Eskom	Scope of Work	Kriel Power Station

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1 Description of the *works*

1.1 Executive overview

Kriel Power Station Kriel (PS) is one of Eskom's coals fired power stations in the coal fleet. The station consists of six units and generates approximately 3000 MW to the Eskom national grid. The station has been in operation since 1979. Each generator is rated 550MVA. The generators have two pole rotors excited from a static excitation system. The static excitation system uses the generator's stator 18kV output voltage, which is then stepped down to 680V AC via three single-phase excitation transformers. The 680V AC then goes through four parallel thyristor bridge converters where it is converted to direct current (DC) which is fed to the rotor slip rings via carbon brushes.
The 11 kV overhead lines (OHL) [05-00AD01 & 05-00AD02] were constructed to supply substations on the Outside Plant and Common Plant.

The substations that are supplied by the OHL are namely:

- Ash conveyor substation
- Contractor's yard
- Ash water return substation (AWR)
- Slurry Plant
- Ash dams (Duck Pond, Ape Pump, Flight Pumps and South Face Seepage pump)

The OHL achieves the supply to the loads using an H-Pole structure, H-Pole structure assemblies, insulators, isolators, links, surge arrestors and an ACSR conductors and XLPE cables.

This *works* information describes the *works* for the replacement of the 11 kV OHL. This intervention aims to address the challenge that is faced by Kriel Power Station where the station is experiencing capacity related challenges due to the deteriorating OHL. The work outlined by this document is for the *Contractor* to perform engineering, design, manufacturing, factory acceptance test, transportation, off-loading, installation, site acceptance test and commissioning. The *Contractor* for this *work* shall also perform all civil and environmental *works* for the replacement project to ensure the integrity of the OHL.

1.2 Design Approach

The design approach to be followed is referenced to the basic design phase (including all nominative, informative and related documents). The process involves the use of the findings from the preliminary assessment (Unique Identifier (UI): 240-89280115), power system studies (UI: 377-KRL-AABB-D00139-79), Kriel Power Station Ash Dam 4 Electrical Basic design (UI: 377-KRL-ADDB-D00180-1) and all the documentation required as input to the basic design according to the ECM process, to propose the capacity for the upgrade of the 11 kV OHL.

The design process for will consist of the following steps:

- Defining the required functionality of the improved system
- Acquiring all information regarding the existing system and analysing its' functionality.
- Analysing modern technology that is available to perform the functions that are required.
- Ensuring compliance with the relevant standards and requirements.
- Development of conceptual design and basic design.
- Assessment of conceptual alternatives.

The loads and the equipment sizing documents available from the design input documents must form the basis of the design. The results obtained from load flow studies, fault simulations, aerial surveys, civil *works* (including Geotech studies, foundation designs etc.), environmental *works*, and all relevant inputs must be considered to recommend a solution to Kriel PS.

1.3 Design Inputs

1.3.1 Main design inputs

The main design inputs will be:

- Preliminary OHL assessment
- Concept and Basic designs
- Load Schedules
- Single Line Diagrams
- Routing Diagrams
- Site Aerial Surveys
- Site Layout Drawings
- Load Flow and Fault Level Studies Report
- Electrical design requirements
- Civil design requirements
- Environmental requirements
- Distribution OHL design package
- Interface methods
- Standard schematics and drawings
- Internal and External Standards and Guidelines (i.e., legal, environmental, civil, electrical, quality etc.)

1.3.2 Normative References

The following documents are to be read in conjunction with this standard. In cases of conflict, the provisions of this standard shall take precedence. Unless otherwise stated, the latest revision, edition, and amendments shall apply.

OHSACT & REGULATIONS	Act 85 of 1993
Fencing Act	Fencing Act No 31 of 1963 as amended.
SAISC	South African steel construction handbook
NEMA	National Environmental Management Act No. 107 of 1998
ECCS	Recommendations for angles in lattice transmission towers, No. 39.
SANS 282	Bending dimensions of bars for concrete reinforcement.
SANS 1089:1991	Round wire concentric lay overhead electrical stranded conductors
SANS 471:1971	Portland cement (ordinary, rapid-hardening and sulphate-resisting).
SANS 60815-1:2009	Selection and dimensioning of high voltage insulators intended for use in polluted conditions
SANS 626:1971	Portland blast furnace cement.
SANS 675:2009	Zinc-coated fencing wire.
SANS 121:2011/ (ISO 1461:2009)	Hot dip galvanised coatings on fabricated iron and steel articles specifications and test methods
SANS 831:1971	Portland cement 15 (ordinary and rapid hardening).
SANS 920:1985	Steel bars for concrete reinforcement.
SANS 1083:1976	Aggregates from natural sources.
SANS 1491-1:1989	Portland cement extenders, Part 1: Ground granulated blast furnace slag.
SANS 1491-2:1989	Portland cement extenders, Part 2: Fly ash.

SANS 1491-3:1989	Portland cement extenders, Part 3: Condensed silica fume.
SANS 1466:1988	Portland fly ash cement
SANS 2001-CC1:2012	Concrete works (structural)
SANS 2001-CC2:2012	Concrete works (Minor works)
SANS 10100-1:1992	The structural use of concrete. Part 1: Design.
SANS 10100-2:1992	The structural use of concrete, Part 2: Materials and execution of work.
SANS 10144:1978	Detailing of steel reinforcement for concrete.
SANS 10162-1:1993	The structural use of steel, Part 1: Limit-state design of hot-rolled steelwork.
SANS 10162-2:1993	The structural use of steel, Part 2: Limit-states design of cold-formed steelwork.
SANS 10162-3:1993	The structural use of steel, Part 3: Allowable stress design steelwork.
SANS 10280-1:2013	Overhead power lines for conditions prevailing in South Africa
SANS 5861-1 to 4: 2006	Concrete Tests: Making, mixing Curing and sampling
SANS 5862-1 to 4: 2006	Slump of freshly mixed concrete.
SANS 5863: 2006	Compressive strength of concrete (including making and curing of the test cubes).
Agriculture Bulletin 399	Department of Agriculture Bulletin No. 399 ISBN0621082589, A primer on soil conservation.
SANS 61089 IEC:	Round wire concentric lay overhead electrical stranded conductors
SANS 50025 parts 1 to 6	Hot rolled products of structural steels
SANS 1200 A to F series	Civil Engineering Construction Aspects
240-56364545	Structural Design and Engineering Standard
240-57127951	Standard for the Execution of site investigations
240-57127953	Execution of Site Preparation and earthworks
240-57127955	Geotechnical and Foundation Engineering Standard
240-56355754	Field Instrument Installation Standard
240-56227443	Requirements for Control & Power Cables for Power stations Standard
240-56356396	Earthing and Lightning Protection
240-56357424	MV and LV Switchgear Protection Standard
240-56030635	General Requirements for Medium Voltage Cable Systems
240-56227573	AC Metal Enclosed (Metal clad) and Control Gear for voltages above 1kV up to 52kV Standard
ISO 9001	Quality Management Systems.
240-147806256	Determination of Conductor Ratings in Eskom
240-75883906	Medium Voltage Reticulation Section 0: General Information and Requirements for Overhead Lines Up To 33kv Standard
240-75883148	Conventional Stay Planting and Compaction, Pole Planting and Compaction and Rock Anchor Installation and Testing Standard
SANS 10280-1	Part 1: Safety
240-47172520	The Standard for The Construction of Overhead Powerlines (Trmscaac5.2)
Eskom Distribution Upgrade of Kriel Power Station 11 kV Overhead Lines 11kV Kingbird line (Vol. 1-6)	
474-285	Specification for anti-theft measures
474-9428	Line Impedance measurements
32-247	Procedure for vegetation clearance and maintenance within overhead power line servitudes and on Eskom owned land
TSP 41-604	Design, manufacturing, and installation specification for transmission line labels

TST 41-321	Earthing of transmission lines
ASCE Manual 1097	Guide for design of steel transmission towers
IEC 60826:2003	Design criteria for overhead transmission lines.

1.3.3 Informative References

240-53113685	Design Review Procedure
240-53114002	Engineering Change Management Procedure
240-53114026	Project Engineering Change Management Procedure
240-76992014	Project/Plant Specific Technical Documents and Records Management Work Instruction.
SANS 754	Eucalyptus poles, cross-arms and spacers for power distribution and communications systems
240-89280115	Kriel 1kV line: Preliminary Assessment
377-KRL-AABB-D00139-79	Kriel Ash Dam Load Flow and Fault Studies Report
377-KRL-ADDB-D00180-1	Kriel Power Station Ash Dam 4 Electrical Basic Design
32-644	Eskom documentation management standard.
474-285	Specification for anti-theft measures
NRS 061-2:2004	Specification for overhead ground wire with optical fibre. Part 2: Installation guidelines.
NWS 1074	Guy strand grips for transmission lines.
SHEQ	Eskom SHEQ Policy

1.4 Employer's objectives and purpose of the works

The purpose of this document is to provide details of the stakeholder requirements that will ensure that the *Contractor* gives Kriel PS a reliable, available, and maintainable 11 kV OHL to preserve continuity of supply to the common and outside plants until Station's end of life

This document specifies *Contractor's* minimum requirements for engineering work, drawings, procurement, manufacture, quality control & assurance, supply, delivery, installation, decommissioning, commissioning, testing, training, maintenance and handing over of Kriel PS 11 kV OHL replacement.

The scope of work covers the following:

- Complete replacement (including dismantling) of Kriel PS 11 kV OHL including all civil, electrical, and environmental *works*
- Cable *works*
- Plant Interfacing

1.5 Interpretation and terminology

The following definitions and abbreviations are used in this *Works* Information:

1.3.1 Assembly	A combination of one or more low voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc.., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural part.
1.3.2 Overhead Line	An overhead power line is a structure used in electric power transmission and distribution to transmit electrical energy across large distances. It consists of one or more uninsulated electrical cables (commonly multiples of three for three-phase power) suspended by towers or poles.
1.3.3 Capability	Capability is the ability of a resource to achieve its objectives quantified as the sum of expertise and capacity.

1.3.4 Classification	Controlled disclosure**:** controlled disclosure to external parties (either enforced by law, or discretionary).
1.3.5 Switchgear	Switchgear is a generic term and includes the entire range of switching devices and their combination with associated control, measuring, protecting and regulating equipment. The assemblies of such devices and equipment with associated inter-connections, accessories, enclosures and supporting structures, intended, in principle, for use in connection with the generation, transmission, distribution and conversion of electric energy also form switchgear
1.3.6 System	An integrated set of constituent pieces that are combined with an operational or support environment to accomplish a defined objective. These pieces include people, hardware, software, firmware, information, procedures, facilities, services, and other support facets.
1.3.7 Primary Plant	Equipment directly associated with the transmission and distribution of electricity operating at high and extra high voltage. This equipment that is typically segregated in a high voltage yard or building, and includes inter alia transformers, circuit breakers, instrument transformers, isolators, shunt reactors, shunt capacitors and post insulators
1.3.8 Secondary Plant	Low voltage equipment for control, monitoring and protection of primary plant. Interface between this equipment and primary equipment is by means of instrument transformers.
1.3.9 Employer	The party for whom the *works* are to be executed and, in this standard, means Eskom (Transmission, Distribution, Technology, Power Delivery Projects) and where applicable, includes Eskom's appointed successor in title but not, except with the written content of the *Contractor*, any assignee of Eskom.
1.3.10 Contractor	The party appointed by the *Employer* to "Provide the *works*".
1.3.11 Design Engineer/Designer	The person responsible in terms of the "Occupational Health and Safety Act and Regulations" for the *Employer* from time to time to act in the capacity and notified, by name and in writing by the *Employer* to the *Contractor*, as required. He/she shall be ECSA accredited as a professional Engineer/Technologist. All communication to the design engineer shall be done via the Project Manager.
1.3.12 Eskom Site Representative	The person appointed by the *Employer* from time to time to act in the capacity and notified, by name and in writing by the *Employer* to the *Contractor*, as required in "The NEC Engineering and Construction Contract", FIDIC or any applicable contract.
1.3.13 Project Manager	Appointed by the *Employer* under Act 16.2 & Sect 4h (5) of CR as the client's Agent to act as his/her representative. The person responsible for coordinating all aspects of a project. All communication must be channelled via the Project Manager.
1.3.14 Line Specification	A document that specifies the requirements for the relevant line, turn-in or bypass that needs to be constructed, refurbished or any other work that may be required to be executed as part of the project. Specific requirements outlined in the line specification shall take precedence over requirements specified in this document.
1.3.15 Lands	Refers to cultivated land or land set aside for exclusive use.
1.3.16 Design Engineer	Engineers, as practitioners of engineering, are professionals who invent, design, analyse, build and test machines, complex systems, structures, gadgets and materials to fulfil functional objectives and requirements while considering the limitations imposed by practicality, regulation, safety and cost.

