 Type G2 plus the addition of long ground rods or ground rod extensions driven to a depth agreed by the Engineer

Type G4 Type G2 or G3 plus the addition of at least 150 m length of counterpoise laid in diagonally opposite directions and with the counterpoise installed under the outside phase conductors and in opposite directions (at least 75 m length in each direction).

Type G5 Type G4 plus the addition of at least 150 m length of counterpoise, installed as above and located under the opposite phase conductors

Type G6 Type G5 plus the addition of one (1) continuous counterpoise to one of the adjacent towers, installed under a pair of outside phase conductors

Type G7 Type G6 plus an additional continuous counterpoise installed under the opposite outside phase conductors.

All tower foundations shall be designed to include two (2) copper leads suitably bolted to the main stub angle and of a sufficient length to extend through the concrete of the foundation and to provide a minimum length outside the concrete of 500 mm such that connections can conveniently be made to ground rods, grounding grid or counterpoise. One of the leads shall be located approximately 500 mm below ground level and the other near the base of the foundation. The method by which the leads pass through the concrete of the foundation shall be subject to the approval of the Engineer.

Materials used for the grounding system shall comply with, or be at least equivalent to, the following: -

Ground Rods shall be formed of copper or copper clad steel, shall be a minimum of 16 mm diameter and of 3 m length. Provision shall be made for coupling rods together. Suitable clamps shall be provided for the connection of copper ground wires or leads.

Grounding Grids shall be formed using minimum sized hard drawn copper wires, either 3-strands of 3.7 mm diameter wire or 1-strand of 6.4 mm diameter wire.

Foundation internal leads shall consist of hard drawn copper wires of the same minimum sizes as specified for the grounding grids. Connections of the lead shall be by sweated lugs and bi-metal connectors where necessary. Clamps to tower steel shall be made of bronze or copper as recommended by the manufacturers, such that galvanic corrosion is eliminated.

Counterpoise shall be formed of annealed copper clad steel wire with a single strand of minimum diameter 6.54 mm.

Connections shall be thoroughly cleaned prior to being liberally coated with an approved electrical jointing compound. Where copper is to be joined to metals other than copper or bronze, the copper shall be tinned in accordance with standard practice. Copper wires shall be joined together using a Cadwelding technique or an otherwise approved method. Where mechanical jointing is used, correctly sized connectors shall be correctly bolted to ensure good electrical connections. All joints shall be protected by means of Denso compound and/or Denso tape or by other approved means.

Each section of grounding system shall be separately bolted to the tower in order that it can later, if required, be disconnected for the purpose of earth resistance measurements.

At each tower connected to grounding system the Contractor shall measure the electrical footing resistance to earth with the grounding system connected. The measurements shall also be recorded by the Contractor on the tower footing earth resistance profile.

Over the last 1.5 km of line into any substation, all towers, including the terminal towers, shall be connected together by continuous counterpoise cable. Radial counterpoise shall not normally be installed at towers connected by continuous counterpoise. The terminal towers shall be connected to the substation grounding grid.

The counterpoise shall be buried at not less than the following depths in trenches excavated and reinstated along a route as far as possible straight. The counterpoise shall not be laid as a straight line in the trench but shall be given a wave form to prevent the counterpoise lifting out of the ground due to temperature changes or other causes.

Minimum depths of burial of counterpoise

Rocky terrain	100 mm min
Normal soil	500 mm min
Under roads or railways, etc.	700 mm min
Cultivated land	800 mm min

Galvanizing shall be in accordance with Clause 9.1 of this Specification.

Metallic fence wires within 60 m of the centre line of the route shall be grounded every 100 m of length by means of grounding cables buried for a length of 2 m at least 750 mm in the ground.

12.4 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 chipping or 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 are excluded from insulator ball and socket joints.

12.5 Crossing of public services

At crossings of roads, buildings, railways, waterways, telegraph and telephone lines, over or under other power lines, the provisions of any Regulations to which the Ministry of Electricity 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, railways, 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.

To effect the crossing of existing high voltage lines, the Contractor shall take all necessary precautions to avoid damage to them. Plans and method statements for such crossings shall be proposed well in advance and shall be approved by the Engineer. In cases where the circuits to be crossed can de-energized, the “permit-to-work” system will be in force. Written permission shall be obtained from the Ministry of Electricity before infringing the prescribed electrical clearance to the line conductors of the existing circuits. Permits-to-work shall be cancelled and returned to the appropriate Ministry of Electricity Engineer as soon as possible.

Where railway, or other 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. Where required by the railway authority’s work shall be carried out outside normal working hours.

When required by the Authorities, permanent cradle guards designed to approval shall be provided over railways, telegraph and telephone lines at the prices given in the Schedules.

12.6 Erection sags and tensions

The line conductors and earthwires shall be erected so that the tensions at “everyday temperature” in still air shall be the figures stated in Schedule D 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 earthwire sag shall be approximately 25 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 "ruling 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.

$$\text{Ruling span length} = \sqrt{\frac{L_1^{\,3} + L_2^{\,3} + \ldots\ldots\ldots L_n^{\,3}}{L_1 + L_2 + \ldots\ldots\ldots L_n}}$$

where L_1, L_2, .., L_n are individual span lengths within a ruling span section

The following sagging tolerances against the specified sag for the conductors in all spans shall be observed:

a. no sag decrease shall be allowed in any conductor,

b. the maximum sag increase over the specified sag given on the sag data sheets shall be 150 mm,

c. the maximum distance between sub-conductors of a bundle shall be ± 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 conductors and earthwires 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.

12.7 Erection of line conductors and ACSR earthwires

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 conductor and earthwire 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, railways, navigable waterways or buildings or in the spans immediately adjacent thereto. All joints shall be at least 30 m away from towers.

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 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 Clause 13 of this 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. Where the joint includes bolted parts, the resistance to be measured is that of the complete assembly. The values of resistance measured shall be recorded on a schedule which 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. The following general rules shall be observed:

a. for damage which reduces the strength of the outer layer of the conductor by an amount equivalent to one strand but not more than three strands, the use of a compression repair sleeve may be allowed. Repair sleeves shall not be allowed within a distance of 3 m from the suspension clamps.

b. for damage in excess of three broken strands or any damage to the strands of an inner layer, the damage shall be replaced with new conductor and compression joints used.

c. any strand which has lost 50 per cent or more of its cross-sectional area shall be considered as having lost all of its strength.

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 conductors and earthwires 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, of approved materials and with dimensions as given in the following table:

	Minimum diameter from bottom of groove
Running out block	34 times the conductor diameter
Sheave	18 times the conductor diameter
Groove radius:	
minimum	0.525 times the conductor diameter
maximum:	
1 or 2 layer conductors 3 layer conductors 4 or more layer conductors	1.10 times the conductor diameter 0.75 times the conductor diameter 0.625 times the conductor diameter
Groove Depth :	
Bull wheel	Same as groove radius
Sheave	Minimum 1.25 times the conductor diameter
Groove flare:	
minimum	15° from vertical
maximum	30° from vertical

Conductors shall be clamped in, vibration dampers and spacers shall be erected, as soon as practicable but in any case within 48 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 the 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 75 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 field work commencing.

12.8 Erection of optical fibre (OPGW) earthwires

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 and ACSR earthwires shall apply also for OPGW earthwires.

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 earthwire 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 earthwire terminated with connectors carried out in both directions at 1310/1550 nm.

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

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

Optical attenuation of the OPGW earthwire 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 field work commencing.

12.9 Work at end of the line

As specified in Clause 2.4 the slack span connections of conductors and earthwires from the terminal towers to the substation gantry structures are included in the scope of this Contract.

The slack spans will comprise line conductors and earthwires of the same size and type as used on the associated transmission lines, and will be at reduced tensions, with insulator sets of the low duty tension type, as required.

The overhead earthwire system will be connected to the earthwire peaks of substation structures. OPGW, however, will be terminated in the junction boxes to be mounted on the substation gantry structure.

12.10 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.

   Bituminous 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 conductor and earthwire fittings are erected in accordance with the drawings and are complete. The line conductors and the earthwire are correctly clamped.

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

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

2. **Along the transmission line**. The conductors and the earthwire are clean, without strand damage and free of mud, foliage, loose wires, etc. The sags of all conductors and of the earthwire 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.

13. TESTS

13.1 General

The following tests shall be carried out in order to determine whether the materials and apparatus comply with the Specification.

Not less than three 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. Three copies of the records of all tests shall be furnished to the Engineer.

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.

13.2 Summary of tests

The following tests shall be carried out in accordance with the details as specified in the following sections.

13.2.1 Tests to be carried out at the manufacturer's works (unless otherwise specified or approved):

1. Line conductors and earthwires - routine and sample tests.

2. OPGW earthwires - type, routine and 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.

13.2.2 Tests to be carried out on the Site:

1. Tests on cement and concrete - type and sample tests.

2. Tests on foundations - type tests.

3. Tower footing resistances - routine tests.

4. OPGW earthwires - routine tests.

5. Tests on conductor joints and clamps - routine tests.

6. Line insulation and conductivity - routine tests.

7. Such tests as are required by the Engineer to prove compliance with the Specification independently of any tests which may have already been carried out at the Manufacturer's Works, or elsewhere.

13.3 Line conductors and earthwires

13.3.1 Applicable codes and standards

IEC: International Electrotechnical Commission:

- IEC 61089 -Round wire concentric lay overhead electrical stranded conductors
- IEC 60889 - Hand drawn aluminium wire for overhead line conductors
- BS EN 50326 - Characteristics of grease for bare overhead line conductors
- BS EN 50189 - Conductors for overhead lines – zinc coated steel wires

BSI: British Standards Institution:

- BS 183 – Galvanized steel wire strand

13.3.2 Type tests

Conductor grease. 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 Schedule D and to confirm the absence of corrosive substances.

13.3.3 Routine tests

Samples of individual wires from each length of line conductor or earthwire before stranding and also a sample from each length of finished line conductor or earthwire shall be taken at the option of the Engineer 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.

13.3.4 Sample tests

Sample tests shall be carried out on the complete conductor to prove compliance with the details in Schedule D.

13.4 OPGW earthwires

13.4.1 Applicable codes and standards

IEC: International Electrotechnical Commission:

- IEC 61089 - Round wire concentric lay overhead electrical stranded conductors
- IEC 60889 - Hand drawn aluminium wire for overhead line conductors
- IEC 61232 – Aluminium-clad steel wires for electrical purposes
- IEC 60693 - Dimensions of optical fibres
- IEC 60793-1 - Optical fibres - Part 1. Generic Specification.
- IEC 60794-1 - Optical fibre cables - Part 1. Generic Specification.

CCITT: The International Telegraph and Telephone Consultative Committee:

- Recommendation G.651.
- Recommendation G.703.

ISO: International Organization for Standardization:

- 9223- 1992 - Corrosion of metals and alloys – corrosivity of atmospheres - classification

ANSI/EIA: American National Standards Institute/Electrical Industry Association:

- 455-37-1983 Fibre optic cable bend test, low and high temperatures
- 455-85-1984 Fibre optic cable twist test.
- 455-91-1985 Fibre optic cable twist-bend test.
- 455-14-1983 Fibre optic shock test (specified pulse).
- 455-89-1983 Jacket elongation and tensile strength for optical fibre cables.

ASTM: American Society for Testing and Materials:

- ASTM B416 Concentric lay stranded aluminium-clad steel conductors.
- ASTM B415 Hard-drawn aluminium-clad steel wire.

IEEE: Institution of Electrical and Electronic Engineers (USA):

- IEEE Std 1138 - IEEE Standard Construction of Composite Fibre Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines.

BSI: British Standards Institution:

- BS EN 187200 - Optical cables to be used along electrical power lines (OCEPL).
- BS EN 50189 - Conductors for overhead lines – zinc coated steel wires
- BS EN 50183 - Conductors for overhead lines, aluminium – magnesium – silicon alloy wires.
- BS 4803 - Radiation safety of laser products and systems.

– Part 1 - General

– Part 2 - Specification for manufacturing requirements for laser products

– Part 3 - Guidance for users.

- BS 1559 - Reels and drums for bare wire.

CEPT: Conference Europeene des Administrations des postes et des telecommunications:

- The latest edition or revision of these Standards shall apply.

13.4.2 Type tests

Tests on complete composite fibre optic earthwire shall be carried out in general accordance with the methods outlined hereafter. Any deviation from these methods or any alternative methods proposed must have prior approval from the Engineer.

13.4.2.1 Repetitive tensile test

A specimen length of 10 m shall be used and the gauge length shall be 5 m.

The initial tensile loading shall be 8 per cent and the following loading schedule shall be applied:

- Initial - 30 per cent Ultimate Tensile Strength (UTS) (0.5 hour hold)
- Initial - 50 per cent UTS (1 hour hold)
- Initial - 70 per cent UTS (1 hour hold)
- Initial - 95 per cent UTS (0.5 hour hold).

This cycle should be repeated five times with the specimen being held at 95 per cent UTS for 3 hours on the last cycle.

During this test the optic fibre shall be spliced in series and the optical attenuation measured throughout the test using a laser LED or power source and meter or an optical time domain reflectometer. The optic fibre should be restrained at each end of the test specimen. The attenuation shall not exceed the values given in the Technical Schedules.

13.4.2.2 Ultimate tensile strength test

Following completion of the fifth cycle of 13.4.2.1 above the specimen loading shall be increased up to breakage or up to the specified ultimate tensile strength of the composite earthwire.

Breaking shall not occur below the specified UTS. Attenuation shall be monitored and evaluated as in 13.4.2.1 above.

13.4.2.3 Creep test

Creep tests shall be performed using a constant tensioner at 30°C for both 20 per cent and 40 per cent UTS for a period of 1000 hours. During these tests the attenuation shall be monitored as in 13.4.2.1 above. The creep shall be equivalent to that for a concentric lay stranded overhead earthwire.

13.4.2.4 Vibration proof characteristics

These tests should be carried out using strain and suspension fittings designed for use with the composite optic fibre earthwire.

About 40 m of the conductor should be tensioned to 20 per cent UTS using the designed assemblies. The vertical disposition of the units should be such as to reproduce the angles at the centre fitting corresponding to a typical span length. The specimen should be vibrated at between 30 Hz to 40 Hz for 1000 hours with an amplitude to give 300 microstrain peak to peak at 89 mm from the mouth of the suspension clamp. Attenuation should be measured during and on completion of the test as per 13.4.2.1 above and levels should not exceed those specified. The aluminium clad steel strands or the aluminium tube or other components should not have failed in fatigue.

13.4.2.5 Short-circuit current test

This test should be carried out at a UTS of 20 per cent on a sample of approximately 100 m length.

The specimen shall be subjected to the current required to raise the temperature of the composite optic fibre earthwire up to the intermittent short-term rated temperature. The sag shall be measured.

During the test the optic fibres shall be spliced in series and the optical attenuation measured. The attenuations shall not exceed the values referred to in 13.4.2.1 above.

13.4.2.6 Optical fibre cable

Type tests shall be carried out on optical fibre and accessories in accordance with the appropriate clauses of IEC 60793-1, IEC 60794-1 and ANSI/EIA Standards specified above. The samples shall be taken from the outer ends of 10 per cent of the drums in any of one consignment.

13.4.3 Routine and sample tests

All tests on aluminium clad steel strands shall be carried out in accordance with the requirements of IEC 61232 and aluminium alloy strands shall comply with the requirements of BS EN 50183 and this Specification.

Routine and sample tests shall be carried out on optical fibre and accessories in accordance with the appropriate clauses of IEC 60793-1, IEC 60094-1 and ANSI/EIA Standards specified above. The samples shall be taken from the outer ends of 10 per cent of the drums in any of one consignment.

The tests proposed shall be to the approval of the Engineer and shall be sufficient to demonstrate compliance with this Specification.

13.4.4 General

The supplier shall forward to the Engineer copies of certificates proving that all the required tests have been carried out and that the materials and construction comply with the specified requirements. No delivery of cable or accessories shall be made prior to the approval by the Engineer of the test certificates.

13.5 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.

13.5.1 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.

13.5.1.1 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 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.

13.5.1.2 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 Clause 13.6 "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.

13.5.2 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.

13.6 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:

a. IEC 60383-1, IEC 60383-2 - Insulators for overhead lines with a nominal voltage above 1000 V,

b. IEC 60437 - Radio interference test on high-voltage insulators,

c. IEC 60797 - Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric,

d. BS 5049:Part 2 - Radio interference characteristics of overhead power lines and high voltage equipment – methods of measurement and procedure for determining limits,

e. IEC 61109 - Composite insulators for ac overhead lines with a nominal voltage greater than 1000 V - Definitions, test methods and acceptance criteria,

f. IEC 61466 - Composite string insulator units for overhead lines with a nominal voltage greater than 1000 V,

g. IEEE 987 - Guide to the application of composite insulators,

h. IEC 61284 - Overhead lines – Requirements and tests for fittings,

i. IEC 61854 - Overhead lines - Requirements and tests for spacers,

j. IEC 61897 - Overhead lines - Requirements and tests for Stockbridge type aeolian vibration dampers,

k. CIGRE Report – Guide to fittings for optical cables on transmission lines, Part 2A – testing procedures OPGW fittings and OPPC fittings, ELECTRA No.188 February 2000,

together with the following additions.