1.6 Abbreviations

Abbreviation	Description
A	Ampere
AC	Alternating Current
AWR	Ash Water Return
DC	Direct Current
Dx	Distribution
EA	Environmental Authorisation
EDWL	Engineering Design Work Lead
EIA	Environmental Impact Assessment
EMAP	Engineering Management Plan
EMD	Electrical Maintenance Department
EMP	Environmental Management Plan
EPE	Electrical Plant Engineering
EOD	Electrical Operating Desk
Gx	Generation
PS	Power Station
kV	Kilo Voltage
LDE	Lead Design Engineer
LPS	Low Pressure System
LV	Low Voltage
MV	Medium Voltage
MW	Megawatts
OEM	Original Equipment Manufacturer
OHS	Occupation Health and Safety
OPS	Operating Department
OHL	Overhead Lines
QC	Quality Control
PCM	Process Control Manual
PTM	Protection Testing Metering
SANS	South African National Standards
SHEQ	Safety, Health, Environment and Quality

2 *WORKS* INFORMATION

2.1 Environmental

2.1.1 General

This section refers to Eskom's safety, health, environmental and quality (SHEQ) policy. All activities relevant to the establishment of power line construction and design implementation should be undertaken in accordance with the Eskom SHEQ Policy. Where a discrepancy exists between this document and the SHEQ policy, the SHEQ policy takes precedence and must be adhered to. The environmental management during the construction activities is to ensure that the environmental impact assessment (EIA) recommendations, the statutory environmental authorisation (EA) conditions, the environmental management plan (EMP), the landowners' special conditions and all relevant environmental legislation are implemented, by monitoring the site *works* and regular reporting.

2.1.2 Supervision

The *Contractor* shall give or provide all necessary superintendence during the execution of the *works*. The *Contractor* or a competent and authorised appointee approved of in writing by the *Project Manager* (which approval may at any time be withdrawn) shall be always on the *works* when *work* is being performed or when the *Employer* shall reasonably require it. The *Contractor* shall employ only such persons that are competent, efficient, and suitably qualified with related experience in the environmental field. *Project Manager* shall be at liberty to object to and require the *Contractor* to remove from the works any person, who, misconduct's himself or is incompetent in the proper performances of his duties.

2.1.3 Precautions against damage

a) In accordance with applicable legislation, the *Contractor* shall take all reasonable precautions for the protection of life and property on, or about, or in connection with the *works*.

b) The *Contractor* shall comply strictly with the "Special Conditions" stipulated by the landowners in the negotiated Options.

c) The *Contractor* shall comply with all the conditions specified in the EMP during construction. In general, soil disturbance should be kept to a minimum. The disturbance of land contour banks or other erosion control structures shall be avoided.

d) No damage shall be caused to any crops unless both the landowner and the *Eskom Site Representative*, prior to the work commencing agree upon the extent of the intended damage.

e) There shall be no littering of the veld. The *Contractor* shall provide suitable containers for any waste.

f) No fires shall be allowed on site under any circumstances.

g) The *Contractor* shall be held liable for all damage arising from actions or negligence on the part of his workforce and any such damage shall be repaired immediately.

h) Any additional agreement concluded between the *Contractor* and a landowner not relating to providing the *works*, must be in writing and a copy made available to the *Eskom Site Representative* within 48 hours of such an agreement being concluded.

i) Any environmental incident as specified in the EMP, or accident during construction of the works shall be immediately reported to the *Eskom Site Representative*.

2.2 Sanitation

The *Contractor* is to provide portable toilet facilities for the use of his workforce at all work sites. Under no circumstances shall use of the veld be permitted. To prevent the occurrence of measles in cattle, employees may require to be examined for tapeworm and treated or treated irrespective of whether they are infested or not. Proof of such treatment is to be supplied to the *Eskom Site Representative*. The drug "Niclosamide" (Yomesan, Bayer) is freely available and highly effective against tapeworms in humans. A health care professional (HCP) should be consulted prior to administering. It does not however, prevent re-infestation and regular examination and/or

treatment is required.

2.2.1 Wildlife

a) It is illegal to interfere with any wildlife, fauna or flora as stipulated in the Environmental

Conservation Act No 73 of 1989.

b) When stipulated in the EMP, two different coloured bird diverters are to be fitted on both earthwires (where applicable) along the indicated spans at 5m intervals.

2.2.2 Access

a) The *Contractor* shall negotiate with each landowner the access to reach the servitude

and each tower position. The access agreement will be formalised in the form "TPL 004/005 - Property Access Details" and signed by the three parties. The *Contractor* will mark the proposed route and/or a competent representative will accompany the equipment when opening the access. Any deviation from the written agreement shall be closed and re-vegetated immediately.

b) The *Contractor* shall signpost the access roads to the tower positions, immediately after the access has been negotiated.

2.2.3 Existing Roads

a) Maximum use of both the existing servitudes and the existing roads shall be made. In

circumstances where private roads must be used, the condition of the said roads must be recorded prior to use (e.g., photographed) and the condition thereof agreed by the landowner, the *Eskom Site Representative,* and the *Contractor*.

b) All private roads used for access to the servitude shall be maintained by the Contractor and upon completion of the works, be left in at least the original condition.

c) Access shall not necessarily be continuous along the line, and the Contractor must therefore acquaint himself with the physical access restrictions such as rivers, railways, motorways, mountains, etc. along the line. As far as possible, access roads shall follow the contour in hilly areas, as opposed to winding down steep slopes.

d) Access is to be established by vehicles passing over the same track on natural ground, multiple tracks are not permitted. Access roads shall only be constructed where necessary at

watercourses, on steep slopes or where boulders prohibit vehicular traffic.

e) The *Contractor* is to inform the *Eskom Site Representative* before entering any of the following

areas:

- Naturally wet areas: vlei, swamps, etc.
- Any area after rain.
- Any environmentally sensitive area.

f) If access is across running water, the *Contractor* shall take precautions not to impede the natural flow of water. If instructed, the *Contractor* is to stone pitch the crossing point. There shall be no pollution of water. Access across running water and the method of crossing shall be at the approval of the *Eskom Site Representative* and the landowner.

g) Where the *Eskom Site Representative and/or Project Manager*, deems that damage to the access roads is irreparable, the *Contractor* shall use alternative construction methods compatible with the access and terrain, as agreed with the *Project Manager*.

h) Existing water diversion berms are to be maintained during construction and upon Completion be repaired as instructed by the *Eskom Site Representative*.

i) Where access roads have crossed cultivated farmlands, the lands shall be rehabilitated by ripping to a minimum depth of 600mm.

2.2.4 Construction of new roads

a) Where construction of a new road has been agreed, the road width shall be determined by need, such as equipment size, and shall be no wider than necessary.

b) In areas over 4% side slope, roads may be constructed to a 4% out slope. The road shall be constructed so that material will not be accumulated in one pile or piles but distributed as evenly as possible. The material shall be side-cast as construction proceeds and shall not be side-cast to make a barrier on the downhill side. The cut banks shall not overhang the road cut and shall if necessary be trimmed back at an angle which would ensure stability of the slope for the duration of the *works*. The sides or shoulders of roads shall not act as a canal or watercourse.

c) Water diversion berms shall be built immediately after the opening of the new access road. In addition, water outlets shall be made at intervals where berms are installed, and suitably stone pitched if instructed by the *Eskom Site Representative*.

d) No cutting and filling shall be allowed in areas of 4% side slope and less.

e) Existing land contours shall not be crossed by vehicles and equipment unless agreed upon, in

writing, by the landowner and the Eskom Site Representative.

f) Existing drainage systems shall not be blocked or altered in any way.

2.2.5 Closure of roads

a) Upon completion, only roads as indicated by the *Eskom Site Representative* shall be closed.

b) In areas where no cut or fill has been made, barriers of earth, rocks or other suitable material shall affect closure.

c) In areas 30 % slope and less, the fill of the road shall be placed back into the roadway using equipment that does not work outside the road cut (e.g., back-hoe). In areas of greater that 30 % slope, the equipment shall break the road shoulder down so that the slope nearly approximates to

the original slope of the ground. The cut banks shall be pushed down into the road, and a near normal side slope shall be re-established and re-vegetated.

d) Replacement of earth shall be at slopes less than the normal angle of repose for the soil type involved.

2.2.6 Construction of water diversion berms

a) Where the in-situ material is unsuitable for the construction of water diversion berms, alternative methods of construction must be investigated and proposed by the *Contractor* and submitted to the *Project Manager* for acceptance.

b) Borrow pits - The *Contractor's* decision as to the location of borrow pits, shall be at the *Eskom Site Representative's* acceptance. The *Contractor* shall be responsible for the rehabilitation and re-vegetation of the borrow pits. It is the *Contractor's* responsibility to negotiate the royalties for the borrow pits with the landowner.

2.2.7 Levelling at tower sites

a) No levelling at tower sites shall be permitted unless approved by the Eskom Site Representative.

b) The steep slopes formed by the cut banks and respective fillings when building the tower platforms are to be trimmed back to an angle that ensures stability of the slope. When the ground is loose, berms are to be built on the top of the slope, 2m long logs spaced evenly must be pegged across the downslope, re-vegetated with appropriate local grass seeds together with fertiliser.

2.3 Gates

2.3.1 General

a) Attention is drawn to the Fencing Act No. 31 of 1963 as amended, about, the leaving open of gates and the dropping of fences for crossing purposes, climbing, and wilful damage or removal of fences.

b) At points where the line crosses any fence in which there is no suitable gate within the extent of the line servitude the *Contractor* is to, on the *Eskom Site Representative's* instruction, provide and install a servitude gate as detailed in the relevant drawing. The *Contractor* will mark these crossing points when the tower positions are being pegged.

c) Where applicable game gates are to be installed in accordance with the relevant drawing.

d) All vehicles shall pass through gates when crossing fences and the *Contractor* shall not be allowed to drop fences temporarily for the purpose of driving over them. No construction work shall be allowed to commence on any section of line unless all gates in that section have been installed. Installation of gates in fences on major road reserves shall comply with the ordinances of the relevant Provincial Authority. No gates may be installed in National Road and Railway fences.

2.3.2 Installation of gates

a) Care shall be taken that the gates shall be so erected that a gap of no more than 100 mm to the ground is left below the gate.

b) Where gates are installed in jackal proof fencing, a suitable reinforced concrete sill as shown on the drawing shall be provided beneath the gate.

c) The original tension is to be maintained in the fence wires.

d) Where required, the Contractor shall replace rusted or damaged wire strands on either side of the gate with similar new wiring to prevent the movement of animals. The extent of the replacement shall be on the *Eskom Site Representative's* instruction.

e) Where existing servitude gates are used, they must be refurbished to the latest standard for gates as per the latest approved gate drawings.

2.3.3 Securing of gates

a) The *Contractor* shall ensure that all servitude gates used by him are kept closed and always locked.

b) The *Contractor* shall provide locks for all servitude gates, and when the line is taken over these locks shall be recovered by the *Contractor* and replaced by locks supplied by *the Employer*. The *Contractor* shall also ensure that all existing farm gates used by him are kept closed. The *Contractor* shall provide the *Eskom Site Representative* with keys for the above locks. No keys shall be provided to landowners to avoid conflict situations between neighbouring landowners.

2.4 Line Survey

2.4.1 Plans and profiles

The route of the line will be surveyed by the *Employer*, who will provide all necessary route plans and templated profile drawings, on which, tower types and the position thereof will be indicated.

Position of aircraft warning spheres, bird guards, bird flights diverters and other site-specific environmental considerations will be indicated on the construction profiles.

2.4.2 Setting out of the route

The line route will be set out by the *Employer* prior to the commencement of construction. Bend positions are to be demarcated with iron pegs, set in concrete, and clearly labelled as per approved profile. The diameter of the iron pegs must not be less than 16 mm with 20 mm diameter preferred in rural areas. To ensure visibility of bend positions a cairn of stones must be placed around the peg and whitewashed. The route must further be demarcated by online reference stakes at least 1,2 m high and at approximately 2 km intervals and should in most cases be inter-visible.

2.4.3 Survey beacons at the bend points

At bend positions, the original iron pegs indicating the centre line of the transmission line route are on no account to be disturbed or removed, as these are required for servitude registration purposes. During foundation installation, the *Contractor* is to cast the bend pegs in position with concrete.

2.4.4 Survey by the contractor

a) The pegging of tower positions, and where necessary, the establishing of self-supporting tower leg extensions and guy anchor positions for guy towers, shall be carried out by registered surveyors.

b) The *Contractor,* on completion of each 20 km or suitable section of the line, is to supply records of all distances measured for each individual tower position. These should agree with the profiles, and any discrepancy reported immediately to the *Design Engineer* via the *Project Manager*.

c) It is the *Contractor's* responsibility to inform the Eskom Site Representative immediately, should

1) there be any discrepancy between the topography shown on the profiles and the actual ground.

2) errors be found, for example where a tower position is physically in "lands" and the profile states "no-tower zones".

3) Any new or existing features or other services either above or below the ground be found and which are not reflected on the line profiles. This includes land use, roads, telephone or power lines and pipelines/irrigation equipment which may adversely affect tower positions and/or statutory clearance requirements.

4) The *Contractor*, in his opinion, finds that the site chosen is not suitable for a tower

position, or the tower type indicated on the profiles is not suitable for the tower position e.g., excessive side slope.

d) It is the *Contractor*'s responsibility to ensure that the surveyor is familiar with the limitations and restrictions of the tower types and construction methods used.

2.5 Pegging by the Contractor

2.5.1 Procedure

a) The *Contractor* shall undertake the pegging of the transmission line tower positions along the intended line route. Pegging shall proceed far in advance of foundation nomination and construction.

b) Tower centre position is to be marked with a steel peg not more than 50 mm high. This peg is to be made clearly visible by a stake driven into the ground (1.2 m high) or by rocks, both painted white. The pegs are to carry a tag showing the tower number, tower type and height. The pegs are to be left in position until the tower is erected.

2.5.2 Setting out of angle tower

All angle towers shall be positioned in such a way that the centre phase conductor is on the centre line of the servitude. Off-setting of towers may be required to achieve this. The amount of off-set can be obtained from the relevant tower drawings or by calculation.

2.5.3 Correct placing tower

It is the *Contractor's* responsibility to ensure that accepted survey methods are used, and that checks are done to ensure the correct placing of towers.

NOTE: As numerous numbers appear on the profile drawings, the *Contractor* is to ensure that the actual span distances add up to the length of the straight or section of line between two bends. Any distance which are shown from a line point to a tower are to be taken as unchecked.

2.6 Foundations

2.6.1 Design and Geotechnical

2.6.1.1 Foundation design loads

All foundations shall be designed to the ultimate load as per the relevant line/project standard.

The *Contractor's* prerogative must supply his own design for acceptance by Eskom. The design accountability rests solely with the Contractor.

2.6.1.2 Soil and rock classification

a) Hard Rock: hard to very hard solid or moderately fractured continuous solid rock and including hard to very hard rock of any other description which meets the strength requirements.

b) Soft Rock: weathered or decomposed soft continuous fractured rock but not very/extremely fractured and including rock of any other description which meets the strength requirements for

classification.

c) Type '1' soils: competent soil with equal or better consistency (strength or toughness) than one would encounter in stiff cohesive soils or dense cohesionless soils above the water table. This soil shall have a broad balanced texture (constituent particle sizes) with high average combinations of undrained shear strength and internal angle of friction, with minimum values of $80kN/m^2$ and 30° respectively. The minimum dry specific weight (dry density) shall not be less than 1700 kg/m^3.

d) Type '2' soils: a less competent soil than type "1", with equal or less consistency than one would encounter in firm to stiff cohesive soils, or dry poorly graded medium dense to dense cohesionless soils above the water table. This soil has a dominating texture of clay or sand and silt and with minimum undrained shear strength of $40kN/m^2$. The minimum dry specific weight (dry density) shall not be less than $1550kg/m^3$.

e) Type '3' soils: dry loose cohesionless soil or very soft to soft cohesive soil. Where excavated material does not provide the required backfilling for the foundation type, methods of soil improvement i) shall be considered. If a very pebbly/stony soil or boulders are encountered these must be disposed j), then use imported backfill.

f) Type '4' soils: less competent submerged cohesion and cohesive less soils below the

permanent water table, including soils below a re-occurring perched water table, or permeable soils in low-lying areas subjected to confirmed (known) seasonal flooding. This will be very permeable soils with high water retention capacities where strong water seepage is encountered in the investigation pits.

For Geotechnical design parameters see **Appendix A**

2.6.1.3 Soil/rock: foundation nomination

a) The *Contractor* shall be responsible for the soil/rock investigation and shall delegate this work to an experienced registered professional duly authorised to do so on behalf of the *Contractor* and, who shall accept the responsibility for all the foundation test pit investigations and the foundation type nominations for the corresponding soil profiles. The signed foundation-soil type nomination list and *Contractor's* soil profile log sheets shall be submitted to the *Design Engineer* for acceptance. All soil profiling investigations shall be done in the presence of the *Eskom Site Representative*.

b) The minimum soil investigation requirement shall be the number of test pit excavations as per the illustration shown in Annex E, to allow for the in-situ inspection of the soil. Recording thereof shall be on the Eskom's soil profile and summary sheets, of all the foundation-soil type assessments. Soil profiling standards shall be in accordance with SANS 10161 (i.e., each stratum/layer must be described in terms of MCCSSO). The test pits shall be excavated outside the zone of influence of the appropriate foundation and shall be taken down to a depth equal to the lesser of the depth of the foundation system to be constructed or 3m. In addition, appropriate soils tests shall be carried out where further clarification is required for the correct identification of a soil category. The soil/ rock foundation type nominations based on the procedures shall take place well in advance of actual foundation installation, so as not to disrupt construction activities, and to allow for the possibility of having to conduct laboratory tests on border case or mix layer type soils and/or rocks.

c) Due to the fact that combinations of two or more of the soil or rock classifications could occur at any one foundation position, including rock boulders in a soil matrix, the soil or rock nomination in terms of one of the six classifications shall then be conservatively based on the load transfer of the soil and/or rock encountered over the depth of influence of the approved foundation system. For example, a combination of a type '1' soil and soft rock over the depth of influence of an approved type '1' soil foundation design shall be nominated as a type '1' soil condition and the approved type '1' soil foundation system shall be installed. By following this procedure, the soil or rock nomination at each foundation position shall be one of the six classifications and this shall in turn define which foundation type and system design is to be installed.

d) The test pit shall be suitably backfilled and levelled immediately after the relevant inspections and tests have been completed.

e) Should the foundation conditions at the actual foundation location be found to differ from those identified at the corresponding test pit, the *Contractor* shall immediately inform the *Eskom Site Representative* and a revised assessment made. The acceptance by the *Eskom Design Engineer* of the soil type foundation nomination shall not relieve the *Contractor* of this responsibility. When actual excavation conditions differ from test pit data, and rock or large boulders are encountered at depth, special rock foundations should be designed incorporating the existing rock and/or large boulder(s) as part of the foundations.

f) Where difficult site conditions are encountered, such as, environmentally sensitive areas, i.e., water courses, waterlogged areas-type 4 nominations, slopes with erodible dispersive soils, access etc., an additional more detailed Geotechnical investigation of the area shall be done by the *Contractor* and acceptance of the proposed procedures shall be obtained from *Line Engineering*. Where type 4 soils (waterlogged) are nominated a more detail profile investigation and description is required, i.e., the depth of where the seepage occur, the seepage flow rate, and a description the surrounding area i.e., low lying area, distance to the wetland, river, or seasonally active water course. etc.

g) In waterlogged cases, 2 or more pumps must be used at sumps in the excavation bottom corners to lower the water level allowing installation. The use of well-points method (pumping water out) around the foundation to lower the water level must be investigated before specialised foundations will be considered.

h) Pressure Grout Injected Micro Piles - geotechnical investigation

Where specialised grout injected anchor foundation systems is being installed a more applicable geotechnical investigation for this type of anchor must be done with minimum requirements entailing the following:

☐ An investigative hole must be drilled next to foundation to be installed and flushed with water only, to establish the geotechnical conditions. From the changes of drilling rates, the depths and consistency of layers, can be determined.

☐ The rate of drilling and continuous grout pressure must be recorded for each hole drilled, including all installation information that is: anchor type, size, diameter, depth, etc.

☐ From the pumped-out suspension some characteristics of the soil/rock can be determined and recorded for the layers as encountered. That is: For soil: 1) a clay or sandy soil, 2) hard or soft soil, 3) the colour etc., For rock: 4) hard or soft rock, 5) flushed out as powder, chips, or sandy grains, 6) colour etc.

☐ All this information must be logged (see inspection sheets See Appendix F) for every drilled hole of the foundation. If there are differences between the investigation hole and the actual anchor holes of the foundation, a further investigation hole on the opposite side of the foundation can be drilled to determine more accurate information of the geotechnical conditions.

☐ Soil frictional /shear values and or strengths and other geotechnical conditions influencing the anchor performance shall be confirmed by a minimum of 10% anchor tests as per specification before foundation installation commence.

2.6.1.4 Soil and rock tests

a) In addition to the minimum soil/rock investigation requirements, tests shall be carried out by the *Contractor*, if so, required by the *Design Engineer*, to confirm a soil or rock type classification and shall be conducted in accordance with accepted, good geotechnical engineering practices, and shall include but not be limited to the following:

1) Standard penetration tests or Dutch Cone penetrometer tests.

2) Visual classification of soils.

3) Determination of present and probable water table level.

4) Laboratory and/or site tests to determine soil friction angles and cohesion values.

5) Laboratory tests to determine stress-strain modules of soils and rock.