13.6.1 Insulator units

13.6.1.1 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.

13.6.1.2 Routine tests of insulator units

Routine tests shall be carried out in accordance with IEC 60383-1.

13.6.1.3 Sample tests of insulator units

Sample tests shall be carried out in accordance with IEC 60383-1.

When a batch of insulator units bearing a certain identification mark has been rejected after test, no further units bearing this mark shall be submitted and the Contractor shall satisfy the Engineer that adequate steps will be taken to mark or segregate the insulators constituting the rejected batch in such a way that there is no possibility of these insulators subsequently being resubmitted for test or supplied for use.

13.6.2 Insulator sets

13.6.2.1 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.

13.6.3 Corona type tests

13.6.3.1 Arrangement of equipment for corona and radio interference type tests

Corona and radio interference type tests shall be made on each complete suspension, tension, light duty tension (upright and reversed) and jumper insulator sets (if these are to be employed) and conductor mechanical protective devices. For the tests the insulator sets and conductor mechanical protective devices shall be mounted in a manner representing the service condition as closely as possible.

Suspension sets and jumper sets shall be suspended vertically from an earthed metal crossarm of the same dimensions as the crossarm of the tower in service. The conductor arrangement to be used in service shall be attached to the line end of the set. The conductor overall length shall be at least 2.0 times that of the insulator set under test and may be simulated by means of smooth metal tube of approximately the same diameter as the phase conductors.

Tension sets shall be tested in a horizontal position supported by conductors compressed into dead-ends. The load in the conductors shall be at least equivalent to 4.5 kN per insulator string and the conductors shall be at least 1.5 times the length of the insulator set. A metal crossarm to the same dimensions as those of the tower in service shall be attached to the earth end of the set. Jumper conductors compressed into the jumper dead-ends shall be attached to the sets.

The conductor mechanical protective devices may be fitted to the conductors of insulator sets undergoing type tests to enable corona and radio interference tests to be carried out simultaneously on the conductor protective devices and on the insulator sets.

The free ends of the conductors of suspension and tension sets shall be terminated with stress reducing shields. No other object shall be nearer to the sets under test than 1.5 times the length of the insulator sets. The insulator sets shall be arranged so that the electrostatic field of the test transformer has negligible effect on the insulator sets tested.

If it is necessary, it will be acceptable to make radio noise measurements on tension sets fixed vertically but the crossarm and any other steelwork must be fixed in the correct service position relative to the set under test.

The insulator units forming the insulator strings shall have already passed the routine tests.

13.6.3.2 Corona tests

The corona test shall be conducted in complete darkness, allowing 10 minutes for the observer's eyes to become accustomed to the darkened conditions before the tests are commenced. A voltage at least 20 per cent in excess of the corona test voltage stated in Schedule D shall be applied to the insulator sets and maintained at this voltage for 5 minutes. The voltage shall then be slowly reduced and the extinction voltage level of any corona which may have formed shall be noted. The observations for corona shall be made with binoculars of minimum objective 50 mm, no corona shall be visible on the set under test at the voltage stated in Schedule D.

If the altitude of the test station differs from sea level, an agreed allowance shall be applied to the test voltage. The atmospheric conditions prevailing during the test shall be recorded on the test sheet.

13.6.4 Radio interference tests

13.6.4.1 Arrangement of equipment for radio interference measurements

The radio noise measurement shall be made at a frequency of 1.0 MHz ±10 per cent, using a measuring set conforming to BS 5049 Part 2.

The background noise level indicated by the measuring circuit at the specified test voltage shall be at least 6 dB less than the specified single unit and insulator set radio noise levels.

The relative humidity of the atmosphere of the laboratory or test room shall be within the range 50 to 80 per cent when RI tests are made and the barometric pressure and wet and dry bulb thermometer readings shall be entered on the test record.

The rf filter impedance shall be greater than 20 000 ohms at the test frequency and shall be tuned to this frequency, in situ, by using a signal generator.

All readings shall be expressed in dB above 1 microvolt measured across the effective resistance of 300 ohms. By agreement with the Engineer, other values of resistance will be permitted and the specified noise levels adjusted accordingly.

13.6.4.2 Type test on single insulator units and complete insulator sets, including the distribution of insulator set potential

A sample equal to the number of units in each complete insulator set shall be selected and tested singly in a screened room using a measuring circuit as shown in IEC 60437 and BS 5049 Part 2. Measurements of RI voltage shall be made on each unit at the voltage levels specified in Schedule D.

The Engineer shall then select one pair of units (per insulator string) from those tested in the above manner for placing at the line-end and adjacent line-end positions of the complete insulator sets. These units shall be selected from those having the highest RI voltages from the single unit tests carried out initially.

Each complete insulator set mounted as described previously shall then be radio noise tested in accordance with IEC 60437 and BS 5049 Part 2. The test voltage applied to the set shall be raised to a level in excess, but not exceeding 1.5 times the voltage specified in Schedule D. This voltage may be maintained for 2 minutes to allow the insulation to become conditioned. The voltage shall then be reduced in suitable steps until the instrument threshold or the background interference level is reached. The RI voltage shall be measured and recorded at each decrement.

The RI performance of the complete insulator sets are satisfactory if at the RI test voltage stated in Schedule D the RI voltage does not exceed the noise level specified in Schedule D.

The attenuation factors of each complete insulator set shall next be measured using the method described in BS 5049 Part 2 or a suitable alternative method approved by the Engineer.

Following the RI tests the potential distribution of each insulator set shall be measured by means of a calibrated sphere gap, of minimum self capacitance, fitted in turn across each of the five line-end insulator units. The potential developed across the most highly stressed of these units is then identified and expressed as a percentage, K, of the total applied voltage across the set.

13.6.4.3 Sample test for radio interference

Samples of each batch of single units offered shall be tested for radio noise prior to tests in accordance with IEC 60383-1. A sample of 0.5 per cent of the batch shall be tested as described above on single unit RI type tests except that the test voltage shall be equal to K per cent of the respective specified RI insulator set test voltage.

The maximum permissible RI voltage shall be equal to that given in Schedule D for the complete insulator sets plus that level attributable to the attenuation of the complete string.

If more than 3 units per 100 fail to pass the sample test, a further sample equal to 1 per cent of the number in the batch shall be tested. If no more than 3 units per 100 fail the test, the whole batch shall be accepted. No batch offered shall contain less than 2000 units unless otherwise approved by the Engineer.

13.6.5 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 requirement of 50% of the specified minimum failing load to IEC 61284 “Overhead lines – Requirements and tests for fittings”.

13.6.6 Fault current tests on spacer dampers and 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 which will be supported under the 'everyday' still air tension given in Schedule D. 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.

13.6.7 Mechanical tests on spacer dampers and spacers

Each type of spacer damper shall show no evidence of mechanical damage or permanent deformation of any of its component parts when subjected to the following static loading test; test loads shall be applied to mandrels of the proper diameter clamped in the spacer damper clamps as would be normal when fitted on the conductor. The mandrels shall not slip in the testing machine. The test loads of 1600 N, each applied simultaneously in opposing direction towards the centre of the spacer damper, shall be applied from 0 to 1600 N in 5 seconds and held for 2 minutes. The loads

shall be released and the spacer damper examined for signs of permanent deformation or mechanical damage.

A second unit shall be tested in a similar manner except that when the load has been held at 1600 N for 2 minutes, the load shall then be increased at a rate of 4450 N per minute until failure occurs. The nature of the failure shall be descriptively recorded.

The above tests shall be carried out for each production lot. The samples to be chosen shall be tested at random. The number of samples to be tested per production lot shall be determined by recognised industry standards and shall have been approved by the Engineer prior to the start of manufacture and recorded in the report of the tests.

To supplement the claimed performance of spacers, the engineer may require certain mechanical and fatigue tests to be carried out to substantiate the claimed service performance data.

13.7 Towers and metal fittings for towers

13.7.1 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.

13.7.2 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.

13.7.3 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 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 tangent 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 Schedules.

13.8 Zinc coatings

13.8.1 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.

13.9 Tests on cement and concrete

13.9.1 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 4027 or ASTM C-150 Type V 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. Where required by the Engineer test results to confirm both the cement content and the dry density of the concrete shall be presented.

13.9.2 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.

13.10 Tests on foundations

13.10.1 Type tests

Uplift and compression tests to ultimate design loadings or to destruction shall be carried out on each class and each type of standard foundation given in the Schedules, including rock foundations, to ensure that the design parameters of the foundations are suitable for the range of ground design conditions. Tests shall be carried out to IEC 61773. The results of each foundation test are to be correlated to soil properties at the same location to establish a routine soil test procedure for determining the foundation class for each tower site on the line route. The soil properties at each test site shall be determined primarily by 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 the cohesion and/or internal friction of disturbed backfill soil with surrounding undisturbed soil.

The location for each test and choice of foundation to be subjected to test shall be to the Engineer's approval. Details of the proposed type testing equipment and a programme and procedure for testing shall be submitted in advance to the Engineer for approval and each shall be in accordance with modern foundation engineering practice. Each foundation shall be subjected to such test loads as the Engineer may specify in order to prove compliance with the ultimate loading conditions stated in the Schedules. The maximum dimensions for settlement and uplift shall be consistent with the type of structure to be supported and comply with the maximum differential movement under simultaneous ultimate loadings given in Schedule D.

One satisfactory test for each class and type of foundation in all representative ground classifications shall be included in the Contract Price. Any further tests requested by the Engineer for which the results are approved will be paid for at the rates stated in the Schedules.

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

13.11 Tower footing resistances

13.11.1 Routine tests

The resistance to earth of each tower shall be measured and recorded in an approved manner. Following the installation of a grounding system to any tower the new resistance to earth of the tower shall be measured, all prior to the erection of the earthwires.

13.12 OPGW earthwire

13.12.1 Routine tests at site

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 wave lengths given in Schedule D.

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.

13.13 Tests on conductor joints and clamps

13.13.1 Routine tests at site

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 earthwires shall not commence until the instruments are on site and ready for use.

13.14 Line insulation and conductivity

13.14.1 Routine tests

Tests shall be made on all lines after erection to establish continuity and absence of accidental earth connections.

MINISTRY OF ELECTRICITY

IRAQ SUPERGRID PROJECTS 132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

PLATE DRAWINGS FOR VOLUME 1

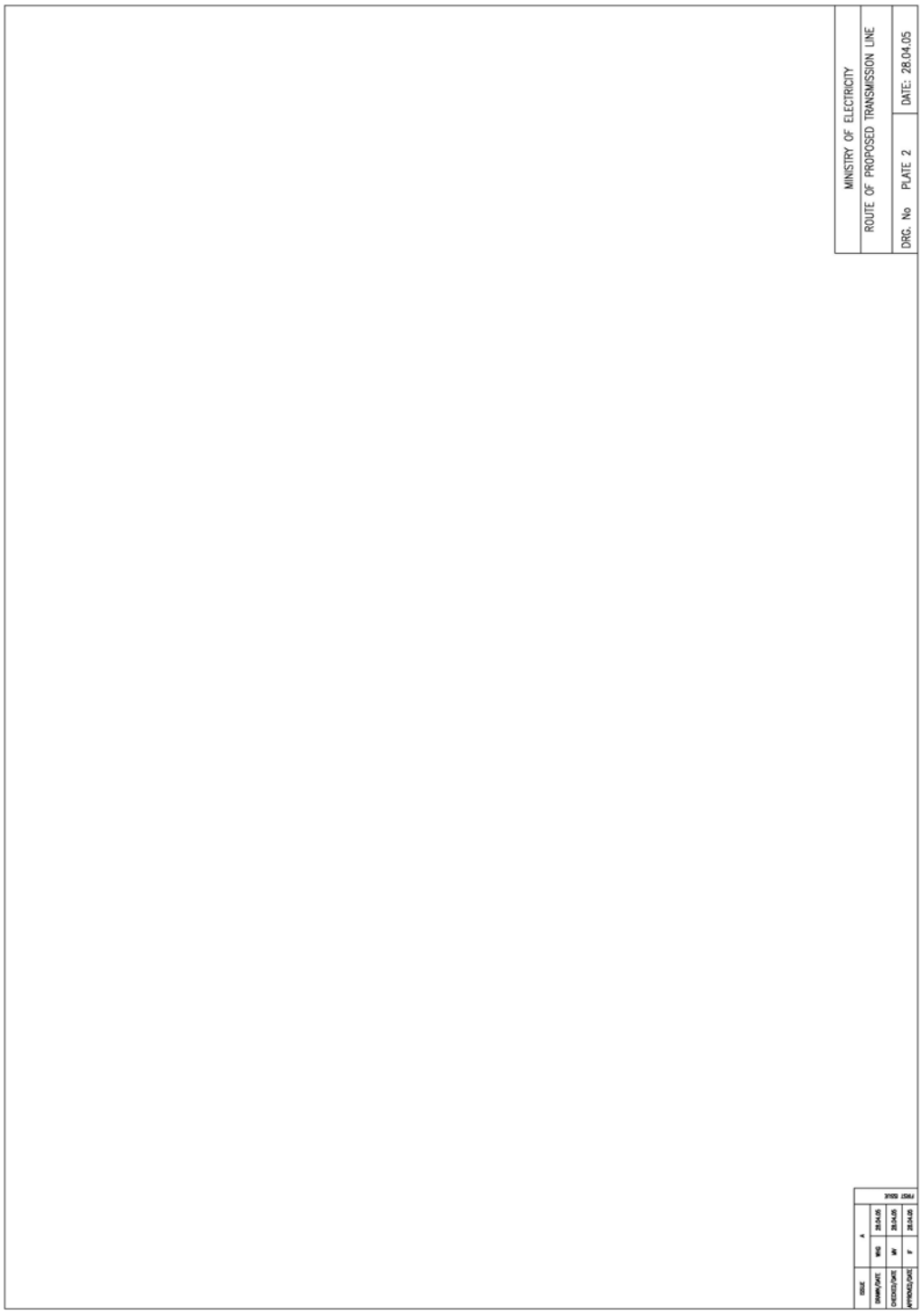
OCTOBER 2006

LIST OF REVISIONS

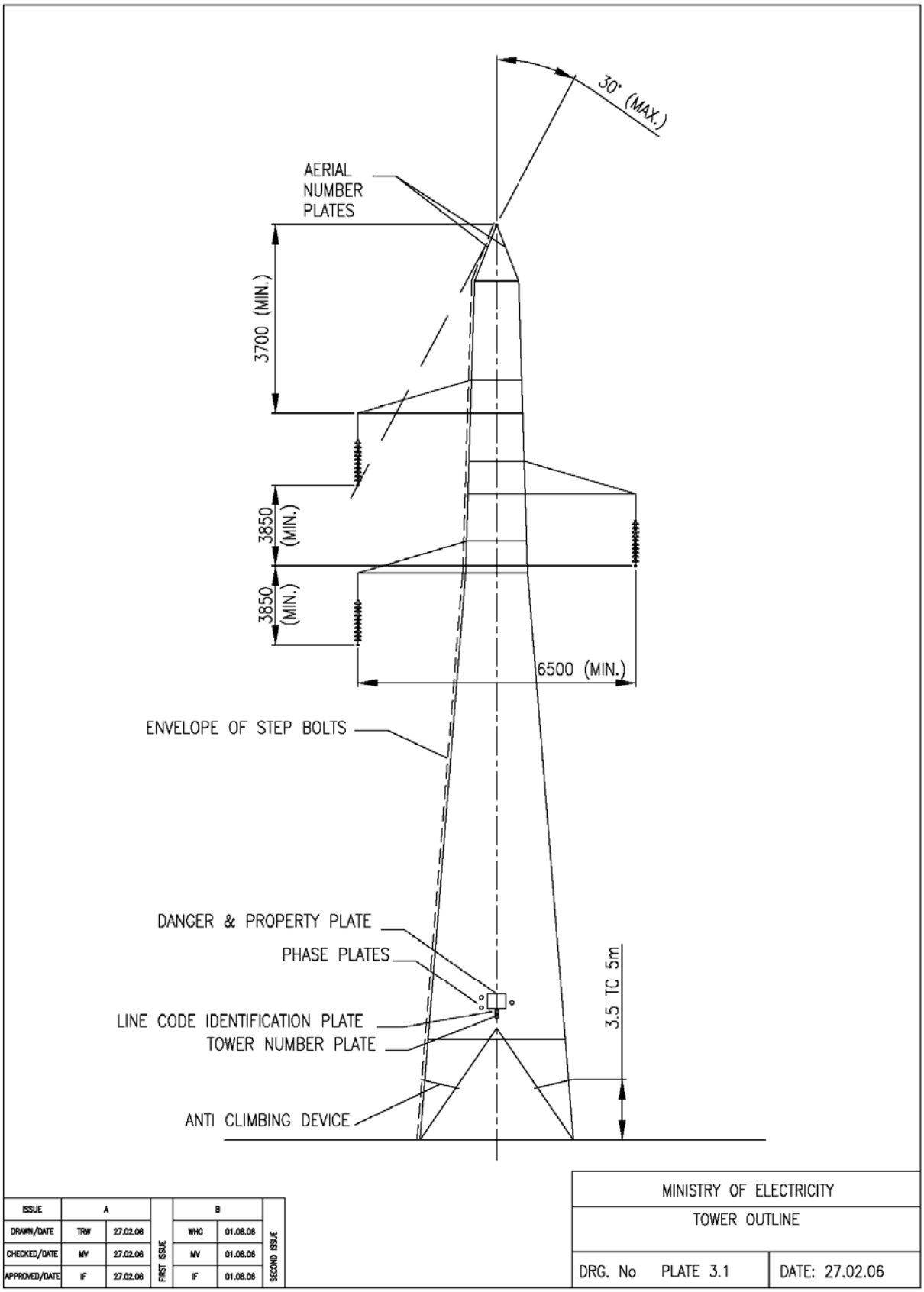
Current Rev.	Date	Page affected	Prepared by	Checked by (technical)	Checked by (quality assurance)	Approved by
D	October 06	All	MJ VANNER	RI FAIR	S CHARLTON	J WICHALL
Original	May 05		REVISION DETAILS Issued as Document No 2005/TD341			
A	July 2006		Not issued			
B	Mar 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 11/12 Nov 05.Issued as Document No. 2005/TD341B			
C	July 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06. Issued as Document No. 2005/TD341C			
D	October 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06 with additional correction of typographical errors and with changes to match the wording of the 400 kV Specification Issued as Document No. 2005/TD341D.			

ISSUE	A		
DRAWN/DATE	RHS	15.03.05	
CHECKED/DATE	MV	15.03.05	
APPROVED/DATE	IF	15.03.05	

MINISTRY OF ELECTRICITY	
LOCATION MAP	
DRG. No PLATE 1	DATE: 15.03.05



Note: Route plan to be added by Ministry of Electricity

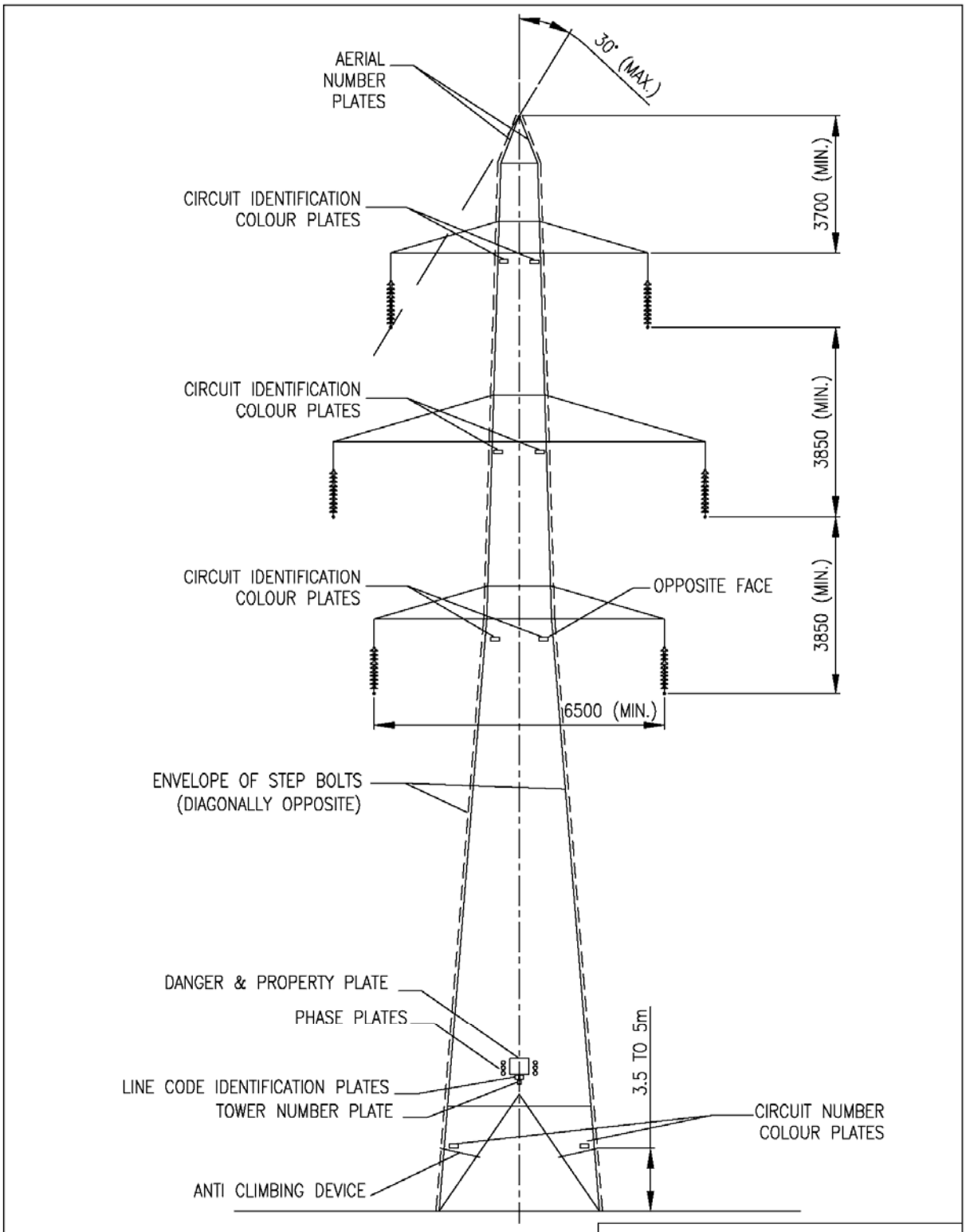


ISSUE	A		FIRST ISSUE	B		SECOND ISSUE
DRAWN/DATE	TRW	27.02.06		WHG	01.08.06	
CHECKED/DATE	MV	27.02.06		MV	01.08.06	
APPROVED/DATE	IF	27.02.06		IF	01.08.06	

MINISTRY OF ELECTRICITY

TOWER OUTLINE

DRG. No PLATE 3.1 | DATE: 27.02.06

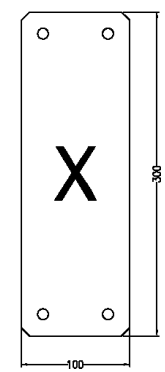


ISSUE	A		FIRST ISSUE	B		SECOND ISSUE
DRAWN/DATE	TRW	27.02.06		WHG	01.08.06	
CHECKED/DATE	MV	27.02.06		MV	01.08.06	
APPROVED/DATE	IF	27.02.06		IF	01.08.06	

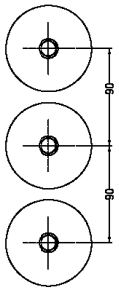
MINISTRY OF ELECTRICITY

TOWER OUTLINE

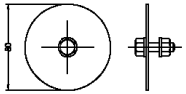
DRG. No PLATE 3.2 | DATE: 27.02.06



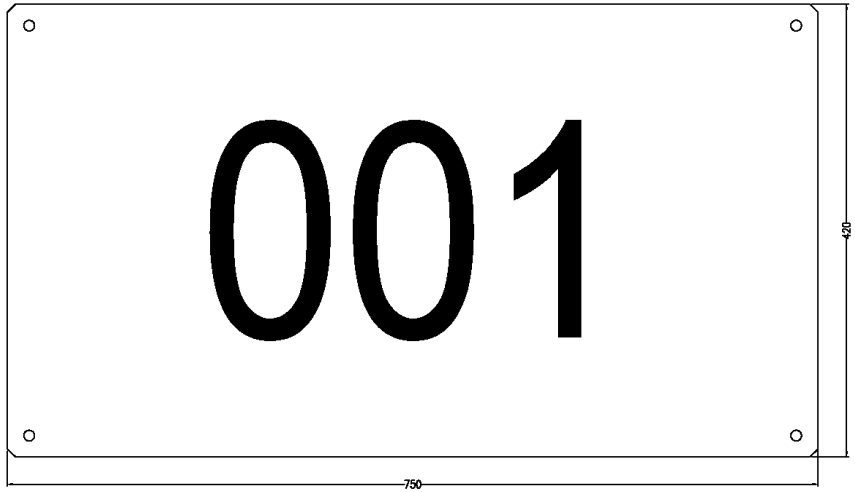
CIRCUIT IDENTIFICATION COLOUR PLATE
DETAILS AS NOTE 8



TYPICAL PHASING PLATE ARRANGEMENT



PHASE COLOUR PLATE
DETAILS AS NOTE 7



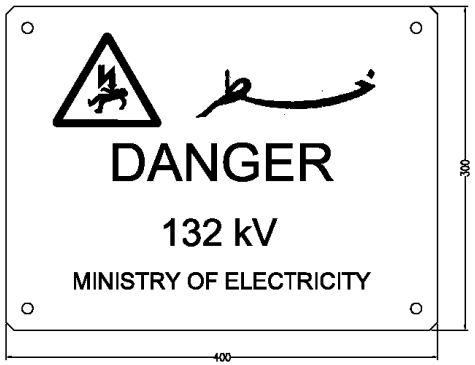
AERIAL NUMBER PLATE
DETAILS AS NOTE 4

NOTES:

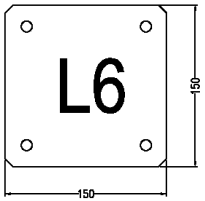
1. ALL PLATES TO BE 1.6mm MILD STEEL PLATE.
2. DANGER & PROPERTY PLATE TO HAVE WHITE LETTERS ON RED BACKGROUND.
3. NUMBER & ROUTE CODE IDENTIFICATION PLATES TO HAVE BLACK LETTERS ON WHITE BACKGROUND.
4. AERIAL NUMBER PLATE TO HAVE BLACK NUMBERS ON YELLOW BACKGROUND.
5. FINISH TO BE VITREOUS ENAMEL.
6. FIXING BOLTS TO HAVE FIBRE WASHERS BACK AND FRONT.
7. PHASE PLATES TO BE COLOURED RED, YELLOW AND BLUE
8. CIRCUIT 1 BLACK WRITING ON GREEN BACKGROUND
   CIRCUIT 2 BLACK WRITING ON BROWN BACKGROUND

DRAWING REFERENCE:

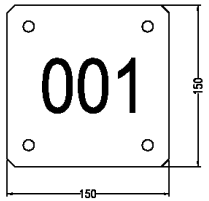
PLATE 3 – TOWER OUTLINE



DANGER & PROPERTY PLATE
DETAILS AS NOTE 2



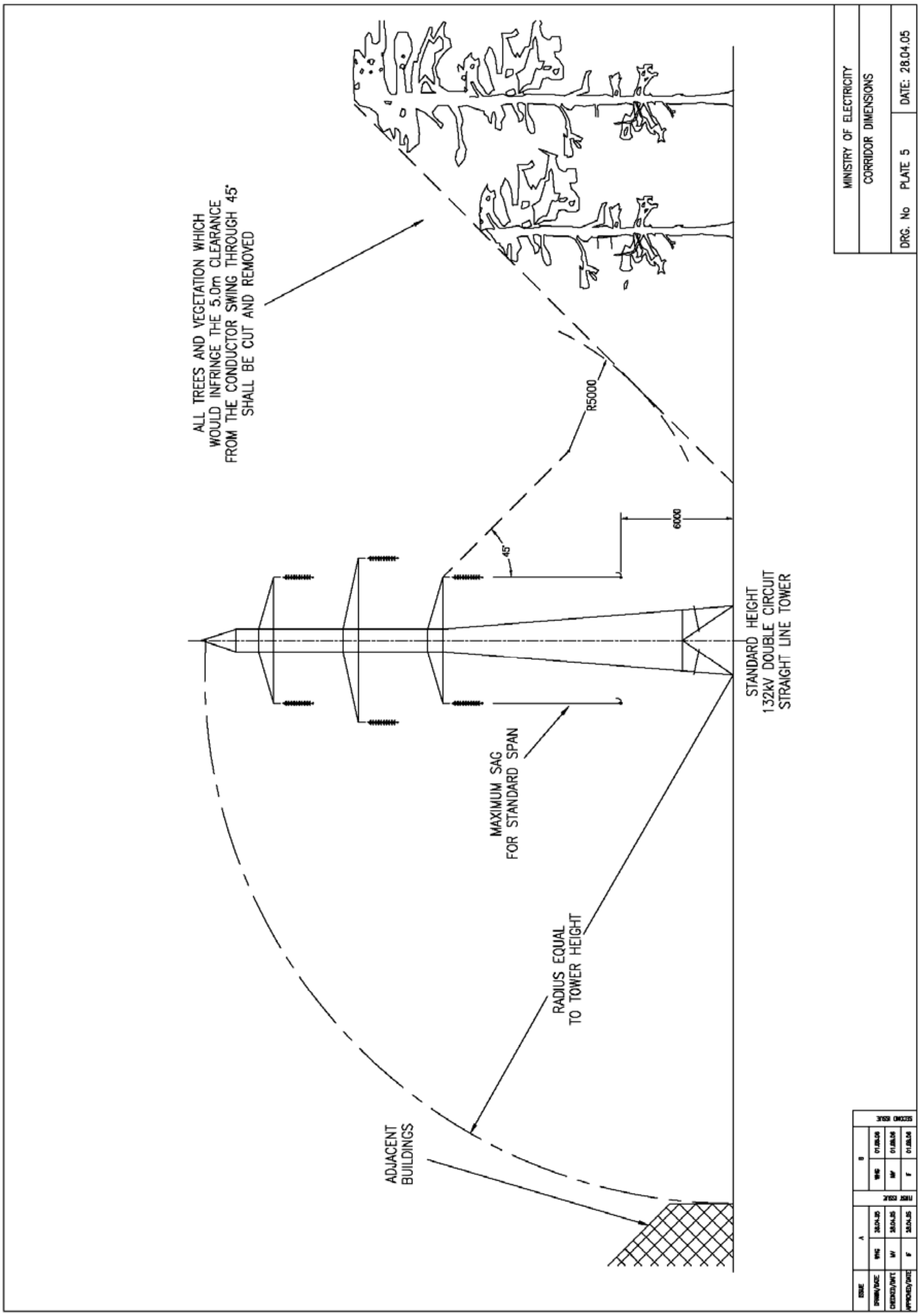
LINE CODE IDENTIFICATION PLATE
DETAILS AS NOTE 3



TOWER NUMBER PLATE
DETAILS AS NOTE 3

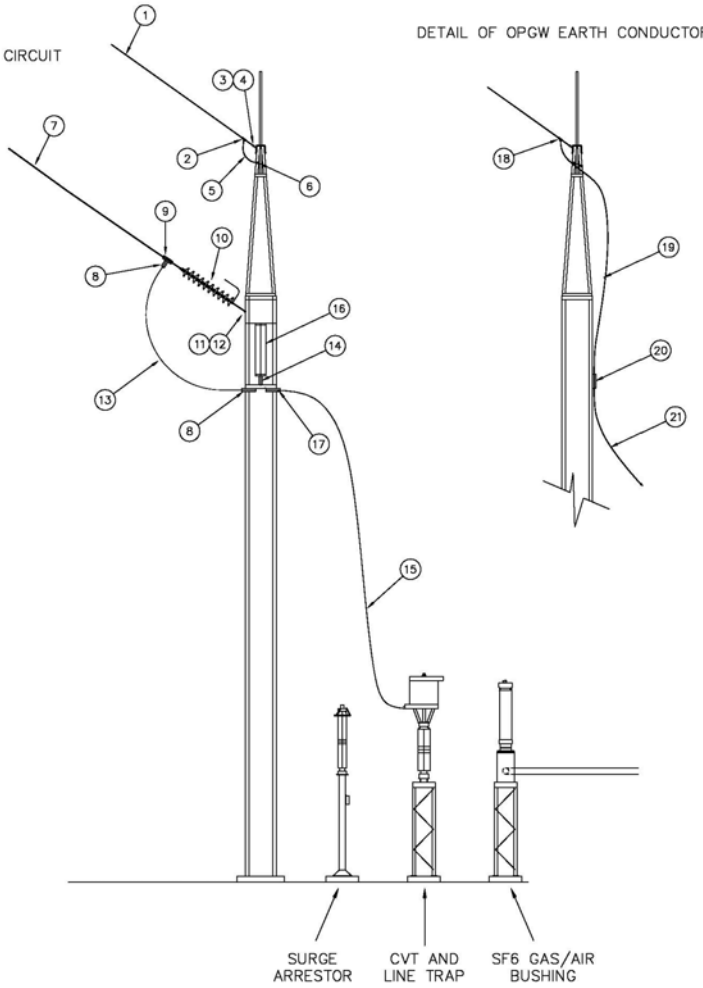
ISSUE	A		FIRST ISSUE	B		SECOND ISSUE
DRAWN/DATE	WHC	28.04.05		WHC	01.08.06	
CHECKED/DATE	MV	28.04.05		MV	01.08.06	
APPROVED/DATE	IF	28.04.05		IF	01.08.06	