6) Laboratory and/or site tests to determine soil unit weights.

7) Laboratory and/or on-site tests to determine the soil texture i.e., whether the soil is

predominantly clay, silt, sand, or gravel.

8) Continuous rock cores with recovery values and drilling times.

The standard penetration tests and recovery of soil samples shall be obtained in each soil strata encountered or at 1.5 m intervals, whichever is less. Rock cores shall extend a minimum of 3.0 m into sound rock.

b) The soil/rock investigation shall be conducted to recognised standards to ensure that all

encountered soil and/or rock strata are identified and delineated by area along the line route. It shall be the *Contractor's* responsibility to perform adequate soil/rock investigations to the satisfaction of the *Eskom Design Engineer* to determine the soil/rock suitability at each site.

2.6.1.5 Drilled foundations, geotechnical design parameters

Soil /rock design parameters for final design and construction of drilled foundations shall be determined by pile tests, foundation tests or comprehensive soil /rock investigations. The *Contractor* is fully responsible for the final foundation designs.

As a guide only, "average" parameters are set out below:

a) In type '1' or type '2' soils, a skin friction with a maximum of 80 kPa in a type '1' soil, and a maximum of 40 kPa in a type '2' soil, may be used. The skin friction values that are used shall not exceed 80% of the ultimate friction determined from appropriate soil tests.

b) In soft rock, when non-shrink grout or concrete is utilised, a maximum skin friction of 135 kPa may be used in all piles or anchors. A 37° frustum shall be used to check an anchor group pull out resistance. The skin friction value shall not exceed 80% of the ultimate friction determined from appropriate rock tests.

c) In hard rock, when non-shrink grout or concrete is utilised, a maximum skin friction of 350 kPa may be used in anchors with a maximum diameter of 150 mm. A 45° frustum shall be used to check anchor group pull out resistance. The skin friction value shall not exceed 80% of the ultimate friction determined from appropriate rock tests.

d) The depth of any pile(s) in a pile group in soils shall be so calculated to resist the uplift force on the pile or pile group. For a type '1' soil, a 30° frustum for suspension towers, and a 25° frustum for angle strain towers may be assumed. Similarly for a type '2' soil, a 20° frustum for suspension towers, and a 15° frustum for angle strain towers may be assumed.

e) No horizontal shear resistance on the piles or pile cap shall be assumed for re-compacted excavated soil. The lateral resistance of undisturbed soil shall be ignored in the top 300mm from ground line, and taken as the lesser of 100kPa or 80% of the permissible bearing determined from appropriate tests from 300mm below ground level to the bottom of the pile cap. If the pile cap is not capable of restraining the entire horizontal base shear, the piles and pile cap shall be designed to resist the shears and moments introduced from the pile cap to the individual piles. A soil bearing pressure of 200kPa in type '1' or 100kPa in type '2' soil shall be allowed under the pile cap. End bearing components for compressive loads shall not be considered in soil replacement type piles with a diameter less than 750mm.

2.6.1.6 Strength factors for foundation systems

For overhead lines supporting voltages more than 132kV (Reliability level 2 and higher), the determination of appropriate design loads for foundations will consider Failure Sequencing strength factors as defined in SANS 10280-1, Table 2.

For overhead lines of 132kV and lower (Reliability level 1), the use of failure sequencing strength factors is at the *Design Engineer's* discretion.

2.6.2 Foundation Systems

2.6.2.1 General

a) Before foundation excavation commences the *Contractor* shall submit to the *Project Manager* drawings and relevant design calculations of all the proposed foundations intended to be use for acceptance by the *Design Engineer*. Acceptance by the *Design Engineer* does not relieve the *Contractor* of his responsibility for the adequacy of the design, dimensions, and details. The *Contractor* shall be fully responsible for his designs and their satisfactory performance in service. A registered *Civil Engineer* or *Civil Engineering Technologist*, duly authorised to do so on behalf of the *Contractor*, shall accept responsibility for all foundation designs and drawings submitted to the *Design Engineer*, and shall sign all drawings accordingly. If the *Employer* provides foundation designs and/or drawings, a registered *Civil Engineer,* or *Civil Engineering Technologist*, acting on behalf of the *Contractor*, shall check and assume responsibility for such designs and/or drawings. All foundation design loads are to be shown on the relevant foundation drawing.

b) No foundation shall be constructed without the *Design Engineer* acceptance. All drawing revisions shall be submitted to the *Design Engineer* before being issued for construction purposes.

c) Only with the specific permission of the *Design Engineer*, may more than one design per soil or rock type of any foundation system for a tower type be utilised.

d) A ground slope of up to and including 12 degrees to the horizontal in any direction shall be assumed at all foundation positions for design purposes.

e) No grillage or steel plate type foundations are allowed.

2.6.2.2 Pad and pier/column foundations for self-supporting towers

a) The foundations shall be designed to withstand, with less than 20 mm of differential settlement or displacement, the maximum foundation reactions resulting from the withstood loadings stated in the Works Information, with the dead weight of the tower included at unity factor of safety.

b) The foundations shall be designed for the maximum combinations of compression, uplift, and horizontal shear forces. In addition, a 250 mm minimum and 650 mm maximum projection of the pier and stub above ground level shall be incorporated in the design unless special approval has been granted by Eskom. The stub only is to be encased in concrete; the tower steel above the members is not to be encased.

c) All concrete subjected to tension, where the permissible tensile stress is exceeded, shall be adequately reinforced with deformed reinforcing steel bars. The design shall be in accordance with the requirements of SANS 10100. The maximum permissible tensile stress in the concrete shall be 1.75 MPa. Piers shall be reinforced for their full length with the reinforcing properly anchored in the pad. The minimum number of longitudinal vertical bars provided in a pier shall be four 16 mm diameter bars with a minimum yield stress of 450 MPa. The links shall be 10mm diameter minimum mild steel bars at a maximum spacing of 300mm.

d) Pads designed with a 45° plinth only may be utilised. All faces of such a core where the permissible tensile stress in the concrete is exceeded is to be adequately reinforced to prevent the development of tension cracks.

e) The foundation shall be designed to resist the vertical compression load at the bottom of the foundation. The foundation shall be checked to ensure that "punch-through" of the stubs shall not occur. The maximum soil bearing pressure allowed due to the vertical compressive load, plus the mass of the foundation, less the mass of the soil displaced by the foundation, shall not exceed the values for the soil type involved.

f) In addition to the vertical compression and tension loadings, the foundations shall be designed for the overturning moment and resultant soil toe pressure due to the remaining horizontal base shears applied at the top of the foundation, including the maximum foundation projection. The maximum soil toe pressure shall not exceed the value for the soil type involved.

g) The foundation shall be designed to resist the vertical uplift load, by means of the mass of the foundation plus the nett mass of the soil frustum acting from the bottom of the foundation base. Bracing shear forces shall be considered in the pier design of towers.

h) The structural steelwork shall be firmly keyed into the concrete by means of adhesion between steel and concrete and bolted-on cleats. The load shall be transferred by means of bolted-on cleats where the bolts shall have no thread in the shear planes. The cleats shall be so positioned on the structural steel member, to limit punching shear in the concrete due to both tension and compression load cases. When calculating the number and size of cleats required the maximum contact pressure between cleat and concrete shall not exceed 10MPa. The number of cleat bolts required shall be calculated for the ultimate shear stress with no thread in the shear plane. Galvanising of stubs and cleats shall be in accordance with SANS 121:2011 / ISO 1461. Galvanising thickness to be minimum 105 microns.

i) The least lateral dimension 'd' of a pier/column shall not be less than the greater of 400mm or L/5, where 'L' is the lesser of the vertical height measured from top of pad level to the top of the concrete pier, or the vertical height measured from founding level to the top of the concrete pier when a pad is not utilised. For circular pier sections 'd' represents the diameter and for square or rectangular sections 'd' represents the length of the shortest side.

2.6.2.3 Pad and plinth foundations for guyed tower centre supports

a) The foundations shall be designed to withstand, with less than 20 mm of settlement, the maximum foundation reactions resulting from the loadings stated in the standard, with the ultimate load.

b) The minimum depth of the mast support foundation(s) shall be 750 mm in type '1' and type '2' soil, and 1000 mm in type '3' and type '4' soil. The soil at the bottom of the foundation shall resist all stresses resulting from the vertical compressive loads and toe pressures due to horizontal shear forces. The mass of the foundation less the mass of the soil displaced by the foundation shall be included in the vertical load applied.

c) The foundations shall be designed for the maximum combinations of compression and horizontal shear forces. In addition, a 1500mm projection of the plinth above ground level in the case of cross rope suspension type towers, and a 650mm projection in the case of guyed 'V' type towers, shall be incorporated in the design to allow for leg extension increments.

d) All concrete subjected to a tension where the permissible tensile stress is exceeded, shall be adequately reinforced with steel reinforcing bars in compliance with SANS 920. The design shall be in accordance with the requirements of SANS 10100.

e) Anchoring of the tower bases of guyed "V" towers shall be by means of anchor bolts. The maximum shear on anchor bolts shall be 0.6 times the ultimate tensile strength of the bolt. If the anchor bolts must resist compression loads from the base plate, the compression load shall be resisted by mechanical anchorage, and not by adhesion between steel and concrete, unless deformed bars are utilised for anchor bolts.

f) In some cases of soil type 1 to 4 pad foundations where rock is encountered at shallower depth than required by the soil foundation, a combination of rock anchors (to provide the additional uplift resistance) can be utilised.

2.6.2.4 Drilled foundation

The *Contractor* shall have equipment for, and personnel knowledgeable and experienced in, the evaluation construction of this type of foundation.

2.6.2.4.1 General

1) The *Contractor* shall allow for the testing of two separate piles/anchors in each of the soil or rock types for which they have been designed. Pile/anchor tests if so, required by the *Design Engineer*, are to be successfully tested to the *Design Engineer's* satisfaction prior to construction of cast-in-situ pile/anchor foundations.

2) All design clauses relating to drilled concrete foundations shall apply.

3) Piles shall be designed to limit ground line vertical deflection, at maximum loadings, to less than 12 mm.

4) The minimum centre to centre spacing of any two piles in a group of piles shall be three

pile diameters of the pile with the larger diameter, unless otherwise accepted by the *Design Engineer*.

5) The structural steelwork shall be firmly keyed into the concrete by means of bolted-on

cleats. The adhesion between steel and concrete shall not be relied upon to transmit the

load to the foundation. The cleats shall be so positioned on the structural steel member, so

as to limit punching shear in the concrete due to both tension and compression load cases. When calculating the number and size of cleats required the maximum contact pressure between cleat and concrete shall not exceed 10MPa. The number of cleat bolts required shall be calculated in accordance with SANS 10162-1: 2005.

6) Pile caps shall have a minimum thickness and width of 750mm for loads above 400kN.

2.6.2.4.2 Single cast-in-situ piles

Foundations utilising one cast-in-situ concrete pile will be considered by the *Design Engineer* if the following criteria are met:

1) If a pile cap is not utilised, the pile shall have a minimum diameter of 350 mm in order that the structural steel attachment of the tower can be accommodated without conflict with the reinforcing steel. The option of raking with the correct set to reduce shear may be considered should a pile cap be utilised, the minimum pile diameter shall be 300 mm.

2) The pile shall be constructed vertically and shall be designed for the maximum combinations of uplift and compression loadings, and the total horizontal base shear forces associated with the vertical loadings. Total horizontal shear applied at the top of the foundation, including the 650 mm maximum projection above ground level, is to be included. Lateral load design bending moments shall be calculated considering possible plastic soil deformation. Raked piles will be accepted upon submission of all method statements and review of calculations and drawings by the Design Engineer for acceptance.