MINISTRY OF ELECTRICITY	
TOWER NOTICE PLATES	
DRG. No PLATE 4	DATE: 28.04.05


ALL TREES AND VEGETATION WHICH
WOULD INFRINGE THE 5.0m CLEARANCE
FROM THE CONDUCTOR SWING THROUGH 45°
SHALL BE CUT AND REMOVED
R5000
6000
45°
STANDARD HEIGHT
132kV DOUBLE CIRCUIT
STRAIGHT LINE TOWER
MAXIMUM SAG
FOR STANDARD SPAN
RADIUS EQUAL
TO TOWER HEIGHT
ADJACENT
BUILDINGS
MINISTRY OF ELECTRICITY
CORRIDOR DIMENSIONS
DRG. No PLATE 5
DATE: 28.04.05

OVERHEAD LINE CIRCUIT

DETAIL OF OPGW EARTH CONDUCTOR



ITEM	DESCRIPTION	ITEM REF. No. OR DIMENSIONS	SUPPLY AND ERECT UNDER THIS CONTRACT	SUPPLY UNDER THIS CONTRACT ERECT BY OTHERS	SUPPLY AND ERECT BY OTHERS
1.	EARTH CONDUCTOR		✓		
2.	COMPRESSION DEADEND FOR ACSR		✓		
3.	'D' SHACKLE (VERTICAL PIN)		✓		
4.	EARTH CONDUCTOR LANDING PLATE				✓
5.	EARTH CONDUCTOR TAIL		✓		
6.	CLAMP FOR EARTH CONDUCTOR TAIL		✓		
7.	INCOMING LINE CONDUCTOR		✓		
8.	LUG CONNECTOR		✓		
9.	COMPRESSION DEADEND ASSEMBLY		✓		
10.	TENSION INSULATOR SET		✓		
11.	'D' SHACKLE (VERTICAL PIN)		✓		
12.	LINE CONDUCTOR LANDING PLATE				✓
13.	DOWN DROPPER CONDUCTOR		✓		
14.	POST INSULATOR FLAG				✓
15.	DROPPER CONDUCTOR			✓	
16.	UNDERHUNG POST INSULATOR				✓
17.	LUG CONNECTOR			✓	
18.	PREFORMED HELICAL DEADEND FOR OPGW		✓		
19.	OPGW		✓		
20.	OPGW TERMINATION JOINT BOX		✓		
21.	FIBRE OPTIC CABLE				✓

ISSUE	A		
DRAWN/DATE	WHG	28.04.05	FIRST ISSUE
CHECKED/DATE	MV	28.04.05	
APPROVED/DATE	IF	28.04.05	

MINISTRY OF ELECTRICITY

SUBDIVISION OF WORK AT SUBSTATIONS

DRG. No PLATE 6 | DATE: 28/04/05

MINISTRY OF ELECTRICITY

IRAQ SUPERGRID PROJECTS 132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

VOLUME 2
TECHNICAL SCHEDULES

OCTOBER 2006

LIST OF REVISIONS

Current Rev.	Date	Page affected	Prepared by	Checked by (technical)	Checked by (quality assurance)	Approved by
D	October 06	All	MJ VANNER	RI FAIR	S CHARLTON	J WICHALL
Original	May 05		REVISION DETAILS Issued as Document No 2005/TD341			
A	July 2006		Not issued			
B	Mar 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 11/12 Nov 05.Issued as Document No. 2005/TD341B			
C	July 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06. Issued as Document No. 2005/TD341C			
D	October 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06 with additional correction of typographical errors and with changes to match the wording of the 132 kV Specification Issued as Document No. 2005/TD341D.			

CONTENTS SHEET

CONTENTS

VOLUME 1

TECHNICAL SPECIFICATION

VOLUME 2

TECHNICAL SCHEDULES

VOLUME 3

PRICES AND ESTIMATED QUANTITIES

_____

VOLUME 2

TECHNICAL SCHEDULES

132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

SCHEDULE A
GENERAL DESCRIPTION OF WORK

Section for purposes of payment and taking over	Line conductors	Earthwires	Type of construction	Estimated route length in kilometres
	Twin ACSR Teal	1 x ACSR Dorking or 1 x OPGW	Single circuit, lattice steel	
	Twin ACSR Teal	1 x ACSR Dorking or 1 x OPGW	Double circuit, lattice steel	

SCHEDULE B
DATES FOR MANUFACTURE, INSPECTION, COMPLETION AND TESTING

The Schedule to be completed by the Tenderer and the times entered are to be binding on the Contractor and signed by him. All periods are to be in weeks and shall show the commencement and completion for each item. The Contractor shall refer to the construction programme noting key dates and periods.

Commencement Date:

Completion Date:

Total period of Contract:

Description	Weeks	
	Start	Complete
Survey and profiling		
Tangent tower and foundation design Tangent tower tests Tension tower and foundation design Tension tower tests Insulator sets, type tests Foundation steelwork, manufacture and inspection Towers, manufacture and inspection Line conductor, manufacture and inspection Earthwire, manufacture and inspection OPGW conductor, manufacture and inspection Grounding materials, manufacture and inspection Insulator units, manufacture and inspection Insulator fittings and conductor fittings, manufacture and inspection		
Shipment of tower and foundation steelwork Shipment of line conductors Shipment of ACSR earthwire Shipment of OPGW earthwire Shipment of insulators, fittings and grounding material		
Route clearing Foundation construction Tower erection Conductor stringing Final inspection Line constructed ready for testing		

SCHEDULE C
MANUFACTURERS AND PLACES OF MANUFACTURE, TESTING AND INSPECTION

Item	Manufacturer	Place of manufacture	Place of testing and inspection
Line conductors (ACSR):			
a. Aluminium billets			
b. Drawing aluminium wires			
c. Steel billets			
d. Drawing steel wires			
e. Stranding complete conductor			
Earthwires (ACSR):			
a. Aluminium billets			
b. Drawing aluminium wires			
c. Steel billets			
d. Drawing steel wires			
e. Stranding complete conductor			
Earthwires (OPGW)			
a. Steel billets			
b. Drawing steel wires			
c. Aluminium billets			
d. Drawing aluminium wires			
e. Fibre optic wire			
f. Stranding complete conductors			
Insulator units			
HV testing laboratory	-	-	
Insulator set fittings			
Earthwire (ACSR) fittings			
Earthwire (OPGW) fittings			
Conductor joints			
Conductor spacers/spacer dampers			
Vibration dampers			

Item	Manufacturer	Place of manufacture	Place of testing and inspection
Steel towers: a. Design b. Steel billets, etc c. Steel sections d. Fabrication e. Galvanizing f. Check assembly g. Tower tests Aircraft warning markers Bolts and nuts Tower fixtures and fittings Grounding materials Engineer's Transport			

SCHEDULE D
GENERAL PARTICULARS AND GUARANTEES

SCHEDULE D1 - MINIMUM FACTORS OF SAFETY TO BE APPLIED TO ASSUMED SIMULTANEOUS WORKING LOADINGS	
Line conductors and earthwires, based on ultimate strength:	
Final tension with maximum design working wind pressures at 0 deg C	2.50
Final tension with 0.4 x maximum design working wind pressures on 10mm radial ice at –5 deg C	2.25
Final tension in still air at everyday temperature of 25 deg C	5.00
Final tension in still air at minimum temperature of –15 deg C	2.74
Initial erection tension in still air at temperature of –10 deg C	2.92
Line conductor and earthwire compression fittings, based on maximum design working loads	2.38
Steel supports, foundation structures, based on elastic limit of members in tension and on crippling loads of compression members, or on tests on complete supports (but not tests on the foundations):	
All supports, based on maximum design working loads	1.50
All supports, based on maximum stringing and maintenance working loads	2.00
Foundations, based on maximum design working loads.	1.95
Foundations, based on maximum stringing and maintenance working loads.	3.00
Suspension insulators, based on maximum design or stringing and maintenance loads	2.00
Suspension insulator conductor hardware: based on maximum design or stringing and maintenance loads.	2.00
Line conductor hardware: minimum failing load to be equal to or greater than the rated M&E strength of the suspension insulator string	
Hardware for support of earthwires:	
Based on maximum design working loads	2.40
Based on maximum stringing and maintenance working loads	3.20
Tension insulators, sets and fittings, based on maximum design working loads	2.50

SCHEDULE D2 - ASSUMED WORKING LOADING CONDITIONS			
		Central and Southern Iraq	Northern Iraq
Climatic conditions:			
Minimum temperature of line conductors and earthwires	ºC	-15	-15
"Everyday" temperature	ºC	25	25
Minimum temperature assumed for location	ºC	- 15	- 15
Maximum operating temperature of line conductor	ºC	90	90
Density of ice (combined wind and ice)	kg/m^3	N/A	900
Radial ice thickness (combined wind and ice)	mm	0	10
Maximum design gust wind speed (at an elevation of 10m above ground)	m/s	40	40
Design gust wind speed (at an elevation of 10 m above ground) for combined wind and ice	m/s	-	26
(Design working wind gust pressures shall be calculated according to the formulae given in Clause 6.7.1 of Volume 1)			
Average design wind speed (at all elevations above ground)	m/s	15	15
Working design wind pressures for application during broken wire, cascade collapse, construction and maintenance loading conditions to be calculated according to the formulae given in Clause 6.7.2 of Volume 1)			
Site altitude above sea level	metres	0 - 1000	0 - 1000

*** Note:**

Central and Southern Iraq is defined as that territory south of latitude 35° N.

Northern Iraq is defined as that territory north of latitude 35° N.

SCHEDULE D3 - SPAN LENGTHS

Description		Particulars
Basic span (except for tower types 1R2 and 2R2)	m	325
Basic span (for tower types 1R2 and 2R2)	m	455
Maximum sum of adjacent spans (except for tower type 1R2 and 2R2)	m	720
Maximum sum of adjacent spans (for tower type 1R2 and 2R2)	m	1000
Maximum single span (except for tower types 1R2 and 2R2)	m	535
Maximum single span (for tower types 1R2 and 2R2)	m	750
Tower design spans:		
a. wind spans:		
- tangent towers (Types 1S2 and 2S2)	m	360
- tangent towers (Types 1R2 and 2R2)		500
- tension towers (at maximum angle of deviation)	m	360
b. maximum weight spans:		
- tangent towers	m	650
- tension towers	m	650
c. minimum weight spans:		
- tangent towers	m	0
- tension towers (uplift net)	m	- 430

SCHEDULE D4 - LINE CONDUCTOR AND FITTINGS			
Description		**Required**	**Offered**
Complete line conductor:			
Number of conductors per phase		2	
Horizontal distance between conductor centres of one phase			
a. line	mm	400	
b. jumper	mm	400	
c. slack span	mm	400	
Each single conductor:			
Code name		Teal	
International Standard		IEC 61089 EN 50182	
National Standard		ASTM B232	
Material of conductor		ACSR	
Number and diameter of wires			
a. aluminium	No/mm	30/3.61	
b. steel	No/mm	19/2.16	
Total area of conductor	mm^2	376.7	
Overall diameter of stranded conductor	mm	25.24	
Resistance of conductor (dc) at 20ºC	ohm/km	0.09426	
Mass of conductor (without grease)	kg/km	1398	
Total mass of greased conductor (greased to Case 2 of IEC 61089)	kg/km		
Ultimate rated strength of conductor	Newton	133060	
Assumed equivalent modulus of elasticity of conductor	kg/mm^2	8000	

SCHEDULE D4 - LINE CONDUCTOR AND FITTINGS (continued)

Description		Required	Offered
Assumed equivalent coefficient of linear expansion of conductor	per ºC	18×10^{-6}	
Maximum length of conductor on drum	km	2.0 – 2.5	
Individual wires before stranding:			
Aluminium			
a. tensile breaking stress	N/mm^2	165	
b. wrapping test to ISO 7802	turns	8	
Steel			
a. grade of steel to BS EN 50189		ST1A	
b. tensile breaking stress	N/mm^2	1300	
c. minimum stress of steel at 1% elongation	N/mm^2	1100	
d. minimum elongation on 250 mm gauge length at break	%	3.5	
Conductor grease:			
Type	" "	-	
Minimum drop-point temperature	ºC	120	
Mass of grease per kilometre of conductor (all inner layers greased – case 2 to IEC 61089)	kg	40	
Vibration damping system:			
Type of system (vibration damper + spacer or spacer damper):			
Vibration damper			
Type of vibration damper		Stockbridge	
National/International Standard		IEC 61897	
Number of wires in messenger cable	No	minimum 7	
Clamp for conductor diameter	mm	25.24	
Mass of damper	kg		

SCHEDULE D4 - LINE CONDUCTOR AND FITTINGS (continued)

Description		Required	Offered
Maximum span for:			
a. one vibration damper at each end of span	m		
b. two vibration dampers at each end of span	m		
c. three vibration dampers at each end of span	m		
Dimensions from clamp mouth to vibration damper attachment			
a. first damper	mm		
b. second damper when required	mm		
c. third damper when required	mm		
Spacer or spacer damper:			
Type of spacer or spacer damper			
National/International Standard		IEC 61854	
Clamp for conductor diameter	mm	25.24	
Bundle separation	mm	400	
Mass	kg		
Symmetrical / asymmetrical in-span spacing			
Maximum sub-span length	m	75	
Number of spacers for maximum span length:			
360 m span	No		
425 m span	No		
490 m span	No		
Number of spacer dampers for maximum span length			
360 m	No		
425 m	No		
490 m	No		

SCHEDULE D4 - LINE CONDUCTOR AND FITTINGS (continued)			
Description		**Required**	**Offered**
Armour rods:			
Material		Aluminium alloy	
Number of rods per set	no	11	
Diameter of rods	mm	7.62	
Lay of rods	RH/LH	RH	
End form of rods	Type	Ball ended	
Overall length of armour rod set	mm	2337	

SCHEDULE D5 - EARTHWIRE AND FITTINGS

Description		ACSR		OPGW	
		Required	Offered	Required	Offered
Complete earthwire system					
Number of earthwires		1		1	
National/International Standard No		IEC61089 ASTMB232		EN187200 IEEE1138	
Designation and material of earthwire		ACSR 'Dorking'		(To match ACSR 'Dorking' properties, both electrical and mechanical)	
Number and diameter of wires					
aluminium	No/mm	12/3.2			
aluminium clad steel	No/mm	7/3.2			
Number and diameter of wires					
aluminium-clad steel	No/mm				
aluminium/aluminium alloy	No/mm				
Total area of earthwire	mm^2	152.8			
Overall diameter of conductor	mm	16.0			
Mass of conductor (without grease)	kg/km	717			
Total mass of greased conductor (greased to Case 2 of IEC 61089)	kg/km				
Rated tensile strength of conductor (RTS)	Newton	80340			
Assumed equivalent modulus of elasticity of conductor	kg/mm^2	10702			
Assumed equivalent coefficient of linear expansion of conductor	per ºC	15.3×10^{-6}			
Minimum bending radius	mm				
Short circuit current rating for 1 sec	kA				

SCHEDULE D5 - EARTHWIRE AND FITTINGS (continued)

Description		ACSR		OPGW	
		Required	Offered	Required	Offered
Maximum length of conductor on drum	km	5 – 6		5 - 6	
Individual wires before stranding:					
Steel					
a. grade of steel to BS EN 50189 (zinc coated)		-		-	
to BS EN 61232 (aluminium-clad)		20SA		30SA	
b. tensile breaking stress	N/mm^2	1340		880	
c. minimum stress of steel at 1% elongation	N/mm^2	1200		650	
d. minimum elongation on 250 mm gauge length at break	%	1.5		1.5	
Aluminium					
a. tensile breaking stress	N/mm^2	165		-	
b. wrapping test to ISO 7802	turns	8		-	
Aluminium alloy					
a. tensile breaking stress	N/mm^2	-	-	290	
b. wrapping test to ISO 7802	turns	-	-	8	
Conductor grease:					
Type	" "	-			
Minimum drop-point temperature	^oC	120		120	
Mass of grease per kilometre of conductor (all inner layers greased – Case 2 to IEC 61089)	kg	10			

SCHEDULE D5 - EARTHWIRE AND FITTINGS (continued)

Description		ACSR		OPGW	
		Required	Offered	Required	Offered
Vibration damping system:					
Type of vibration damper		Stockbridge		Stockbridge	
National/International Standard		IEC61897		IEC61897	
Number of wires in messenger cable	No	min 7		min 19	
Clamp for conductor diameter	mm	16.0			
Mass	kg				
Maximum span for:					
a. one vibration damper at each end of span	m				
b. two vibration dampers at each end of span	m				
c. three vibration dampers at each end of span	m				
Dimensions from clamp mouth to vibration damper attachment:					
a. first damper	mm				
b. second damper when required	mm				
c. third damper when required	mm				
Armour rods:					
Number of layers per set	no	1		#	
Material of rods				#	
a. outer layer		-			
b. inner layer		Aluminium alloy			
Numbers of rods per set:				#	
a. outer layer	No	-			

SCHEDULE D5 - EARTHWIRE AND FITTINGS (continued)

Description		ACSR		OPGW	
		Required	Offered	Required	Offered
b. inner layer	No	12			
Diameter of rods:				#	
a. outer layer	mm	-			
b. inner layer	mm	4.47			
Lay of rods:				#	
a. outer layer	RH/LH	-			
b. inner layer	RH/LH	RH			
End form of rods:				#	
a. outer layer	Type	-			
b. inner layer	Type	Ball ended			
Overall length of armour rod set				#	
a. outer layer	mm	-			
b. inner layer	mm	1626			

Details to be in accordance with the recommendations of the OPGW manufacturer and the suppliers of the suspension clamps and vibration dampers for the OPGW.