3) The pile shall be designed to ensure that it acts as a rigid pile. Horizontal deflection at the top of the projected pile under ultimate loading shall be limited to 5 mm.

4) Single in line guy anchor piles shall only be designed for type 1 soil and with an additional load factor of 1.2, a minimum diameter of 300mm and meet all the requirements.

5) The lateral pressure on the leading face of the cap in the rock, as well as the friction on the two side faces in the rock shall be 135kPa for soft rock and 300kPa for hard rock or 80% of the permissible value determined from appropriate tests.

6) All Piles shall be tested.

2.6.2.4.3 Multiple cast-in-situ piles

Foundations utilising multiple cast-in-situ piles of a minimum diameter of 300 mm, will be

considered by the *Design Engineer* if the following criteria are met:

1) A minimum of two vertical piles per leg are used, connected to the structural steelwork by means of a reinforced concrete pile cap. Raked piles will be upon submission of all method statements and review of calculations and

drawings by *Design Engineer*.

2) The piles and pile cap shall be designed for the maximum combinations of uplift and compression loadings, and the total horizontal base shear forces associated with the vertical loadings, including leg shear. Lateral load design bending moments shall be calculated considering possible plastic soil deformation.

3) The piles shall be reinforced for their entire lengths to resist the applied axial and bending forces and sufficient reinforcing hoops shall be provided to support the vertical reinforcing. The reinforcement shall extend into the pile cap sufficiently and shall be suitably anchored to ensure full transfer of forces from pile cap to pile. The pile cap shall be reinforced to withstand the shear and bending forces applied by the structural steelwork.

4) The minimum pile centre to centre spacing shall be three times the pile diameters. Allowance shall be made for the smaller group effect when two or more piles, with a centre to centre spacing of less than three pile diameters, are used in a group.

2.6.2.4.4 Rock anchors

Foundations utilising grouted rock anchors will be considered by the *Design Engineer* if the

following criteria are met:

1) A minimum of four vertical rock anchors shall be used and connected to the structural steelwork by means of a reinforced concrete pile/anchor cap. Inclined rock anchors shall not be used without the *Design Engineer's* prior acceptance.

2) Rock anchor foundations shall be designed to anchor and accommodate rock up to 2.5m depth below the ground surface with the tower leg/stub in a reinforced column like the pad and column foundation.

3) The rock anchors shall be designed to resist the full axial forces imparted by the maximum combinations of uplift and compression loadings, and additional axial loads due to the total horizontal base shear. The design shall incorporate a 650 mm maximum projection of the foundation above ground level. The rock anchors shall not carry any horizontal shear load.

4) The pile/anchor cap shall be designed to resist the total horizontal base shear. No horizontal shear resistance shall be assumed for re-compacted excavated soil. The base of the pile cap shall be extended to a minimum of 150 mm below the top of sound rock over its full area irrespective of horizontal shear resistance requirements.

5) The rock anchors shall be reinforced for their entire length to resist the applied axial forces and the reinforcing extend into the pile cap sufficiently and is suitably anchored to ensure full transfer of forces from pile/anchor cap to anchor(s). The cap shall be reinforced to withstand the shear and bending forces applied by the structural steelwork. The rock anchor reinforcing steel shall be a minimum diameter of 25mm and de-bonded, by a method accepted by the Design Engineer for a length of 100 mm above and 300 mm below the pile cap base.

6) Rock anchors shall only be installed in hard rock, or sound competent soft rock. Proposals to utilise rock anchors in materials such as shale etc. shall be specifically accepted by the *Design Engineer* after a pile/anchor test has been conducted. An additional test to verify that the pile cap will resist the entire horizontal base shear may also be required if so, specified by the *Design Engineer*. The lateral pressure on the leading face of the cap in the rock, as well as the friction on the two side faces in the rock

shall be 135kPa for soft rock and 300kPa for hard rock or 80% of the permissible value

determined from appropriate tests.

7) The use of grout mixes, including proprietary mixes, shall be accepted by the *Design Engineer* prior to the use of such. Documented evidence of use in other similar applications, which have been accepted by a recognised authority, shall be submitted as

proof of suitability. In-situ rock anchor testing shall be carried out.

8) Rock anchors with diameter smaller than 85mm shall only be installed in sound competent rock where the holes have uniform diameters, straight sides and special grouts are used (epoxy or similar with 50MPa minimum strength) as approved by the *Design Engineer*. In-situ rock anchor testing shall be carried out.

9) Allowance shall be made for all possible group effects when two or more anchors, are used in a group. For 40 mm anchors the centre to centre spacing shall be greater than or equal to 500 mm and for 100 mm anchors the centre to centre spacing shall be greater than or equal to 650 mm.

10) Rock anchors shall be tested.

11) Inclined rock anchors shall have galvanized anchor bars. To ensure complete compaction of the grout/epoxy, it shall be pumped into the holes from the bottom upwards.

2.6.3 Guy anchors

2.6.3.1 General

a) The *Contractor* shall be responsible for the type of anchors chosen and the design thereof. Anchors requiring or relying on post tensioning will not be allowed. The design of guy anchors shall include a minimum of 105-micron thick hot dip galvanising on steel link plates (type S355JR steel) with the following minimum cross-sectional dimensions for the respective voltages

1) For 275/400kV power lines – link plate minimum cross-sectional dimensions to be 120 mm width x 25 mm thick.

2) For 765kV power lines- the link plate minimum cross-sectional dimensions to be 130 mm width x 30 mm thick.

3) All link plates width to be orientated with the width in a vertically plane (include sketch

below). In addition, the U-bolts (both U legs in the same angled level plane) should be

covered adequately to prevent cattle from being caught.

4) All link plates must be painted with a bitumastic paint 500mm below ground level and 500mm above ground level.

b) Unless otherwise specified, the anchors shall be capable of resisting a tension as stated in the Line Specification Contract documents and satisfy the test requirements.

c) Owing to the dissimilarities in anchor performance and conventional foundation performance in uplift conditions, the *Contractor* shall exercise extreme caution in utilising soil / rock parameters for the design of anchors. Full-scale load tests shall be utilised to determine actual soil holding capacities of anchor designs for 5% of installed anchors. The depth of dead man type anchors shall be determined with respect to the dead man and not the attachment point.

d) All steel link plates extending below the ground level, shall be encased in concrete (minimum grade 25MPa/13 mm coarse aggregate) using a 300 mm diameter minimum HDPE (High Density Polyethylene) pipe as permanent formwork. The encasement shall be proud of the ground by a minimum of 250 mm with an appropriately smooth trowelled watershed top surface.

e) Steelwork of the guy anchors shall be so selected by the *Contractor* to have the following minimum properties:

All ferrous material representing the final product shall have a minimum Charpy V-notch impact energy of 27 joules at 20°C.

Ductility of all ferrous material at room temperature shall be sufficient to provide a minimum elongation in a gauge length of $5.65\sqrt{So}$, including the fracture, of 18 percent. (So= cross section area of the test specimen). Grade S355JR steel which, when tested, meets the above requirements may be accepted at the Design Engineer's discretion.

f) Guy anchors shall be installed in such a manner that the legs of the U-bolt are in the vertical plane. The design of the hole to fit the U-bolt must be adequately chamfered to cater for the complete profile of the U-bolt. Hole edge chamfering alone is not adequate for the thickness of the link plates used. See also 7.3.

g) The total anchor assembly (link plus reinforcing steel) for single in line drilled anchors less than 250 mm in diameter shall be hot dip galvanised. The entire link assembly for single in line drilled anchors greater or equal to 250 mm in diameter shall be hot dip galvanised. All hot dip galvanizing shall be in accordance with SANS 121.

h) The link plate shall be firmly keyed into the concrete by means of bolted-on cleats. The cleats bearing pressure on the concrete shall not exceed 10MPa. When calculating the number and size of cleats required, the number of cleat bolts required shall be calculated in accordance with the bolt grade ultimate strength.

i) Anchors blocks shall have a minimum thickness and width (i.e., cross section) of

750mm.

2.6.3.2 Single inclined drilled pile anchors

a) Inclined drilled anchors shall be design with of maximum tension capacity of 0.7 (as per 6.17, SANS 10280 Table2) that is 1.43 times the ultimate applied load.

For single in line drilled micro pile and pile anchors, the following top depths from the surface shall be ignored for anchorage purposes:

1) for rock anchors in hard rock ignore the top 350 mm of the rock profile

2) for rock anchors in soft rock ignore the top 650 mm of the soil profile

3) for soil anchors ignore the top 1200 mm of the soil profile

b) Inclined Rock anchors smaller than 150mm diameter shall have galvanized reinforcing bars with a minimum diameter of 25 mm.

c) Inclined piles in soil shall be a minimum diameter of 300mm

d) The distance between the highest point of the foundation and the ground surface shall be a minimum of 250 mm and a maximum of 600 mm.

e) The concrete grout shall be pumped into pile hole from the bottom upwards by means of a tremie pipe extending down the full length of the pile hole. A poker vibrator shall be placed in the bottom of the pile hole prior to any concrete placement and gradually lifted together with the concrete pour.

f) Proof load testing (full scale) is to be done on a minimum of 10% of all in line drilled/inclined pile anchors which will be randomly selected or where required by the *Design Engineer* and *Eskom Site Representative*.

2.6.3.3 Foundations for concrete or steel poles

2.6.3.3.1 General

1) The *Contractor* shall be responsible for the design of all foundations for pole structures.

2) The foundations shall be designed to withstand the maximum combinations of induced

factored moment, compression, and torsion loads. The dead weight of the pole shall be

included at unity factor of safety.

3) All foundation designs are to be accepted by the *Design Engineer* prior to the utilisation of any such design for pole installation purposes.

2.6.3.3.2 Testing

1) Prior to the construction of any pole foundations, the *Contractor* shall, if requested by the *Project Manager / Design Engineer* install in each general soil type encountered and at any additional locations, test poles for the purpose of carrying out full scale load tests to determine the moment carrying capacity in each soil type.

2) The test pole and foundation shall not be part of a final foundation.

3) The *Contractor* shall prepare the test procedure and supply all equipment and personnel to perform the tests. The tests shall be conducted in the presence of the *Eskom Site Representative*.

4) The pole foundation shall be capable of withstanding the full design moment (ultimate

moment) for 5 minutes with a displacement at ground level of less than 5 mm.

5) The test shall be continued to failure of either the pole or the foundation i.e., either a creep rate greater than or equal to 2 mm per minute of the pole measured at ground level, or a pole tip deflection greater than or equal to 10° with respect to the original point of intersection of the pole with the ground.

6) Upon completion of the test, the pole shall be either removed or demolished to at least 600mm below ground level and properly disposed of and ground to be rehabilitated.

2.6.3.4 Special foundation designs

If the geotechnical investigation reveals any other severe or extreme conditions applicable to the construction of the foundations, special foundation designs may be required. For example, these special designs can be applied for the construction of power lines over undermined areas, on severe slopes or foundations subjected to water scour or marshy areas. These foundation designs shall be subject to the acceptance by the *Design Engineer.*

2.6.4 Concrete and grouts

2.6.4.1 General

a) Concrete mix designs shall be proportioned to obtain a specified strength of 25MPa, and a target strength of 35MPa, with a minimum cement: water ratio of 1.8: 1 as per SANS 10100-2. No more than one individual 28-day concrete test cube result from the 4-cube batch shall fall more than 3MPa below the minimum specified strength. For moderate to severe conditions the mix design shall comply with SANS10100-2 where the minimum cement content shall be 340 kg/m3 CEM II or CEM I cement with extenders.

b) Grout mix designs for rock anchors shall be proportioned to attain a specified strength of 35MPa at 28 days with any expansive additives included. The use of epoxy grouts will only be allowed after acceptance by the *Design Engineer*.

c) Water shall be of a potable quality, clean and free from all earthy, vegetable, or organic matter, acids or alkaline substances in solution or suspension.