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM			
Description		**Required**	**Offered**
Fibre optic data:			
Mode		Single	
Wavelength	nm	1310/1550	
Number of fibres		24	
Transmission attenuation			
at 1310 nm	dB/km	<0.4	
at 1550 nm	dB/km	<0.25	
Transmission bandwidth	MHz/km	>10,000	
Fibre identification	Colour code		
Chromatic dispersion	ps/nm.km	<3.5	
Splicing loss	dB	<0.1	
Bit error rate (BER)	max		
End to end attenuation	dB		
Availability of repeater without 1+1 protection	years		
Availability of repeater with 1+1 protection	years		
Minimum bending radius	mm		
Optical joint boxes (OPGW-OPGW)			
Manufacturer			
Type reference			
Place of manufacture			
Method of mounting		Details to be submitted with Tender	
Housing		Details to be submitted with Tender	
Protection rating	IP Standard	65	

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)

Description		Required	Offered
Installation		Details to be submitted with Tender	
Maximum number of splices	No.		
Dimensions (Height x Width x Depth) or (Height x Diameter)	mm		
Mass	kg		
Manufacturer quality system in accordance with ISO 9000, 9001, 9002, 9003 AND 9004	Y/N		
Type test certificate to be issued by independent laboratory or independently witnessed type test will be acceptable to the Engineer	Y/N		
Optical joint boxes (OPGW-Approach Cable)			
Manufacturer			
Type reference			
Place of manufacture			
Method of mounting		Details to be submitted with Tender	
Housing		Details to be submitted with Tender	
Protection rating	IP Standard	65	
Installation		Details to be submitted with Tender	
Maximum number of splices	No.		
Dimensions (Height x Width x Depth) or (Height x Diameter)	mm		
Mass	kg		
Manufacturer quality system in accordance with ISO 9000, 9001, 9002, 9003 AND 9004	Y/N		

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)			
Description		**Required**	**Offered**
Type test certificate to be issued by independent laboratory or independently witnessed type test will be acceptable to the Engineer	Y/N		
SDH Optical Multiplex Equipment and Regenerative Repeaters:			
Transmission mode		digital	
Operating wavelength	nm	1550	
Optical transmitter		DFB laser diode	
Optical detector		avalanche photodiode	
Optical transmission rate			
STM-1	Mb/s	155.52	
STM-4	Mb/s	622.08	
Optical interface		Compliant with ITU Rec G957 and Rec G958	
Electrical digital interface		Compliant with ITU Rec G709	
Maximum input attenuation	dB	< 6	
Maximum admissible jitter		Compliant with ITU Rec G812	
Transmission delay	μs	< 1	
Operating voltage	Vdc	48 (+20%, -15%)	
Solar arrays power supply system (if applicable):			
Type of solar cell		silicon based	
Type of batteries		Nickel cadmium	

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)

Description		Required	Offered
Minimum battery autonomy (continuous operation)	h	96	
Output voltage	V dc	48 (±5%)	
Optical regenerative repeaters *(to be completed for each type of repeater used):*			
Manufacturer			
Model reference			
Place of Manufacture			
Number Provided	No		
Is local technical support provided in country of end-use?	Y/N		
Regenerator section length (without the use of optical booster/amplifiers)	km		
Regenerator section length (with the use of optical boosters/amplifiers)	km		
Nominal operating wavelength	nm		
Transmission rate	Mb/s		
Type of optical transmitter			
Minimum transmit level	dBm		
Maximum transmit level	dBm		
Type of optical receiver			
Receiver sensitivity for BER 10^{-9}	dBm		
Is interworking with PDH systems possible?	Y/N		
Details of interfacing with the Telecomms Management System			
Service channels:			
a. number of channels			
b. bit rate			
c. type of interface			

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)

Description		Required	Offered
Engineers order wire:			
a. 2 wire/4 wire interface			
b. impedance			
c. bit rate (for digital)			
d. selective calling facility			
Details of alarm monitoring facilities			
Voltage limits for satisfactory operation:			
a. nominal voltage	V dc		
b. maximum voltage	V dc		
c. minimum voltage	V dc		
Anticipated loading in volt-amperes at 48 V dc	VA		
Electromagnetic interference	IEC Standard		
Operating temperature range	°C		
Operating relative humidity range (non-condensing)	% rh		
Protection rating	IP Standard		
Vibration	IEC Standard		
Shock	IEC Standard		
Details of ventilation required			
Mass of complete equipment	kg		
Mean time between failures (MTBF)	h		
Mean time to repair (MTTR)	h		
Dimensions of cubicle rack (H x W x D)	mm × mm		

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)

Description		Required	Offered
Optical boosters/amplifiers *(to be completed for each type of optical booster / amplifier used):*			
Manufacturer			
Model reference			
Place of manufacture			
Number provided	No		
Is local technical support provided in country of end-use?	Y/N		
Nominal operating wavelength	nm		
Transmission rate	Mb/s		
Minimum output power	dBm		
Maximum output power	dBm		
Input power	dBm		
Pump laser wavelength	nm		
Pump laser power	mW		
Number of pump lasers	No		
Noise level	dB		
Polarisation sensitivity	dB		
Method of installation			
Details of alarm monitoring facilities			
Voltage limits for satisfactory operation:			
a. nominal voltage	Vdc		
b. maximum voltage	Vdc		
c. minimum voltage	Vdc		
Power consumption	W		

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)			
Description		**Required**	**Offered**
Electromagnetic interference	IEC Standard		
Operating temperature range	°C		
Operating relative humidity range (non-condensing)	% rh		
Protection rating	IP Standard		
Details of ventilation requirements			
a. vibration	IEC Standard		
b. shock	IEC Standard		
Dimension of equipment (H × W × D)	mm × mm × mm		
Mass of complete equipment	kg		
Mean time between failures (MTBF)	h		
Mean time to repair (MTTR)	h		
Solar arrays power supply system (if applicable):			
Charger and control unit			
Manufacturer			
Type reference			
Place of manufacture			
Is local technical support provided in country of end-use?	Y/N		
Minimum lighting level required for proper operation of the solar arrays power supply system	lux		
Output supply voltage range of the system	V dc		
Total power output of the solar arrays system	W		
Details of control equipment			
Charging current	A		
Details of alarm monitoring facilities			
Details of remote alarm indications provided			

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)			
Description		**Required**	**Offered**
Operating temperature range	ºC		
Operating relative humidity range (non-condensing)	% rh		
Protection rating	IP Standard		
Vibration	IEC Standard		
Shock	IEC Standard		
Dimension of equipment (H × W × D)	mm × mm × mm		
Mass	kg		
Mean time between failures (MTBF)	h		
Mean time to repair (MTTR)	h		
Solar cells (to be completed for each type of solar cell used):			
Manufacturer			
Type reference			
Place of manufacture			
Number of solar cells provided	No		
Type of solar cells			
Lighting level range required for proper operation of the solar cell	lux		
Voltage output range of each solar cell	V dc		
Power output of each solar cell	W		
Method of mounting solar panels			
Operating temperature range	ºC		
Operating relative humidity range (non-condensing)	% rh		
Protection rating	IP Standard		
Vibration	IEC Standard		
Shock	IEC Standard		

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)

Description		Required	Offered
Dimension of each solar array (H × W × D)	mm × mm × mm		
Dimension of complete solar arrays system (H × W × D)	mm × mm × mm		
Mass of each solar array	kg		
Mass of complete solar arrays system	kg		
Batteries (to be completed for each type of battery used):			
Manufacturer			
Type reference			
Place of manufacture			
Number of batteries provided	No		
Type of batteries			
Number of cells per battery	No		
Voltage output of each battery cell	V dc		
Battery voltage output range	V dc		
Total capacity of the battery system	Ah		
Time required to recharge totally discharged batteries to full capacity	h		
Autonomy of the battery backup support	h		
Ampere hour capacity at 96 hour discharge rate with average temperature at 50ºC	Ah		
Operating temperature range	ºC		
Operating relative humidity range (non-condensing)	% rh		
Dimension of each battery (H × W × D)	mm × mm × mm		
Dimension of complete battery backup system (H × W × D)	mm × mm × mm		
Mass of each battery	kg		

SCHEDULE D6 - FIBRE OPTIC TRANSMISSION SYSTEM (continued)			
Description		**Required**	**Offered**
Mass of complete battery backup system	kg		

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS

Suspension and Tension Insulator Sets and Earthwire Sets: FOG PROFILE INSULATOR UNITS			**Suspension**		**Tension**	
			Required	**Offered**	**Required**	**Offered**
Insulator Units: **Cap and Pin type (Required Offer)**						
Shed Profile			Fog		Fog	
Appropriate IEC Standard			60305		60305	
Material			Toughened glass or porcelain		Toughened glass or porcelain	
Manufacturer's insulator type number						
IEC designation						
Minimum failing load		kN	120		160	
Outside diameter	Nominal	mm	255		280	
	Actual	mm				
Distance between centres of units	Nominal	mm	146		146	
	Actual	mm				
Insulator pin diameter		mm	16		20	
Mass of unit		kg				
Minimum dry lightning impulse withstand		kV				
Minimum power frequency withstand		kV				
Minimum puncture voltage in oil		kV				
Creepage distance		mm				

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)					
Suspension and Tension Insulator Sets and Earthwire Sets: FOG PROFILE INSULATOR UNITS		**Suspension**		**Tension**	
		Required	**Offered**	**Required**	**Offered**
Insulator Sets complete: Cap and pin type.					
Number of insulator strings per phase		1 #		2	
Unobstructed transverse swing of suspension clamp	degree	90		-	-
Minimum failing load of set fittings	kN	120		160	
Number of insulator units in each string	Nominal	10		12	
	Actual				
Overall length of set including clamp and all fittings	mm				
Gap between arching horns fitted both live and earth ends	mm				
Mass of set, complete with all fittings (and arcing horns at both ends)	kg				
Overall length of creepage path per string:	mm	2800		3400	
50 Hz voltage tests:					
a. Dry one minute withstand voltage of complete set*:	kV	275		320	
b. One minute wet withstand voltage of complete set*		230		265	
Dry impulse withstand voltage of complete set*	KV	650		650	
Corona test voltage	kV	92		92	
Set RI voltage	KV	88		88	

Twin string insulator sets are required for road and rail crossings

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)					
Suspension and Tension Insulator Sets and Earthwire Sets: FOG PROFILE INSULATOR UNITS		**Suspension**		**Tension**	
		Required	**Offered**	**Required**	**Offered**
Set radio noise level	dB	34		34	
Earthwire sets:					
Minimum failing load, complete set	KN	70		120	
Overall length of set including clamp and all fittings	mm				
Mass of set	kg				

* All flashover and withstand voltage levels corrected to Normal Temperature and pressure in accordance with IEC 60383.

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)						
Terminal slack-span and Jumper Insulator Sets: **FOG PROFILE INSULATOR UNITS**			**Terminal slack-span**		**Jumper**	
			Required	**Offered**	**Required**	**Offered**
Insulator Units: **Cap and Pin type (Required Offer)**						
Shed Profile			Fog		Fog	
Appropriate IEC Standard			60305		60305	
Material			Toughened glass or porcelain		Toughened glass or porcelain	
Manufacturer's insulator type number						
IEC designation						
Minimum failing load		kN	120		120	
Outside diameter	Nominal	mm	255		255	
	Actual	mm				
Distance between centres of units	Nominal	mm	146		146	
	Actual	mm				
Insulator pin diameter		mm	16		16	
Mass of unit		kg				
Minimum dry lightning impulse withstand		kV				
Minimum power frequency withstand		kV				
Minimum puncture voltage in oil		kV				
Creepage distance		mm				

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)

Terminal slack-span and Jumper Insulator Sets: FOG PROFILE INSULATOR UNITS		**Terminal slack-span**		**Jumper**	
		Required	**Offered**	**Required**	**Offered**
Insulator Sets complete: Cap and pin type.					
Minimum failing load of set fittings	kN	120		120	
Number of insulator units in each string	Nominal	12		10	
	Actual				
Overall length of set including clamp and all fittings	mm				
Gap between arching horns fitted both live and earth ends	mm				
Mass of set, complete with all fittings (and arcing horns at both ends)	kg				
Overall length of creepage path per string:	mm	3400		2800	
50 Hz voltage tests:					
a. Dry one minute withstand voltage of complete set*	kV	320		275	
b. One minute wet withstand voltage of complete set*	kV	265		230	
Dry impulse withstand voltage of complete set*	kV	650		650	
Corona test voltage	kV	92		92	
Set RI voltage	kV	88		88	
Set radio noise level	dB	34		34	

* All flashover and withstand voltage levels corrected to Normal Temperature and pressure in accordance with IEC 60383.

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)

Suspension and Tension Insulator Sets and Earthwire Sets: OPEN PROFILE INSULATOR UNITS			**Suspension**		**Tension**	
			Required	**Offered**	**Required**	**Offered**
Insulator Units: **Cap and Pin type (Required Offer)**						
Shed Profile			Open		Open	
Appropriate IEC Standard			60305		60305	
Material			Toughened glass or porcelain		Toughened glass or porcelain	
Manufacturer's insulator type number						
IEC designation						
Minimum failing load		kN	120		160	
Outside diameter	Nominal	mm	380		380	
	Actual	mm				
Distance between centres of units	Nominal	mm	127		127	
	Actual	mm				
Insulator pin diameter		mm	16		20	
Mass of unit		kg				
Minimum dry lightning impulse withstand		kV				
Minimum power frequency withstand		kV				
Minimum puncture voltage in oil		kV				
Creepage distance		mm				

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)					
Suspension and Tension Insulator Sets and Earthwire Sets: OPEN PROFILE INSULATOR UNITS		**Suspension**		**Tension**	
		Required	**Offered**	**Required**	**Offered**
Insulator Sets complete: Cap and pin type.					
Number of insulator strings per phase		1 #		2	
Unobstructed transverse swing of suspension clamp	degree	90		-	-
Minimum failing load of set fittings	kN	120		160	
Number of insulator units in each string	Nominal	‡		‡	
	Actual				
Overall length of set including clamp and all fittings	mm				
Gap between arching horns fitted both live and earth ends	mm				
Mass of set, complete with all fittings (and arcing horns at both ends)	kg				
Overall length of creepage path per string:	mm	4000		4000	
50 Hz voltage tests:					
a. Dry one minute withstand voltage of complete set*:		275		320	
b. One minute wet withstand voltage of complete set*		230		265	
Dry impulse withstand voltage*	kV	650		650	
Corona test voltage	kV	92		92	
Set RI voltage	kV	88		88	
Set radio noise level	dB	34		34	

Twin string insulator sets are required for road and rail crossings

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)					
Suspension and Tension Insulator Sets and Earthwire Sets: OPEN PROFILE INSULATOR UNITS		**Suspension**		**Tension**	
		Required	**Offered**	**Required**	**Offered**
Earthwire sets:					
Minimum failing load, complete set	kN	70		120	
Overall length of set including clamp and all fittings	mm				
Mass of set	kg				

* All flashover and withstand voltage levels corrected to Normal Temperature and pressure in accordance with IEC 60383.