2.6.4.2 Cement types

a) Concrete shall be batched utilising common cement types manufactured in accordance with SANS ENV 197-1.

b) The minimum cement class used in concrete will be Class 32.5.

c) CEM I - Class 52.5 and accelerating admixtures shall not normally be utilised for concrete batching. Their use will only be considered by the *Design Engineer* in unusual circumstances, to expedite tower erection to facilitate conductor stringing. The *Contractor* shall make test cubes and arrange for their testing, to confirm the concrete strength, and obtain acceptance from the *Eskom Site Representative* before proceeding with other activities.

d) Site blending will be acceptable provided the following criteria are met:

1) Proportion of Portland cement and Extenders are within industry norms (i.e. maximum 50% replacement for slag and maximum 25% replacement for Fly Ash).

2) The cementitious materials shall be weighted into the mix with an accuracy of 2% or better. In special cases the *Design Engineer* may require that the replacement value indicated in i) above be increased.

e) The cement utilised for grout mixes shall be of a “non-shrink” type. Any shrinkage-compensating admixture shall only be used with the *Design Engineer’s* acceptance.

f) Cement extenders used shall comply with the following SANS specifications:

1) Ground granulated blast furnace slag (slag) – SANS 1491-1

2) Fly Ash (FA) SANS 1491-2

3) Condense silica fume SANS 1491-3

g) Lesser durable concrete mixes (without blenders) can be designed if the *Contractor* proof that no severe conditions exist by analysing the soil along the line for Chlorites and Sulphates and testing the concrete aggregate for ASR proneness. These laboratory reports (with results) and tested mix designs and must be submitted to Eskom for approval.

2.6.4.3 Aggregates

a) Fine and coarse aggregate shall be obtained from sources accepted by the Design Engineer and shall be assessed in accordance with SANS 1083.

b) Fine aggregate shall be natural sand or other accepted inert material with similar characteristics, composed of clean, hard, strong, durable, uncoated particles. Fine aggregates shall be free from deleterious amounts of soft, flaky, or porous particles, loam, soft shale, clay lumps or organic material.

c) Fine aggregates shall be selected from local sources to provide a reasonably uniform grading of the various size fractions. Fine aggregates having a large deficiency or excess of any size fraction, shall be avoided to the extent practicable.

d) Coarse aggregate shall consist of crushed stone, gravel, or other accepted inert material of similar characteristics having hard, strong, durable, uncoated pieces free from deleterious substances.

e) Coarse aggregates up to 26.5 mm nominal size may be single-sized stone. Coarse aggregates up to 40 mm nominal size shall be blended consisting of two parts by volume of single-sized 40 mm stone to one part by volume of single-sized 20 mm stone. The content of fine material (less than 4,75mm) in coarse aggregate shall be less than 10% by mass.

f) The bulk void content of fine or coarse aggregate shall not exceed 48%. Aggregate shall not contain any materials that are reactive with any alkali in the aggregate itself or in the cement, the mixing water or in water in contact with the finished concrete or grout in amounts sufficient to cause excessive localised or general expansion of the concrete or grout.

g) The acid soluble chloride as NaCl level in aggregate as a percentage by mass shall not exceed the limits (Notwithstanding the limits on chlorides as per SANS 1083 (BS 882):

NOTE: These limits shall be subject to the overall limit for the concrete as mixed.

h) The maximum nominal aggregate size for concrete batching shall be as follows:

- Unreinforced concrete: 37.5 mm
- Reinforced concrete excluding piles: 26.5 mm
- Piles: 19 mm
- Grout: 10 mm

2.6.4.4 Workability

a) Concrete mix designs and batching shall be conducted in a manner to achieve adequate workability, to ensure that the concrete will be dense, without voids or honeycombing.

b) The design mix workability of the concrete, as determined by the "Slump Test", shall meet the following requirements by application:

1) Unreinforced concrete: 25 mm – 75 mm

2) Reinforced concrete for conventional foundations and pile caps: 65 mm – 100mm

3) Reinforced concrete for cast in-situ piles: 100 mm – 150 mm

4) Reinforced concrete for cast in-situ inclined piles/anchors: 150 mm – 200 mm

c) Adjusting of the slump on site shall only be done by adding the mix design admixture amount strictly to manufacturer's instructions and mix proportions.

d) The consistency of grout mixtures shall be proportioned so that the mixture is pourable. The fine aggregate to cement ratio shall not exceed 3:1 irrespective of workability.

e) Any admixtures to the concrete proposed by the Contractor shall be subject to the *Design Engineer's* acceptance.

2.6.4.5 Reinforcing steel

a) All main reinforcing steel shall conform to SANS 920 Type C, Class 2, and Grade II hot rolled deformed bars with a minimum yield stress of 450MPa. The minimum bar size utilised shall be 10 mm.

b) All secondary reinforcing for stirrups, hoops, and spirals, shall as a minimum conform to SANS 920 Type "A" hot rolled bars of plain cross-section of mild steel with a minimum yield stress of 250MPa.

c) At the Contractor's option or as required by design, Type B or Type C reinforcing steel may be utilised. The minimum bar sizes utilised shall be at least 0.25 times the largest main reinforcing bar, or 0.01 times the average of the cross-sectional dimensions of the concrete with a minimum diameter of 6 mm allowed.

2.6.5 Construction

2.6.5.1 General

The first installation of each foundation per soil type shall be witnessed by the *Design Engineer*.

Two Holding points are required during the foundation construction before proceeding with the next construction phase.

- First holding point; No construction may start without the approval of the foundation -soil nominations by the *Design Engineer*.
- Second holding point; No concrete may be placed before the inspection of the excavation, reinforcing, stubs or link positions, have all been checked by the *Eskom Site Representative.*

The *Eskom Site Representative shall* take photos at the 2nd holding point before concrete placing and then during the backfilling. These photos shall be submitted on a regular basis to the *Eskom Project Manager* and the *Eskom Design Engineer*.

2.6.5.2 Excavation

a) At each tower or pole position, the *Contractor* shall excavate, construct the appropriate foundation, and backfill the excavation as required. Excavation in this instance shall be the removal of soil/rock by any accepted means for the purpose of constructing a particular foundation system, including conventional pad and pier type foundations, spread footings, piles, anchors, etc.

b) No excavation work, other than for soil investigation, shall be commenced on a section of line until the following conditions have been met:

1) The *Contractor* has submitted a schedule of tower leg ground levels and proposed leg

extension lengths to the *Design Engineer*.

2) The *Contractor* has submitted the proposed foundation and soil type nomination

schedules to the *Design Engineer*.

3) If drilled cast-in-situ piles or rock anchors are proposed, soil samples and pile/anchor tests have been conducted, if so, instructed by the *Design Engineer*.

4) The excavated topsoil shall be kept separate from the subsoil

c) Excavations shall be made to the full foundation dimensions required and shall be finished to the prescribed lines and levels. The bottom or sides of excavations upon or against which concrete is to be poured shall be undisturbed for type 1 and type 2 soils. If, at any point in excavation, the natural material is disturbed or loosened or over excavated, the over-excavations shall be backfilled with 10 MPa concrete, including the application of a blinding layer at the base of foundations where these eventualities are likely to occur during the construction process. Soil backfilling will not be accepted.

d) When the material at foundation depth is found to be partly rock or incompressible material, and partly a soil or material that is compressible, all compressible material shall be removed for an additional depth of 200 mm and backfilled with 10 MPa concrete "reimbursable as per to the bill of quantities".

e) The excavations shall be protected to maintain a clean subgrade until the foundation is placed. Any water, sand, mud, silt, or other objectionable material which may accumulate in the excavation including the bottom of pile or anchor holes, shall be removed prior to concrete placement.

f) Excavations for cast-in-situ concrete, including pile caps cast against earth, shall be concreted within seventy-two hours after beginning the excavations. In addition to this general requirement, pile and/or anchor holes that are not adequately protected against the elements, must be corrected and be acceptable to *the Eskom Site Representative*. Soil excavations that remain un-concreted longer than seventy-two hours shall, be required to be enlarged by 150 mm in all sides/directions.

g) The excavations shall be kept covered or barricaded in a manner accepted by the *Eskom Site Representative* to prevent injury to people or livestock. Plastic danger tape shall be added to barricade for visual purposes. Failure to maintain proper protection of excavations may result in the suspension of excavation work until proper protection measures have been restored.

h) The *Contractor* is to notify the *Eskom Site Representative* upon completion of the excavation for the foundations. No concrete is to be placed until the excavation; shuttering and reinforcing steel have been inspected and accepted in writing by the *Eskom Site Representative*.

2.6.5.3 Backfilling

a) After completion of foundation construction, the *Contractor* shall backfill each excavation with suitable material. The *Eskom Site Representative* shall accept the materials used for backfilling, the amounts used and the manner of depositing and compaction of the materials.

b) The material to be utilised for compacted backfill shall be moistened to an optimum moisture content (OMC) of ±10%, and deposited in horizontal layers, having a thickness of not more than 300 mm before being compacted. In backfilling, the pad of the foundation shall be covered, first with a 200 mm layer of well-graded material containing no pieces larger than 20 mm, before any coarse material is deposited.

c) The backfill material to be compacted shall contain no stones more than 150 mm in diameter, and be free from organic material such as trees, brush, scraps, etc.

d) The distribution of material shall be such that the compacted material will be homogenous to secure the best practicable degree of compaction, impermeability, and stability.

e) Prior to and during compaction operations, the backfill material shall have the OMC required for the purpose of compaction, impermeability, and stability.

f) The material shall be mechanically compacted to a minimum of 90% of the dry density of the undisturbed material.

g) The surface of the backfill around the foundation shall be carried to such an elevation that water will not accumulate on top of the backfilled area.

h) Material removed from the excavation, which is either not suitable or not required for backfill, shall be spread evenly over or adjacent to the site, or be disposed of as directed by the *Eskom Site Representative*. Spreading of subsoil in agricultural areas will not be allowed. Excavated soil suitable for backfill will be returned to the excavation by backfilling with the subsoil first and the topsoil last.

i) Where the excavated material is unsuitable for backfill, such as a material with high clay content or a sandy material with little variation in particle size, the *Contractor* shall propose a suitable method of soil improvement for consideration and acceptance by the *Eskom Design Engineer* prior to being implemented. The properties of the soil may be improved by the addition of stabilising agents such as Portland cement in the case of sandy soils and slaked lime in the case of clay soils. Backfill material stabilised in this way shall be mixed in the ratio of cement or lime: soil of 1:10. This material shall be properly mixed, moistened, placed, and compacted in the same manner as other excavated material.

j) Where the material is found to be a matrix of boulders and soil, the removable boulders shall be removed "reimbursable as per to the "bill of quantities." as also the extra-over for the imported backfill.

2.6.6 Concrete foundations

2.6.6.1 Supply of materials

The *Contractor* shall supply all concrete and concrete materials required for construction, including aggregates, cement, water, admixtures (if any), shuttering, reinforcing steel, all embedded steel components, and materials for curing concrete.