‡ Overall length of set to be not greater than that for the Required Offer (Standard Profile) and number of discs to satisfy creepage requirements for open profile sets.

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)

Light Duty Tension and Jumper Insulator Sets: OPEN PROFILE INSULATOR UNITS			**Light Duty Tension**		**Jumper**	
			Required	**Offered**	**Required**	**Offered**
Insulator Units: **Cap and Pin type (Required Offer)**						
Shed Profile			Open		Open	
Appropriate IEC Standard			60305		60305	
Material			Toughened glass or porcelain		Toughened glass or porcelain	
Manufacturer's insulator type number						
IEC designation						
Minimum failing load		kN	120		120	
Outside diameter	Nominal	mm	380		380	
	Actual	mm				
Distance between centres of units	Nominal	mm	127		127	
	Actual	mm				
Insulator pin diameter		mm	16		16	
Mass of unit		kg				
Minimum dry lightning impulse withstand		kV				
Minimum power frequency withstand		kV				
Minimum puncture voltage in oil		kV				
Creepage distance		mm				

SCHEDULE D7 - INSULATOR AND EARTHWIRE SETS (continued)

Light Duty Tension and Jumper Insulator Sets: OPEN PROFILE INSULATOR UNITS		**Light Duty Tension**		**Jumper**	
		Required	**Offered**	**Required**	**Offered**
Insulator Sets complete: Cap and pin type.					
Minimum failing load of set fittings	kN	120		120	
Number of insulator units in each string	Nominal	‡		‡	
	Actual				
Overall length of set including clamp and all fittings	mm				
Gap between arching horns fitted both live and earth ends	mm				
Mass of set, complete with all fittings (and arcing horns at both ends)	kg				
Overall length of creepage path per string:	mm	4000		4000	
50 Hz voltage tests:					
a. Dry one minute withstand of complete set*:	kV	320		275	
b. One minute wet withstand voltage of complete set*		265		230	
Dry impulse withstand voltage of complete set*					
Corona test voltage	kV	92		92	
Set RI voltage	kV	88		88	
Set radio noise level	dB	34		34	

* All flashover and withstand voltage levels corrected to Normal Temperature and pressure in accordance with IEC 60383.

‡ Overall length of set to be not greater than that for the Required Offer (Standard Profile) and number of discs to satisfy creepage requirements for open profile sets.

SCHEDULE D8 - TOWER DESIGN PARTICULARS

Factors of safety to be applied

Description		Required	Offered
Maximum working tension per phase, for purpose of tower design and application:			
a. tangent towers	Newton	According to clause 6.7	
b. tension towers	Newton	According to clause 6.7	
c. slack spans	Newton	16000	
Maximum working tension of each conductor in still air and at every day temperature of 25°C	Newton	26610	
Maximum working tension per earthwire for purpose of tower design and application:			
a. tangent towers	Newton	According to clause 6.7	
b. tension towers	Newton	According to clause 6.7	
c. earthwire slack spans	Newton	6000	
Maximum working tension of each earthwire in still air and at every day temperature of 25°C	Newton	17700	
Minimum clearance between tower steelwork and the nearest point of conductor or live conductor hardware, considering conductor slope 0 - 15 degrees			
a. with assumed transverse swing of suspension insulator set 0 degrees, no wind	mm	1270	
b. with assumed transverse swing of suspension insulator set 30 degrees, average wind	mm	1000	
c. with assumed transverse swing of suspension insulator set 60 degrees, gust wind	mm	500	
Where tension insulators are used:			
a. jumper loops hanging vertically	mm	1270	
b. jumper loops deflected 30º from vertical	mm	1000	
Factors of safety to be applied			

SCHEDULE D8 - TOWER DESIGN PARTICULARS (continued)

Description		Required	Offered
Slack spans, minimum clearances:			
a. phase to phase clearance in still air	mm	2500	
b. phase to phase clearance under conditions of maximum opposing swing and sag	mm	1500	
Earthwire suspension clamps, unobstructed transverse swing angle from vertical	degree	0 – 50	
Earthwire maximum shielding angle from vertical at tower attachment point over outer line conductors	degree	30	
Maximum ratio of unsupported length of steel compression member to their least radius of gyration:			
a. main members		150	
b. stressed bracings		200	
c. unstressed bracings		240	
d. tension only members, detailed with draw, for tower cross-arm hangers		325	
e. tension only members, detailed with draw		400	
Maximum ultimate stresses, for checking tower designs not subjected to test (unless otherwise approved):-			
Compression members, Tenderer to indicate his design assumptions but is to note that the design shall comply with the requirements of ASCE Manual 52 and ANSI/ASCE Standard No 10		Details to be submitted with the tender	
Mild steel	N/mm^2		
High yield steel	N/mm^2		
Tension members (elastic limit)			
Mild steel	N/mm^2	275	
High yield steel	N/mm^2	355	

SCHEDULE D8 - TOWER DESIGN PARTICULARS (continued)			
Description		**Required**	**Offered**
Shear on bolts	N/mm^2		
Mild steel	N/mm^2	234	
High yield steel	N/mm^2	350	
Bearing on bolts	N/mm^2		
Mild steel	N/mm^2	405	
High yield steel	N/mm^2	700	

SCHEDULE D9 - SIMULTANEOUS UNBALANCED LOADING CONDITIONS - LONGITUDINAL LOADS

Factors of safety to be applied.
For transverse and vertical loads and the application: see the Technical Specification.

Description		Required	Offered
Tangent towers (suspension insulators)			
At any one attachment:			
phase	Newton	49840	
or			
earth	Newton	17700	
Cascade collapse conditions at all attachments:			
phase	Newton	29400	
earth	Newton	18650	
Single circuit angle towers (tension insulators)			
At two attachments:			
any one phase	Newton	71200	
and			
any one earth	Newton	25200	
Cascade collapse conditions at all attachments:			
phase	Newton	53400	
earth	Newton	19600	

Phase values are the total of the two sub-conductors

SCHEDULE D9 - SIMULTANEOUS UNBALANCED LOADING CONDITIONS - LONGITUDINAL LOADS (continued)

Factors of safety to be applied.
For transverse and vertical loads and the application: see the Technical Specification.

Description		Required	Offered
Double circuit angle towers (tension insulators)			
At any two attachments:			
phase	Newton	71200	
or			
earth	Newton	25200	
Cascade collapse conditions at all attachments:			
phase	Newton	53400	
earth	Newton	19600	
Single circuit dead-end towers (tension insulators)			
At two attachments:			
any one phase	Newton	0	
and			
any one earth	Newton	0	
Double circuit dead-end towers (tension insulators)			
At any two attachments:			
phase	Newton	0	
or			
earth	Newton	0	

Phase values are the total of the two sub-conductors

SCHEDULE D10 - CONSTRUCTION AND MAINTENANCE LOADING CONDITIONS - CONDUCTOR TENSIONS

Factors of safety to be applied.
For transverse and vertical loads, and the application: see the Technical Specification.

Description		Required	Offered
Tangent towers (suspension insulators)			
Maintenance condition			
Phase	Newton	76900	
Earth	Newton	26000	
Angle and dead-end towers (tension insulators)			
Maintenance condition:			
Phase	Newton	76900	
Earth	Newton	26000	
Temporary dead-end condition			
Phase	Newton	76900	
Earth	Newton	26000	

Phase values are the total of the two sub-conductors

SCHEDULE D11.1 - PARTICULARS OF SINGLE CIRCUIT TOWERS

Type of tower			1S2	1R2	1M2	1T2	1E2		1K2	1SP2
Type of insulator sets			Suspension	Suspension	Tension	Tension	Tension angle	Tension dead-end	Tension Under crossing gantry	Tension Tee-off/ Special purpose
Angles of deviation		degree	0 - 2	0	0 - 30	30 - 60	60 - 90	0 - 45	0	90
Basic span length		m	325	455	325	325	325	325	325	325
Minimum ground clearance of line conductor at 90°C, normal ground		m	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Sag of line conductor in span length at 90°C	assumed	m	9.55	16.10	9.55	9.55	9.55	9.55	9.55	9.55
	offered	m								
Distance of line conductor below crossarm	offered	m			-	-	-	-	-	-
Maximum height above ground of: top crossarm middle crossarm bottom crossarm	offered	m								
Minimum height above ground of: top crossarm middle crossarm bottom crossarm	offered	m								
Height of earthwires above line conductor at tower	minimum	m	5.95	5.95	6.35	6.35	6.35	6.35	6.35	6.35
	offered	m								

SCHEDULE D11.1 - PARTICULARS OF SINGLE CIRCUIT TOWERS (continued)

Type of tower			1S2	1R2	1M2	1T2	1E2		1K2	1SP2
Horizontal spacing between adjacent conductor phases at mid span in still air at maximum angle of line deviation	minimum	m	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	offered	m								
Vertical spacing between phase conductors at tower	minimum	m	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
	offered									
Overall tower height (Standard height tower)	offered	m								
Horizontal distance, from tower centre line to insulator attachment:- top crossarm middle crossarm bottom crossarm	offered	m								
Overall tower base dimensions at ground line (transverse x longitudinal)	offered	m x m								
Total ultimate transverse overturning moment at ground line of standard height tower, load case 1 with load factor	offered	kN m								

SCHEDULE D (continued)
(To be completed by the Tenderer)

Maximum differential foundation movement permitted under ultimate loads	offered	mm								
Mass of complete towers above ground line:	offered									
Standard height tower		kg								
3 metre extended tower		kg								
6 metre extended tower		kg								
9 metre extended tower		kg	-		-	-	-	-	-	-
12 metre extended tower		kg	-		-	-	-	-	-	-
15 metre extended tower		kg	-		-	-	-	-	-	-

SCHEDULE D11.2 - PARTICULARS OF DOUBLE CIRCUIT TOWERS

Type of tower			**2S2**	**2R2**	**2M2**	**2T2**	**2E2**		**2K2**	**2SP2**
Type of insulator sets			Suspension	Suspension	Tension	Tension	Tension Angle	Tension Dead-end	Tension Under crossing gantry	Tension Tee-off/ Special purpose
Angles of deviation		degree	0 - 2	0	0 - 30	30 - 60	60 - 90	0 - 30	0 - 30	90
Basic span length		m	325	455	325	325	325	325	325	325
Minimum ground clearance of line conductor at 90°C, normal ground		m	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Sag of line conductor in span length at 90°C	assumed	m	9.55	16.10	9.55	9.55	9.55	9.55	9.55	9.55
	offered	m								
Distance of line conductor below crossarm	offered	m			-	-	-	-	-	-
Maximum height above ground of:-	offered									
top crossarm		m								
middle crossarm		m								
bottom crossarm		m								
Minimum height above ground of:-	offered									
top crossarm		m								
middle crossarm		m								
bottom crossarm		m								
Height of earthwire above upper line conductor at tower	minimum	m	5.95	5.95	6.35	6.35	6.35	6.35	6.35	6.35
	offered	m								

SCHEDULE D11.2 - PARTICULARS OF DOUBLE CIRCUIT TOWERS (continued)										
Type of tower			**2S2**	**2R2**	**2M2**	**2T2**	**2E2**		**2K2**	**2SP2**
Horizontal spacing between adjacent conductor phases at mid span in still air at maximum angle of line deviation	minimum	m	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
	offered	m								
Vertical spacing between phase conductors	minimum	m	3.85	3.85	3.85	3.85	3.85	3.85	38.5	3.85
	offered	m								
Overall tower height (Standard height tower)	offered	m								
Horizontal distance, from tower centre line to insulator attachment:-	offered									
top crossarm		m								
middle crossarm		m								
bottom crossarm		m								
Overall tower base dimensions at ground line (transverse x longitudinal)	offered	m x m								
Total ultimate transverse overturning moment at ground line of standard height tower, load case 1 with load factor	offered	kN m								

SCHEDULE D (continued)
(To be completed by the Tenderer)

Maximum differential foundation movement permitted under ultimate loads	offered	mm								
Mass of complete towers above ground line:	offered									
Standard height tower		kg								
3 m extended tower		kg								
6 m extended tower		kg								
9 m extended tower		kg	-		-	-	-	-	-	-
12 m extended tower		kg	-		-	-	-	-	-	-
15 m extended tower		kg	-		-	-	-	-	-	-

SCHEDULE D12 - FOUNDATION DESIGN PARTICULARS

Description		Required	Offered
Maximum allowable design stresses in standard concrete foundation design, under ultimate conditions, shall be in accordance with BS 8110, BS EN 206-1 and BS 8500, with the following requirement:			
28 days concrete cube strength (characteristic strength*)	N/mm^2	30	
Maximum angle between the horizontal and a side face of a concrete foundation for the uplift 'frustum' to be taken from the base of the sloping side face	degree	70	
Minimum proportion of stub load to be allowed for in design of stub cleats	per cent	100	
Bond stress between galvanised steel and concrete	N/mm^2	1.1	
Tensile stress in reinforcement [Fy = characteristic yield stress*]	N/mm^2		

* The characteristic strength is that value of stress below which not more than 5 per cent of test results may fall

SCHEDULE D12 - FOUNDATION DESIGN PARTICULARS (continued)

FOUNDATION CLASSIFICATIONS AND PARAMETERS FOR DESIGN

Foundation Class:	**A**	**B**	**C**	**D**
Soil Types:	Rock, hardpan, cemented gravel	Very dense sand, hard clay, compact soils, compact gravel	Dense sand, stiff to medium clay, medium silt, loose gravel	Soft and very soft clay, loose silt, loose sand
Maximum ultimate vertical downward bearing pressure	600 kN/m^2	360 kN/m^2	120 kN/m^2	60 kN/m^2
Maximum ultimate vertical upward bearing pressure	400 kN/m^2	240 kN/m^2	80 kN/m^2	40 kN/m^2
Maximum assumed density of soil resisting uplift	1600 kg/m^3	1440 kg/m^3	1040 kg/m^3	900 kg/m^3
Maximum assumed density of concrete resisting uplift	2240 kg/m^3	2240 kg/m^3	1280 kg/m^3 (submerged weight)	1280 kg/m^3 (submerged weight)
Half-angle of assumed conical frustum resisting uplift	20 degrees	10 degrees	5 degrees	0 degrees
Maximum ultimate lateral soil (passive) pressure to resist horizontal shear	100 kN/m^2/m depth	60 kN/m^2/m depth	20 kN/m^2/m depth	7 kN/m^2/m depth

SCHEDULE D12 - FOUNDATION DESIGN PARTICULARS (continued)

Clause 7 “Foundation Design” of the Technical Specification states that ‘all types of foundation shall be designed to withstand uplift, settlement, overturning and sliding when subjected to the specified conditions of tower loading’.

The preferred formulae to be used for confirming the stability of foundation designs are included in this Schedule D12.

For analysis of the chimney formed by the concrete encased stub between ground level and the pyramid or pad at the base of the foundation, it is recommended that use be made of the data contained within the attached Figure 12.1 ‘Earth Passive Pressure Diagram for concrete encased stub with base pyramid’.

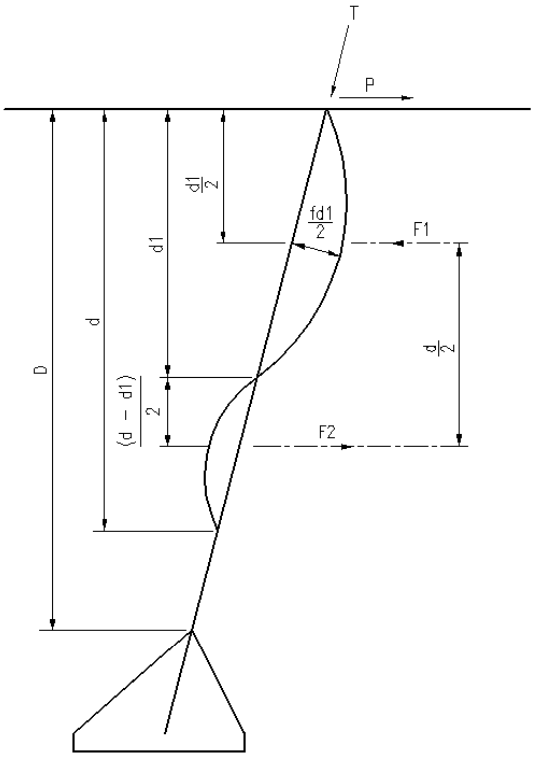
During the confirmation of the overall stability of spread concrete footings, use should be made of Figure 12.2 for foundations subject to uplift forces and of Figure 12.3 for foundations subject to compression or thrust forces.

To confirm the overturning stability of individual piles, use may be made of the technique contained in Figure 12.4.

Figures 12.2, 12.3 and 12.4 are copied from the Design Standard No 10,”Transmisison Structures” published by the United States Department of the Interior, Bureau of Reclamation, in 1965. When using the methods contained in Figures 12.2 and 12.3, attention shall be paid to the statements in Clauses 2.6 and 2.10 of the Standard, where it is stated that working loads are used for the calculations and where the calculations are satisfied provide a minimum factor of safety of 1.5. Suitable adjustments shall be made to the procedures to ensure that the specified factors of safety for foundations (1.95 on maximum design working loads (normal and broken wire) and 3.00 on maximum design stringing and maintenance working loads) can be achieved.

FIGURE D12.1

EARTH PASSIVE PRESSURE DIAGRAM FOR
CONCRETE ENCASED STUB WITH BASE PYRAMID



GIVEN

D = DEPTH TO TOP OF PYRAMID
d = DEPTH OF PASSIVE PRESSURE DIAGRAM
d1 = DEPTH OF UPPER PART OF PASSIVE PRESSURE DIAGRAM
f = PASSIVE PRESSURE PERMITTED BY THE SPECIFICATION
F1 = TOTAL PASSIVE PRESSURE IN UPPER PART OF DIAGRAM
F2 = TOTAL PASSIVE PRESSURE IN LOWER PART OF DIAGRAM
P = HORIZONTAL SHEAR AT GROUND LEVEL
T = AXIAL LOAD IN STUB ANGLE
b = BEARING WIDTH OF CONCRETE COLUMN

EQUATIONS FOR EQUILIBRIUM

① $F1 = P + F2$ ② $F1 \times \frac{d}{2} = P\left(\frac{d + d1}{2}\right)$ ③ $\frac{F1}{F2} = \frac{d1^2}{(d - d1)^2}$ FROM ③ $F2 = F1\frac{(d - d1)^2}{d1^2}$

SUBSTITUTING FOR F2 IN ① GIVES: $F1 = \frac{Pd1^2}{d(2d1 - d)}$

SUBSTITUTING FOR F1 IN ② GIVES: $d1 = .618d$

ALSO: $F1 = \frac{2d1}{3} \times \frac{fd1}{2} \times b = \frac{1}{3} fd1^2 \times b = \frac{Pd1^2}{d(2d1 - d)}$

THEREFORE: $f = \frac{3P}{d(1.24d - d)b} = \frac{12.7P}{d^2 b}$

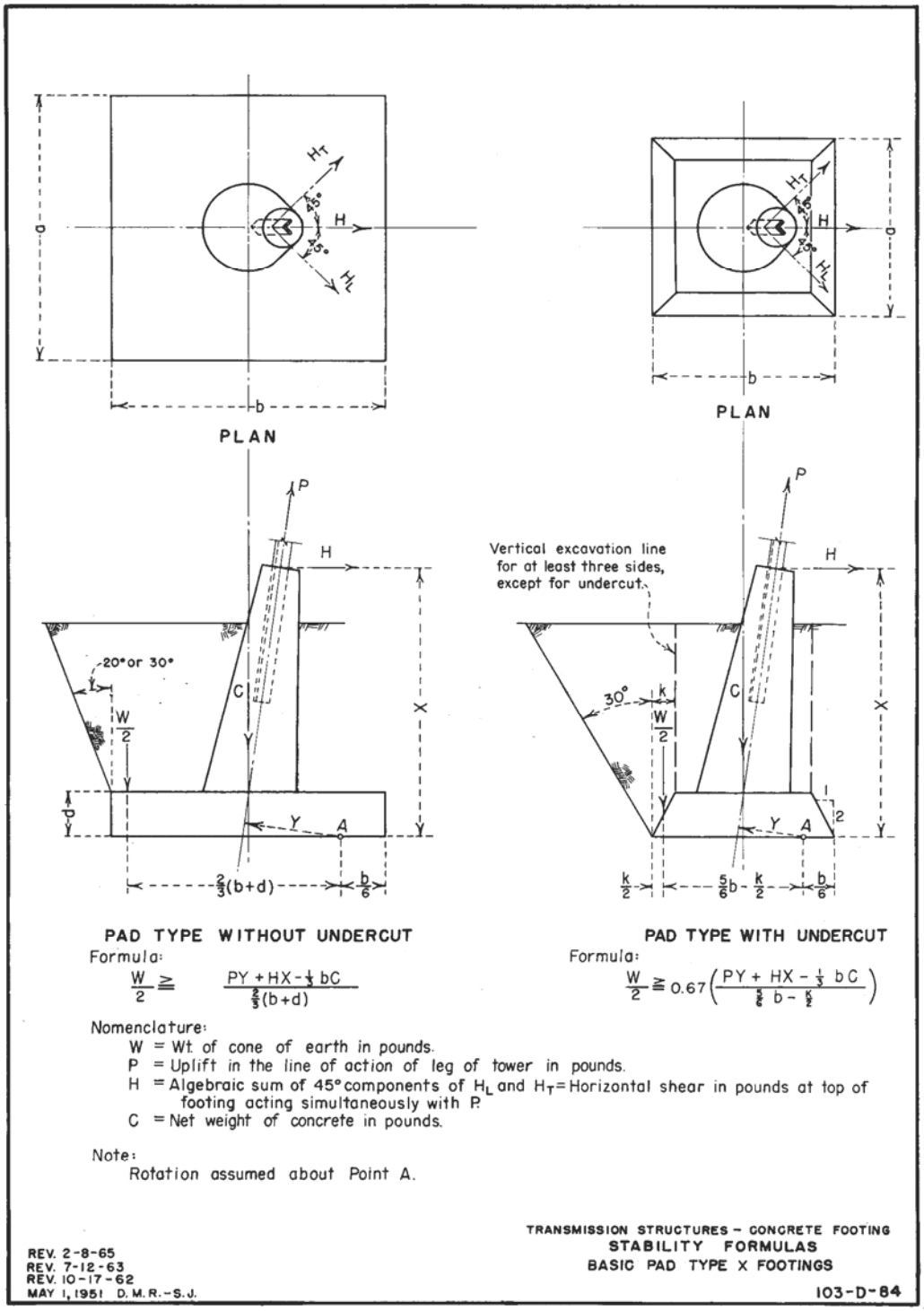
NOTE
d MUST NOT EXCEED D

MAXIMUM MOMENT IN COLUMN = .23Pd
WHICH OCCURS AT DEPTH = .352d

Figure D12.2

Transmission Structures Chap. 2 Concrete Footing Design and Details

STABILITY FORMULAS--BASIC PAD TYPE X FOOTING Fig. 7 Par. 2.6B&C



DS-10-7 - 3/8/65

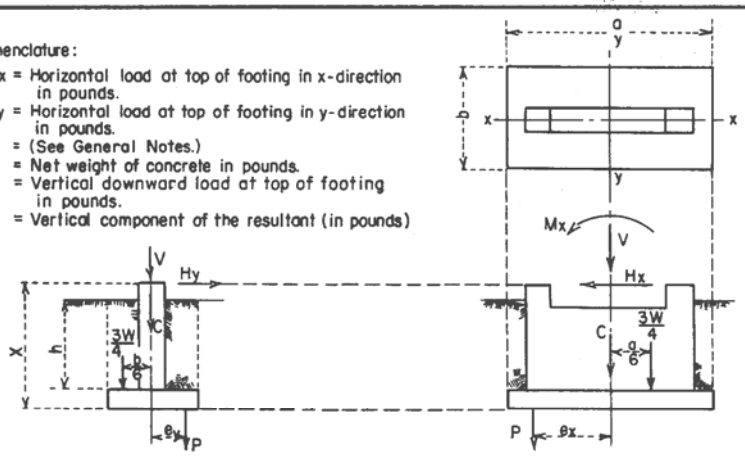
Figure D12.3

Fig. 8 Par. 2.10

STABILITY FORMULAS--DOWNWARD VERTICAL LOAD, BASIC TYPE X-Y FOOTING

Nomenclature:

Hx = Horizontal load at top of footing in x-direction in pounds.
Hy = Horizontal load at top of footing in y-direction in pounds.
W = (See General Notes.)
C = Net weight of concrete in pounds.
V = Vertical downward load at top of footing in pounds.
P = Vertical component of the resultant (in pounds)

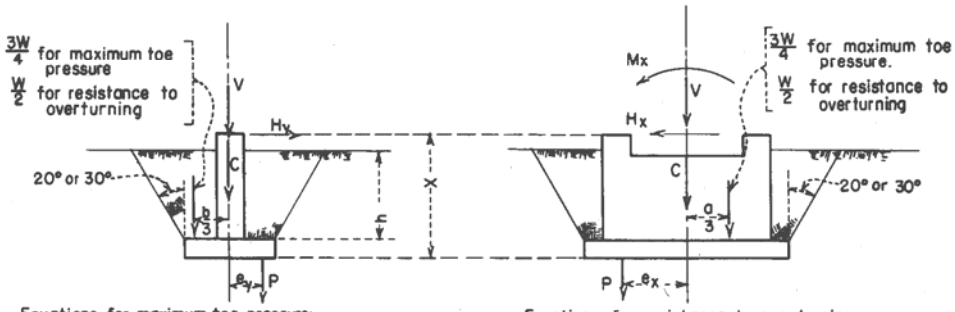


Equations for maximum toe pressure:

① $P = 0.75\,W + V + C$
② $A = ab$
③ $e_x = (M_x + H_x X - 0.125\,aW) \div P$
④ $e_y = (H_y X - 0.125\,bW) \div P$

With values of e_x, e_y, and P determine maximum toe pressure in compression from chart and formulas Dwg. 103-D-217 (Fig. 5, Par. 2.5c).
Overturning is impossible

DOWNWARD VERTICAL LOAD-CONDITION "A"
RESULANT LIES WITHIN MIDDLE THIRD



Equations for maximum toe pressure:

⑤ $P = 0.75\,W + V + C$
② $A = ab$
⑥ $e_x = (M_x + H_x X - 0.25\,aW) \div P$
⑦ $e_y = (H_y X - 0.25\,bW) \div P$

With values of e_x, e_y, and P determine maximum toe pressure in compression from chart and formulas Dwg. 103-D-217 (Fig. 5, Par. 2.5c).

Equations for resistance to overturning:

⑧ $\frac{W}{2} \geq 1.25 \left[\frac{M_x + H_x X - e_x (V + C)}{e_x + 0.33\,a} \right]$

⑨ $\frac{W}{2} \geq 1.25 \left[\frac{H_y X - e_y (V + C)}{e_y + 0.33\,b} \right]$

DOWNWARD VERTICAL LOAD-CONDITION "B"
RESULTANT USUALLY LIES OUTSIDE MIDDLE THIRD

Soil condition assumptions:

30 degree "cone" assumption:
A = Average firm cohesive material
B = Vertical excavation lines.
C = Compacted backfill

20 degree "cone" assumptions:
A = Non-cohesive material such as uncemented sand and gravel
B = Sloped excavation lines
C = Compacted backfill

GENERAL NOTES

Condition "A", W = net volume of earth within the limits of abh in pounds.
Condition "B", W = net weight of 20° or 30° cone of earth in pounds.

TRANSMISSION STRUCTURES - CONCRETE FOOTINGS
STABILITY FORMULAS - DOWNWARD VERTICAL LOAD
BASIC TYPE X-Y

REV. 2-8-65
REV. 10-17-62

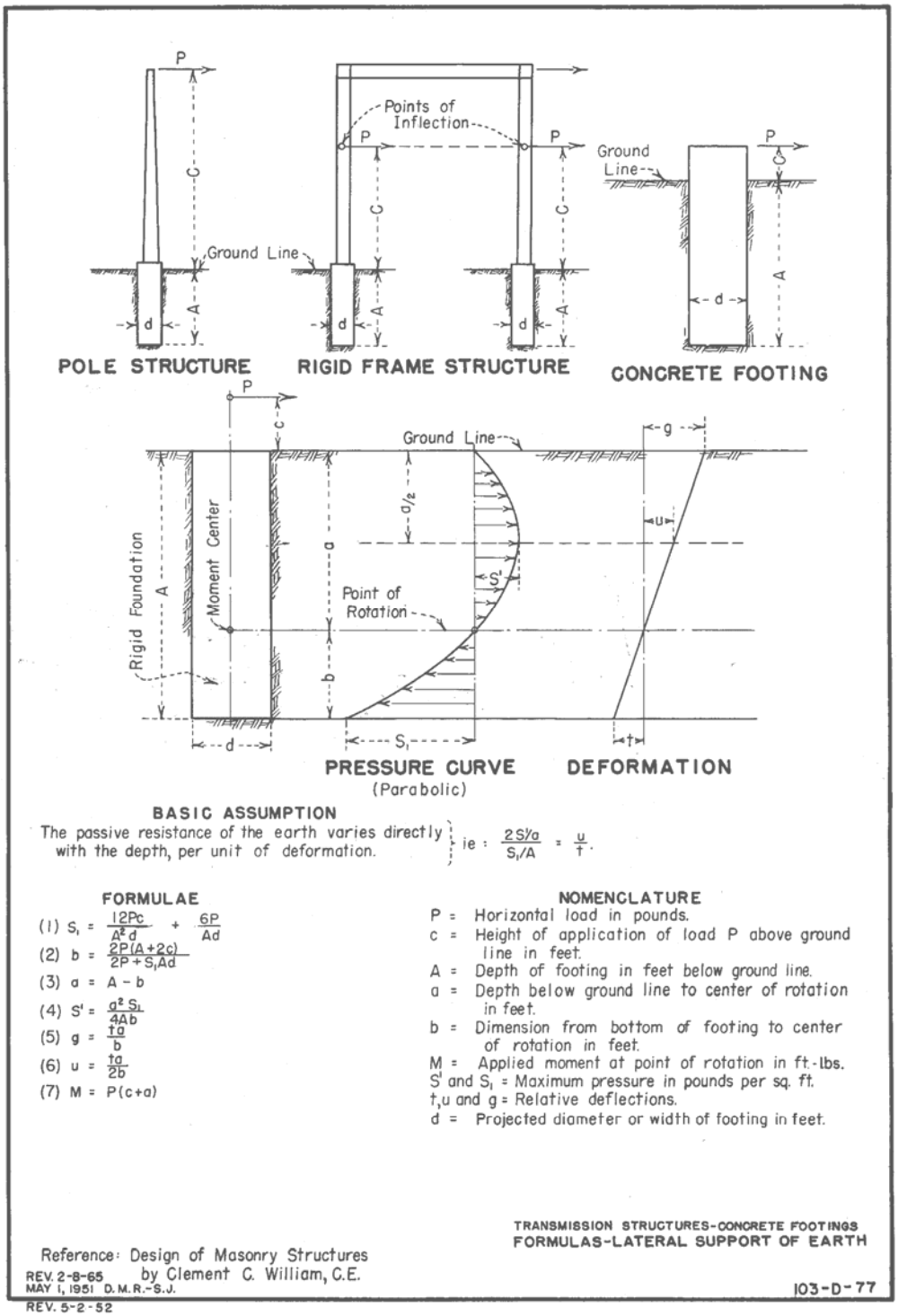
103-D-561

DS-10-7 - 3/8/65

Figure D12.4

Transmission Structures Chap. 2 Concrete Footing Design and Details

FORMULAS--LATERAL SUPPORT OF EARTH Fig. 3 Par. 2.5E



BASIC ASSUMPTION

The passive resistance of the earth varies directly with the depth, per unit of deformation. } ie : $\frac{2S'/a}{S_1/A} = \frac{u}{t}$.

FORMULAE

(1) $S_1 = \frac{12Pc}{A^2 d} + \frac{6P}{Ad}$

(2) $b = \frac{2P(A+2c)}{2P + S_1 Ad}$

(3) $a = A - b$

(4) $S' = \frac{a^2 S_1}{4Ab}$

(5) $g = \frac{ta}{b}$

(6) $u = \frac{ta}{2b}$

(7) $M = P(c+a)$

NOMENCLATURE

P = Horizontal load in pounds.
c = Height of application of load P above ground line in feet.
A = Depth of footing in feet below ground line.
a = Depth below ground line to center of rotation in feet.
b = Dimension from bottom of footing to center of rotation in feet.
M = Applied moment at point of rotation in ft.-lbs.
S' and S_1 = Maximum pressure in pounds per sq. ft.
t, u and g = Relative deflections.
d = Projected diameter or width of footing in feet.

TRANSMISSION STRUCTURES-CONCRETE FOOTINGS
FORMULAS-LATERAL SUPPORT OF EARTH

Reference: Design of Masonry Structures by Clement C. William, C.E.