2.6.6.2 *Works*: Prior to the concrete mix acceptance and placement

a) Well in advance of construction, the *Contractor* shall select the location of aggregate sources for concrete and obtain representative samples of all aggregates. A representative sample shall consist of a blend of twelve separate samples from each aggregate stockpile. The representative samples shall be divided into two portions, one set of which shall be examined and accepted by the *Eskom Site Representative* and maintained on site during concreting operations. The second set which shall be delivered by the *Contractor* to the Portland Cement Institute, or other laboratory accepted by the *Design Engineer*, for examination of suitability of the aggregate in accordance with SANS 1083 and preparation of concrete trial mix design in accordance with the to any concrete placement the *Contractor* shall submit the trial mix designs and results of seven- and twenty-eight-day test cube strengths to the *Design Engineer* for acceptance.

b) The *Contractor* shall obtain, from the ready-mix supplier, aggregate test reports and mix designs and test cube strength reports of all mix designs and submit it to the *Design Engineer* for acceptance prior to placement of any concrete. A ready-mix concrete supplier that does not have SANS 979 recognition shall only be used with the *Design Engineer's* acceptance, and thereafter only after satisfying the above requirements.

2.6.6.3 Tolerances for concrete construction

The intent of this paragraph is to establish tolerances that are consistent with construction practice, and the effect that permissible deviations will have upon the structural action or operational function of the structure. Where tolerances are not stated for any individual structure or feature, permissible deviations will be interpreted in conformity with the provisions of this paragraph. The Contractor shall be responsible for setting out and maintaining concrete excavations, shuttering and structural steelwork within the tolerance limits to ensure completed work within the specified tolerances. Concrete work, that exceeds the tolerance limits specified shall be remedied, or removed and replaced.

a) Variation in structure location

- Transverse to centreline: less than 50 mm
- Longitudinal displacement: less than 300 mm

b) Variation in relative vertical elevation of structural steelwork (one leg to another)

- less than 5mm

c) Variation in horizontal distance between structural steelwork from that computed

- Adjacent legs: less than 5 mm
- Diagonal legs: less than 7 mm

d) Rotation - maximum deviation of transverse axis of structure from bisector of interior line angle

- less than 0° 30'

e) Elevation - variation of tower base from centre-line peg

- minus 150 mm
- plus 350 mm

f) Height of concrete foundations above ground level

- min. 250 mm (±10 mm)
- max. – as per design

g) Variation in relative placement of foundation components from those indicated on drawings, including piles, shuttering, and structural steelwork

- less than 50 mm

h) Tolerances for placing reinforcing steel

- Variation of protective cover: 5 mm
- Variation from indicated spacing: 25 mm

i) Tolerances for guy anchors

Guy anchors shall be installed such that the attachment point of the anchor is within 250 mm of the correct calculated position. The attachment point shall be a minimum of 350mm and a maximum of 750mm above the ground level.

Guy anchors designed for use with anchor rods extending below ground level shall have the anchor rod installed in line with the guy wire slope, within 1:20 (2.8 °) or such lesser tolerance as required by design.

j) Tolerances for pole foundations

Pole foundations shall be constructed such that the pole, and the associated foundation works are within 50mm of the correct calculated position.

2.6.6.4 Workmanship

The Contractor shall ensure that the concrete is proportioned, mixed, placed and finished in such a manner as to be free of honeycombing, segregation, and other defects of workmanship.

2.6.6.5 Formwork

a) Formwork shall be of wood, metal, or other suitable material.

b) The formwork shall be mortar-tight and shall be designed, constructed, braced, and maintained such that the finished concrete will be true to the line and elevation, and will conform to the required dimensions and contours. It shall be designed to withstand the pressure of concrete, the effect of vibration as the concrete is being placed and all loads incidental to the construction operations without distortion or displacement.

c) Where the bottom of the formwork is inaccessible, provision shall be made for cleaning out extraneous material immediately before placing the concrete.

d) All exposed corners of the concrete shall be chamfered approximately 20 mm. A suitable nosing tool may be used for horizontal chamfers only if approved by the *Eskom Site Representative*. All formwork dimensions shall be checked, and if necessary, corrected before any concrete is placed.

e) All formwork shall be treated with a formwork-release agent accepted by the *Eskom Site*

Representative before concrete is placed. Any release agent, which will adhere to, discolour or be deleterious to the concrete, shall not be used.

2.6.6.6 Concrete and grout mixing and testing

The concrete mix shall consist of ordinary Portland cement, fine aggregate, coarse aggregate, and water proportioned in accordance with the mix design accepted by Design Engineer. Adjustments in these proportions may be directed at any time when found necessary because of field tests of the concrete. No change in mix proportions shall be made unless instructed by the *Eskom Design Engineer*. As an alternative to the use of ordinary Portland cement, the *Eskom Design Engineer* may consider the use of other approved types of cement or blends thereof.

a) No change in the source, character or grading of materials shall be made without written notice to the *Eskom Site Representative* and without a revised mix design being prepared and accepted by the *Eskom Design Engineer* prior to use of these materials.

b) During the concrete operations, the concrete mixture shall be tested for each batch by the *Contractor* to determine the slump of the fresh concrete in accordance with SANS Method 5862. Records of slump tests shall be supplied to the *Eskom Site Representative* daily.

c) Test cubes shall be prepared, in accordance with SANS Method 5863 at the initiation of the concrete placement of each truck/batch for the first three batches and twice every day that concrete is batched thereafter or for every 20 cubic meters where this amount is exceeded. Test cubes shall only be made from a concrete batch at the point of discharge in actual use. Unless a concession is granted by the *Employer*, the *Contractor* shall install suitable on-site laboratory facilities for the storage and crushing of test cubes. The crushing equipment shall be appropriately calibrated (with traceability to SANS5863) and always accompanied by up-to date certification available for inspection. The *Eskom Site Representative* shall witness all cube crushing tests.

1) The first set of test cubes shall consist of five cubes, thereafter each set shall consist of

four cubes minimum.

2) One to be crushed at seven days and three to be crushed at twenty-eight days. The written results of the test cube strength tests shall be immediately forwarded to the Supervisor upon receipt.

3) The 5th cube shall be an accelerated 24-hour curing test to be tested, for every first batch of a mix design or new supplier and randomly thereafter as advised by the *Eskom Site Representative* (procedure as per line project appendix).

4) The 5th cube must be cured in water at a temperature of 55°C for 20 hours, then cooled in water at a temperature of 20°C for 2 hours and tested for the compressive strength.

5) Additional test cubes shall be prepared and crushed as directed by the Eskom Site

Representative where the concrete strengths are in question.

6) Grout cubes shall be taken for every tower with grouted anchor foundations and the cubes shall be tested to the same procedures as with the concrete cubes.

d) All cement shall be batched by mass. Cement shall be weighed to within 2% accuracy.

e) Aggregates may be batched by mass or by volume, provided that volumetric batching equipment is calibrated at the start of concrete operations by weighing a typical discharge. The quantities of aggregate batched shall be volume batched within 2% accuracy. Adjustments of fine aggregate volumes due to "bulking" shall be accounted for in batching as to SANS 0100-2.

f) The amount of moisture in the aggregates shall be determined daily by a method accepted by the *Eskom Site Representative*, and the water requirements as per the mix design altered accordingly.

g) Water quantities, including aggregate moisture allowances, shall be determined within 2% accuracy. The use of water meters for dispensing water shall be subject to *the Eskom Site Representative's* acceptance.

2.6.6.7 Mixing of concrete

a) Concrete shall be mixed sufficiently to ensure that the various sizes of aggregate are uniformly distributed throughout the mass, and each aggregate particle is adequately coated with cement paste of uniform consistency. Concrete delivered to site that lacks homogeneity should be mixed for a longer time or discarded, as directed by the *Eskom Site Representative.*

b) For mixers of one cubic metre or less, the mixing time shall not be less than ninety seconds after all ingredients have been discharged into the mixer. For mixers of larger capacities, minimum mixing times shall be increased by fifteen seconds for each additional half cubic metre of mixer capacity, or fraction thereof.

c) Concrete delivered to the job site shall be mixed en-route. Mixing shall be rigorously controlled for agitating time, mixing time and overall time upon arrival at the foundation construction site. Concrete discharge shall be completed within one and one-half hours after introduction of the water to the cement and aggregate.

d) In exceptional cases only with the acceptance of the *Eskom Design Engineer*, may the

Contractor at his own risk add water to a concrete mix at the point of delivery. The maximum amount of water that may be added on site is three litres per cubic metre of concrete. At no time shall the cement / water ratio be less than 1.8.

e) Non-shrink grout shall be mixed in a suitable mechanical grout mixer/pump accepted by the *Eskom Site Representative*.

2.6.6.8 Placement of reinforcing steel

a) The *Contractor* shall install all the reinforcing steel required for foundations. Reinforcing steel shall be fabricated and bent in strict accordance with the drawings and SANS 82.

b) Reinforcing steel, before being positioned, shall be thoroughly cleaned of mill scale and any coatings that will destroy or reduce bond. Reinforcing steel shall be accurately positioned and secured against displacement during placing and vibrating of concrete. Reinforcing bars shall be tied at all intersections with no less than No.18-gauge annealed wire. Reinforcing bars shall be overlapped forty-five diameters at all splices, unless shown otherwise on the drawings. Reinforcing bars shall be provided and placed as detailed on the foundation drawings. Unless otherwise shown on the drawings, the minimum cover to the main reinforcing bars in a pile, a pile cap, or chimney shall be 50 mm and 75 mm for the sides, and bottom of the slab or anchor. Use of suitable accepted spacers or supports shall be made, to ensure that the minimum concrete cover to the reinforcement is maintained during the placement of concrete. Where cover blocks are used to support the lower layers of reinforcing, these shall be at least 75 mm thick to make allowance for the uneven ground surface on which the reinforcing cage rests. Cover blocks are to be made of minimum 25 MPa concrete.

2.6.6.9 Placement of embedded items

a) The *Contractor* shall install all required embedded items shown on the drawings, prior to placing (pouring) of concrete. Structural steelwork or holding down bolts shall be accurately positioned and securely held in place during the placement (pouring) of concrete. The minimum cover to all embedded items, but excluding angle stubs, shall be 150 mm. The minimum cover to angle stubs and cleats shall be 75 mm unless otherwise shown on the drawings.

b) Angle stubs may be supported on the bottom of excavations by either precast concrete slabs set at the correct level by placing suitable grout or concrete underneath it, or on a previously placed blinding layer of 10MPa concrete installed up to the correct level. The precast slab shall be square in plan with a side dimension of 300 mm, and a depth of 75 mm, and shall be constructed using reinforced concrete with a minimum characteristic strength of 25MPa. The placing of loose rubble, stones, bricks, etc. under the precast slab will not be acceptable.

c) Structural steelwork or anchor bolts shall be embedded such that the top of the concrete of the foundation correctly coincides with the designed level.

d) Earthing requirements are to be as per the latest revision of standard "TST41-321 Earthing of Transmission Line Towers".

e) Notwithstanding the above-mentioned standard, if additional earthing buried in soil is to be applied to achieve the required tower footing resistance, the material used, must be copper clad steel with a service lifespan more than 50 years and with a low scrap value.