REV. 2-8-65
MAY 1, 1951 D.M.R.-S.J.
REV. 5-2-52

103-D-77

DS-10-7 - 3/8/65

SCHEDULE D13 - QUALITY OF MATERIALS

Particulars:		**Mild steel**		**High tensile steel**	
Towers:		**Steel members**	**Steel nuts and bolts**	**Steel members**	**Steel nuts and bolts**
Grade					
Tensile breaking stress	N/mm^2				
Elongation at break	%				
Gauge length of specimen	mm				
Diameter of specimen	mm				
Yield point as percentage of breaking stress	%				

Insulators and fittings:		**Insulator unit metalwork**			**Phase and earthwire metal fittings**	
		Steel	**Malleable cast iron**	**Insulator caps**	**Steel**	**Malleable cast iron**
Grade						
Tensile breaking stress	N/mm^2					
Elongation at break	%					
Gauge length of specimen	mm					
Diameter of specimen	mm					
Yield point as percentage of breaking stress	%					

SCHEDULE D 14 - INTERNATIONAL STANDARDS

Particulars	Required IEC/ISO/BS EN Standards	Required or alternative equivalent National Standard offered by Tenderer
Quality assurance	ISO 9001	
Drawings	BS PD 6031	
Overhead line design	IEC 60826	
Loading tests on overhead line structures	IEC 60652	
Steel tower members	BS EN 10025	
Steel bolts and nuts	BS 4190/BS EN 20898-1	
Steel plain washers	BS 4320	
Steel spring washers	BS 4464	
Stainless steel	BS 970 Pt 1	
Galvanizing	BS EN ISO 1461, BS 7371 Pt 6, BS EN 10244 Pt 2	
Round wire concentric lay overhead electrical stranded conductors	IEC 61089	
Hard drawn aluminium wire for overhead line conductors	IEC 60889	
Conductors for overhead lines, aluminium-magnesium-silicon alloy wires	BS EN 50183	
Conductors for overhead lines – zinc coated steel wires	BS EN 50189	
Aluminium-clad steel wires for electrical purposes	BS EN 61232	
Characteristics of grease for bare overhead line conductors	BS EN 50326	
Galvanized steel wire strand	BS 183	

SCHEDULE D 14 - INTERNATIONAL STANDARDS (continued)

Particulars	Required IEC/ISO/BS EN Standards	Required or alternative equivalent National Standard offered by Tenderer
Optical cables to be used along electrical power lines (OCEPL)	BS EN 187200 ISO 9223 IEC 60693 IEC 60793-1 IEC 60794-1 CCITT G.651 CCITT G.652 CCITT G.653 CCITT G.703 ANSI 455-37 ANSI 455-85 ANSI 455-91 ANSI 455-14 ANSI 455-89 BS EN 50189 BS EN 50183 BS 4803 BS1559	
Batteries	IEC 60623	
Insulator units	IEC 60305 IEC 60372 IEC 60383 IEC 60437 IEC 60575 IEC 60672 IEC 60797 IEC 60815 IEC 61109 IEC 61466 BS 5049 Pt 2 IEEE 987	
- pins	IEC 60120	
- caps	IEC 60383 BS EN 1563 or BS EN 1562	
Line conductor and earthwire metal fittings	IEC 61284 BS 3288 Pt 2	
Overhead lines – requirements and tests for Stockbridge type Aeolian vibration dampers	IEC 61897	
Overhead lines – requirements and tests for spacers	IEC 61854	

SCHEDULE D 14 - INTERNATIONAL STANDARDS (continued)		
Particulars	**Required IEC/ISO/BS EN Standards**	**Required or alternative equivalent National Standard offered by Tenderer**
Soils testing	BS 1377	
Foundation testing	IEC 61773	
Sulphate resistant cement	BS 4027	
Aggregate	BS 882 / BS EN 12620	
Concrete	BS 8500 / BS EN 206 Pt 1 BS 1881	
Reinforced concrete	BS 8110	
Reinforcement for concrete	BS 4449	

SCHEDULE E
DRAWINGS, DOCUMENTATION AND SAMPLES

E.1 DRAWINGS AND DOCUMENTATION

E.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.

E.1.2 Drawings attached to the Specification

Plate No 1 Location map

Plate No 2 Route of proposed transmission line

Plate No 3 Tower outlines

Plate No 4 Tower notice plates

Plate No 5 Corridor dimensions

Plate No 6 Subdivision of work at substations

E.1.3 Submittals to be attached to the Tender

E.1.3.1 Drawings

The following are the drawings to be submitted with the Tender.

Tenderer's Drawing Number		
Single Circuit Tower Type	**Tower Outline with clearance diagram**	**Foundation outline for all standard designs**
1S2		
1T2		
1E2		
1R2		
1K2		
1SP2		

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.

Tenderer's Drawing Number		
Double Circuit Tower Type	**Tower Outline with clearance diagram**	**Foundation outline for all standard designs**
2S2		
2T2		
2E2		
2R2		
2K2		
2SP2		

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.

Description	Tenderer's Drawing Number
Diagram of external loads:-	
Tangent towers	
Tension towers	
General arrangement of:-	
Suspension insulator sets and fittings	
Tension insulator sets and fittings	
Light duty insulator sets and fittings	
Reversed light duty insulator sets and fittings	
Jumper set, if offered	
Detailed drawings of:-	
Insulator unit	
Line conductor tension anchor clamp and midspan joint	
Line conductor suspension clamp	

Description	Tenderer's Drawing Number
Earthwire ACSR tension clamps and midspan joints Earthwire ACSR suspension clamps 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. Earthwire (OPGW) tension clamps and midspan joints Earthwire (OPGW) suspension clamps Line conductor vibration damper Line conductor spacer/spacer damper Earthwire ACSR vibration damper Earthwire (OPGW) vibration dampers	

E.1.3.2 Documentation with Tender

The following is a list of documentation to be submitted with the Tender.

a. Programme of anticipated works, to conform with completion times required in Schedule B.

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 conductors and earthwires in environments at least as hostile as that for the present project.

f. Detailed sets of foundation calculations for the tangent tower types considering two foundation classes, one of which must be Class D (Schedule D12).

g. Other supporting documentation considered appropriate by the Tenderer.

E.1.4 Submittals during contract period

E.1.4.1 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 'Free on Board' (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

E.1.4.2 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 which 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.

E.1.4.3 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 conductors and earthwires 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 earthwire attachments and complete with all necessary erection information.

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 ACSR earthwires.

Tension make-offs and suspension clamps for OPGW earthwires.

Vibration dampers for line conductors and earthwires including calculations to demonstrate the efficacy of the proposed system.

Spacers/spacer dampers for line conductor bundle and in-span location charts including calculations to demonstrate the efficiency of the proposed system.

All OPGW ancillary equipment.

Tower grounding 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 earthwires at different spans and temperatures, all in accordance with the Specification.

Route plans, schedules and profile drawings all in accordance with the Specification.

E.1.5 Contract record drawings

After completion of work on site all Contract Record drawings, as required by the Specification, of:

a. Tower and foundation designs and calculations

b. Tower and foundation details including all types of extensions

c. Insulator sets plus component parts

d. ACSR earthwire suspension and tension sets plus component parts

e. OPGW earthwire suspension and tension sets plus component parts

f. All types of connectors, dampers and joints

g. Grounding details

h. Line conductor and earthwire initial/final sag-tension charts

i. Sag templates

j. Wire clearance diagrams

k. Material lists for each tower

l. Stub setting templates

m. Foundation installation details

n. Foundation setting level diagrams

o. Profiles and strip plans

p. Route maps

q. Structure lists

r. Tower footing resistance chart

s. Tower notice plates and accessories.

E.2 SAMPLES

E.2.1 General

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

SCHEDULE F
DEVIATIONS FROM THE TECHNICAL SPECIFICATION

(information to be provided with the tender)

The Tenderer shall set out below a tabulated statement showing clearly section by section compliance and departures from the Specification and details of alternative proposals. The Tenderer will be deemed to have complied with the Specification in all respects and as written unless qualified in this Schedule.

Section	Departure from the requirements of the Project Specification with details of alternative proposals

SCHEDULE L
SUPERVISORY STAFF AND ERECTION GANGS

Survey Number of Survey Parties: Estimated total route - km of profile surveyed per month:	
Expatriate Field Staff Supervising engineers: Foremen and other grades:	
Maximum Local Labour Force Skilled: Unskilled:	
Foundation Installation Estimated Number of Foundation Gangs: Estimated peak total rate of foundations installed per month:	
Tower Erection Estimated Number of Tower Erection Gangs: Estimated peak total rate of towers erected per month:	
Conductor stringing Estimated Number of Stringing Gangs: Estimated peak total of stringing line km per month:	

MINISTRY OF ELECTRICITY

IRAQ SUPERGRID PROJECTS 132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

VOLUME 3 PRICES AND ESTIMATED QUANTITIES

OCTOBER 2006

LIST OF REVISIONS

Current Rev.	Date	Page affected	Prepared by	Checked by (technical)	Checked by (quality assurance)	Approved by
D	October 06	All	RI FAIR	MJ VANNER	S CHARLTON	J WICHALL
Original	June 05		REVISION DETAILS Issued as Document No 2005/TD341			
A	July 05		Not issued			
B	Mar 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 11/12 Nov 05 - Embedded files deleted. Issued as Document No. 2005/TD341B			
C	July 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06. Issued as Document No. 2005/TD341C			
D	October 2006	All	Revised in accordance with agreements made during MoE/SPCO meeting, Amman, 2/4 May 06 with additional correction of typographical errors and with changes to match the wording of the 132 kV Specification Issued as Document No. 2005/TD341D.			

CONTENTS SHEET

CONTENTS

VOLUME 1

TECHNICAL SPECIFICATION

VOLUME 2

TECHNICAL SCHEDULES

VOLUME 3

PRICES AND ESTIMATED QUANTITIES

VOLUME 3

PRICES AND ESTIMATED QUANTITIES

132 kV SINGLE AND DOUBLE CIRCUIT STEEL TOWER TRANSMISSION LINES

PAYMENT

Unit prices

Unit prices are fixed and firm for the duration of the Contract and not subject to variation for any reason including, but not limited to, changes in the actual quantities used as compared to the estimated quantities use for the purposes of tendering.

Measurements of work for payment

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/m3.

All measurement of the cleared strip shall be based on the prices stated in the 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.

Payments for towers and foundations

The rates given in the Price Schedules for the standard types of towers, standard foundations, and grounding 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 grounding, 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 which may be required to secure foundations against the effects of soil erosion.

If a combined-use tower is proposed and different prices have been entered in the price schedules for the individual tower types it shall be noted that payment shall only be made for the tower type that was necessary at the location; for instance a combined 15°/30° duty tower at a location with say 8°deviation will only be paid at the scheduled rate for a 15°duty tower.

The rates for modified standard foundations shall be made up from the rates in the Price Schedules or shall be otherwise approved.

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 Price Schedules, 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 the Price Schedules. 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 the Schedules and the special extension and the foundations shall be paid for at the appropriate rates stated in the Price Schedules. 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 the Price Schedules.

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.

Payment for tests

The cost of a satisfactory and approved type tests 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. Any costs incurred by the 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.

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 the Price Schedules or, if not defined in the Schedules 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 reimbursed should such tests prove satisfactory, but the Contractor will be called upon to pay all expenses incurred by the Engineer in respect of any work or material found to be defective, of inferior quality, adulterated or otherwise unacceptable.

Work at time and material rates

If the Contractor is required to carry out work at Time and Material Rates the Engineer will furnish the Contractor with such particulars as are necessary to enable the Contractor to prepare detailed drawings and schedules of all such work.

All work at Time and Material Rates shall be paid in accordance with the rates stated in Schedule K, Labour and Equipment Rates for Extra Field Work.

No work shall be carried out on a Time and Material basis without the consent of the Engineer in writing. When this work is in progress the Contractor shall render daywork sheets in duplicate to the Engineer, showing the number of men so employed with the number of hours worked and the detailed quantities of materials used. The Contractor shall obtain the Engineer's certification of the daywork sheets at the time such work is carried out and failure to do so shall render the Contractor liable to forfeit payment.

All applications for payment for such work by the Contractor shall be accompanied by statements authorizing the carrying out of such work, duly signed by the Engineer, and shall be submitted within 3 months of the completion of the work.

SCHEDULE G
PRICES AND ESTIMATED QUANTITIES FOR DEFINITE WORK –

PREAMBLE

Schedules of Prices and Estimated Quantities for Definite Work follow.

The prices inserted in Schedule G shall include all the requirements in the Invitation to Tender. The quantities, rates and prices in Schedule G shall include all design, testing, inspection, plant, labour, supervision, materials, erection, maintenance, transportation, handling, storage, supply and use of Contractor's equipment, temporary works, insurance, profit; together with all general risks, liabilities and obligations set out or implied in the Contract.

Unit prices are fixed and firm for the duration of the Contract and not subject to variation for any reason including, but not limited to, changes in the actual quantities used as compared to the estimated quantities use for the purposes of tendering.

The cost of items against which the Tenderer has failed to enter a price shall be deemed to be covered in the Tender price. The whole cost of complying with the provisions of the Invitation to Tender shall be included in the items provided in Schedule G and where no items are provided, shall be deemed to be distributed among the rates and prices for related items of work.

SCHEDULE G1S - PRICES AND ESTIMATED QUANTITIES FOR DEFINITE WORK (SINGLE CIRCUIT TOWER LINE)

SCHEDULE G1D - PRICES AND ESTIMATED QUANTITIES FOR DEFINITE WORK (DOUBLE CIRCUIT TOWER LINE)

SCHEDULE G2S - SUMMARY OF SCHEDULE G1S – TOTAL PRICES FOR DEFINITE WORK (SINGLE CIRCUIT TOWER LINE)

SCHEDULE G2D - SUMMARY OF SCHEDULE G1D – TOTAL PRICES FOR DEFINITE WORK (DOUBLE CIRCUIT TOWER LINE)

PRICE SCHEDULES TO BE ADDED BY MINISTRY OF ELECTRICITY

SCHEDULE J1

PRICES AND ESTIMATED QUANTITIES FOR LINE MATERIALS AT THE OPTION OF THE ENGINEER - (information to be provided with the tender)

The schedule of Estimated Quantities for Line Materials at the Option of the Engineer follows.

PRICE SCHEDULE TO BE PROVIDED BY MINISTRY OF ELECTRICITY

SCHEDULE J1S - PRICES AND ESTIMATED QUANTITIES FOR LINE MATERIALS AT THE OPTION OF THE ENGINEER (SINGLE CIRCUIT TOWER LINE)

SCHEDULE J1D - PRICES AND ESTIMATED QUANTITIES FOR LINE MATERIALS AT THE OPTION OF THE ENGINEER (DOUBLE CIRCUIT TOWER LINE

SCHEDULE J2

SPECIAL TOOLS AND TEST EQUIPMENT - PREAMBLE

(information to be provided with the tender)

The Tenderer is required to provide a list of recommended special tools and test equipment for a 5-year period from the end of the Defect Liability Period for the Work. All unit prices quoted shall be valid for any special tools and equipment ordered by the Client in this period. Details of all special tools and test equipment required should also be provided. All unit prices quoted shall be valid for tools and test equipment ordered by the Client during the Contract Period.

Main equipment type	Part no/description	Quantity	Unit price

SCHEDULE K
LABOUR AND EQUIPMENT RATES FOR EXTRA FIELD WORK

(Information to be provided with the tender)

a. Labour and staff

The Tenderer shall indicate below against the various grades of labour and staff employed by him for construction their proposed rates of wages per hour or day. Such rates shall be inclusive of allowances which the Tenderer may make other than such allowances as the Tenderer is obliged by Syrian statute or regulation to make.

	*** Grade of labour/staff**		**Unit**	**Rate per unit**
1.	Engineer	Expatriate	8 hr day	
		Local	8 hr day	
2.	Foreman	Expatriate	8 hr day	
		Local	8 hr day	
3.	Surveyor	Expatriate	8 hr day	
		Local	8 hr day	
4.	Skilled labourer		8 hr day	
5.	Unskilled labourer		8 hr day	
6.	Driver		8 hr day	

* Tenderers to indicate clearly where two or more rates apply to one grade of labour or staff for different types of work.

b. Overhead charges and profit

The Tenderer shall indicate his overhead charges and profit including superintendence, time keeping, clerical work, use of tools and all charges not covered by the rates in a. above except equipment and transport.

On the price of labour and staff given in **a**. above ……..%

c. Transport

The following transport charges shall include fuel, oil, maintenance, overhead charges and profit and the services of one driver. Any extra labour required for loading, handling etc will be as given in a. above:

	Description of vehicle	**Transport in use** Rate per hour	**Transport standing** Rate per hour
1	5t truck		
2.	2t truck		
3.	Land Rover type		
4.	Trailer-tractor		
5.	Bulldozer		
6.	Saloon/sedan car		
7.			
8.			

d. Equipment

	Description of equipment	**Equipment in use** Rate per hour	**Equipment standing** Rate per hour
1	Tractor + winch		
2.	Tractor		
3.	Welding set		
4.	Acetylene cutting equipment		
5.	Air compressor		
6.			
7.			