2.6.6.10 Placement of concrete

a) No concrete for foundations shall be placed (poured) until each foundation has been inspected and accepted by *the Eskom Site Representative*. The foundation at the time of this inspection shall be ready for concrete placement (pouring) including reinforcing steel, embedded items, and any necessary formwork.

b) All surfaces of the foundation upon or against which concrete is to be placed shall be free from mud and/or loose or disturbed material. A blinding layer of 10MPa between 50 mm to 100 mm is to be installed on all bottom surfaces of type 3 and type 4 foundations and were warranted and approved by the *Eskom Site Representative*.

c) The surfaces of dry absorptive materials, against which concrete is to be placed, shall be moistened prior to the placing of concrete to prevent excessive moisture being withdrawn from the fresh concrete.

d) At least two suitable concrete poker vibrators shall be ready for operation at the site prior to placement of concrete.

e) Freshly mixed concrete shall be handled, transported, and deposited in such a manner as to prevent segregation or loss of material. When discharging concrete by chute, the slope of the chute shall be uniform throughout its length and shall not be flatter than 1 in 3 or steeper than 1 in 2. Baffles shall be provided at the end of the chute to ensure a vertical discharge of the concrete into the foundation. The maximum free discharge height shall be three metres, and for heights more than this, a tremie pipe shall be used.

f) Placement (pouring) of concrete shall not commence when the air temperature is below 5°C. Where temperatures can fall to 0 degrees Celsius during the next 24 hours, insulating covering must be placed on the concrete surfaces for at least 2 days to cover and insulate the concrete from the cold.

g) During hot weather concreting operations, the *Contractor* shall take and record of the air

temperature of each batch casting. The temperature of the air immediately before placement (pouring) shall not exceed 32°C.

Where the air temperature exceeds 32°C but is still below 42°C the following measures shall be executed over and above normal curing: For pads insulating sheeting (such as DPC plastic) must be over lain on the freshly casted concrete and applied curing compound with a 50mm layer of sand on top of it. For columns the formwork must be kept on for 3 days and wetted at least 3 times during the first two days.

Where the air temperature exceeds 42°C but is still below 50°C the following measures shall be executed over and above normal curing: For pads insulating sheeting (such as DPC plastic) must be over lain on the freshly casted concrete and applied curing compound with a 50mm layer of sand on top of it. For columns the formwork must be kept on for 4 days and wetted at least 5 times during the first three days. Where the temperature exceeds 50°C the concrete shall be discarded.

h) No concrete shall be placed which has taken its initial set, regardless of whether the specified one and one-half hour period has elapsed or not. If a setting retarder, accepted by the *Eskom Design Engineer*, has been used, the one and one-half hour period may be exceeded provided the concrete has not taken its initial set. The *Contractor* shall dispose of waste concrete in a place acceptable to the *Eskom Site Representative*.

i) Concrete shall be placed under water, with a suitable watertight tremie, accepted by the *Eskom Site Representative*, of sufficient length to reach the bottom of the excavation. The tremie shall be free of water when filled with concrete to the bottom of the excavation. The tremie shall be kept full of concrete during the entire concrete placing operation. The discharge end of the tremie shall not be lifted out of the freshly placed mass of concrete until the concrete placement has been completed.

j) Concrete shall be thoroughly settled and compacted into a dense homogeneous mass throughout the whole depth of each layer being consolidated, using internal vibrators. Excessive vibration, causing segregation, is to be avoided. Concrete vibrator penetrations shall be at ± 400 mm spacing and shall not be used to move concrete.

k) The concrete in cast-in-situ piles shall be vibrated from the bottom upwards.

l) Unless authorised by the *Eskom Site Representative*, the *Contractor* shall not place concrete, unless the *Eskom Site Representative* is present during the entire placement operation.

m) When alternative foundations consisting of multiple cast-in-situ piles and pile caps are utilised, the *Contractor* shall at approximately one tower in twenty, open on two sides of the completed foundation of one leg, the pile cap and top 500 mm of the piles, if so instructed by the *Eskom Site Representative*. If the foundation is rejected for any reason, the *Contractor* shall open as many additional foundations as determined by the *Eskom Site Representative* who will refer it to the *Eskom Design Engineer*, as is necessary to fully assess the problem. Foundations accepted are to be backfilled using 10MPa concrete up to a level at least 150 mm above the base of the pile cap.

n) Concrete in all drilled foundations utilising piles, shall be inspected immediately prior to concrete placement using a suitable high-powered torch and measuring tape. The inspection is required to determine:

1) That no soil has fallen into the drilled hole such that either the design length or the design diameter of the pile has been affected, and

2) That no material from the hole sides has become dislodged and has fallen against

reinforcing. No concrete will be allowed to fall directly against the hole sides during

placement. A poker vibrator shall be placed in the bottom of the pile hole prior to any

concrete placement and gradually lifted with the concrete pour. With inclined piles the

concrete is to be placed by means of a tremie pipe which extends down the full length of the pile. The tremie pipe, together with the poker vibrator can then be gradually lifted

together with the pour.

2.6.6.11 Construction joints

a) In general, foundations shall be constructed monolithically. Construction joints are to be avoided as far as possible. If construction joints cannot be avoided and are accepted by the Eskom Site Representative, the Contractor may be permitted to make a construction joint if the following criteria are met:

1. The concrete is reinforced, and the reinforcing steel will develop full bond strength both sides of the construction joint. No construction joints will be allowed in unreinforced concrete.
2. In multiple cast-in-situ piles, the construction joint is to be 75 mm, and in rock anchors 100 mm, above either the base of the pile cap excavation or the top of blinding level. If the piles are constructed after the excavation for the pile cap has taken place, suitable ring shutters of the same diameter of the piles shall be used to construct the above-mentioned pile/anchor projections.

b) No construction joints will be allowed in piles, pile caps, deadman anchors and pad slabs of pad and pier foundations.

c) At all construction joints, the surfaces of the previously placed and hardened concrete shall be thoroughly cleaned of all foreign matter and primed with a 15 mm thick layer of a wet mix of cement and sand in equal proportions, in the presence of the *Eskom Site Representative* before new concrete is placed. The grout coating shall be brushed over the concrete surface to ensure thorough coverage, particularly between the reinforcing bars. The new concrete shall be placed before the grout coating has taken its initial set.

2.6.6.12 Concrete surface finish

a) The top surface of the foundation shall be at least a wood float finish and shall be contoured to shed water.

b) All concrete placed against shuttering shall be free from irregularities, fins, rock pockets or other imperfections. Any rock/aggregate pockets, porous or defective concrete shall be removed to the extent instructed by the *Eskom Site Representative* and repaired by filling these voids with specialized concrete, cement mortar of a higher strength, as accepted by the *Eskom Design Engineer*.

c) All exposed concrete sections shall be shuttered to a minimum of 250 mm below ground level.

2.6.6.13 Concrete curing

a) The *Contractor* shall provide means of maintaining concrete in a moist condition (for curing) for at least seven days after the placement of concrete.

b) At the *Contractor*'s option, concrete may be cured either by retaining shuttering in place and applying a liquid curing compound which forms a moisture retaining membrane on un-shuttered concrete surface, or by removing shuttering and applying a curing compound as described to all exposed concrete surfaces. Curing compounds utilised shall be of a type accepted by the *Design Engineer*. Notwithstanding these requirements, formwork shall not be removed until at least 36 hours after the final placement of the concrete against such formwork. The *Contractor* shall remove formwork in such a way that shock forces and damage to the concrete are avoided.

2.6.6.14 Concrete cracks repair

For crack widths:

a) All cracks less than 2mm wide and less than 30mm deep must be repaired with Eskom approved compounds.

b) For all larger cracks than specified in (a) above, a non-conformance must be raised and consultation with the *Eskom Design Engineer* must commence.

2.6.6.15 Steelwork

a) All galvanised structural steel at the steel/concrete interface shall be painted with an Eskom approved protective paint. This protection shall extend 500 mm above and 500 mm below the top surface level of the protruding foundation blocks. A final second coat shall be painted after construction on the 500 mm part above the concrete and overlapping onto the concrete for ±100 mm to seal the interface.

b) All embedded steel (i.e., Link plates and stubs) below ground line shall be galvanised and encased in concrete. All link plates shall be encased in concrete using a minimum permanent shutter (i.e., HDPE pipe) of 250 mm diameter minimum with at least 50 mm concrete cover. No structural steel shall be buried or come directly in contact with the soil.

2.6.7 Anchor block (deadman), Pile and Rock Anchor testing

2.6.7.1 Design load (ultimate load) anchor test requirements

General and test setup requirements:

1) Where requested by the *Design Engineer* the *Project Manager* shall, instruct the *Contractor* to install in each general soil type encountered and at any additional locations, a test cast-in-situ anchor for the purpose of verifying the ultimate anchor capacity and concrete/soil frictional resistance values.

2) The *Contractor* shall provide the equipment capable of loading the anchor and personnel to perform the test.

3) *Contractor* shall prepare the test procedure for the testing of deadman anchor, pile, or rock anchor for the load equal to the design load (ultimate load). The test procedure, based on the applicable test requirements, shall be submitted to the *Design Engineer* for acceptance prior to execution of the test.

4) The design load test anchor, pile or rock anchor shall not form part of a final tower

anchors/foundation.

5) Tests shall be conducted in the presence of the *Eskom Site Representative*.

6) Anchor, pile, or rock anchor foundations installed prior to acceptance by the *Design Engineer* of the test results, will be subject to modification or replacement by the

Contractor should the anchor, pile or rock anchor fail the test.

7) The test beam supports shall be placed outside the uplift influence zone of the anchor, pile, or rock anchor to be tested and the distance on either side of the anchor, pile, or rock anchor to the test beam supports shall not be less than "r".

$$r = (l + c) \tan \varnothing$$

where:

l = depth of pile/anchor (or anchor group)

c = depth of pile/anchor cap excavation

$\varnothing$ = frustum angle

8) Two dial gauge micrometres shall be placed on either side of the pulling rod, to eliminate errors due to rotation of the anchor, pile, or rock anchor. The datum frame supports shall also be positioned a similar distance “r” from the test pile/anchor as the test beam supports above. The average reading of these gauges will represent the actual creep. Should this method, for any authentic reason prove impracticable, then suitable approved alternative method may be used.

2.6.7.2 Block Guy Anchor (deadman) design load testing criteria

The design load shall be applied to the block anchor during the test in appropriate increments to 60%, 85% and 100%, each for a minimum holding period of 5 minutes and finally, 100% for at least half an hour. Successive load increments shall not be applied, and the maximum test load shall be held until the rate of movement under the acting load has stabilised at a rate of movement not exceeding 3.75 mm in 5 minutes. The maximum test load shall also be held until the rate of movement under the applied load has stabilised at a rate of movement not exceeding 3.75 mm in 5 minutes. The anchor will be considered to have passed provided the total movement does not exceed 50 mm during the entire test period. The residual anchor movement, once all load has been removed, shall be recorded at the end of the test.

2.6.7.3 Pile design load testing criteria

The design load shall be applied to the pile during the test in appropriate increments to 60%, 85% and 100%, each for a minimum holding period of 5 minutes and finally, 100% for at least half an hour. Successive load increments shall not be applied, and the maximum test load shall be held until the rate of movement under the acting load has stabilised at a rate of movement not exceeding 0.75 mm in 5 minutes. The maximum test load shall also be held until the rate of movement under the applied load has stabilised at a rate of movement not exceeding 0.75 mm in 5 minutes. The pile will be considered to have passed provided the total movement does not exceed 7 mm during the entire test period. The residual pile movement, once all load has been removed, shall be recorded at the end of the test.

2.6.7.4 Rock Anchor design load testing criteria

The design load shall be applied to the anchor during the test in appropriate increments to 50%, 75%, 90% and 100%, each for a minimum holding period of 5 minutes and finally, 100% for at least half an hour. Successive load increments shall not be applied, and the maximum test load shall be held until the rate of movement under the acting load has stabilised at a rate of movement not exceeding 0.25 mm in 5 minutes. The maximum test load shall also be held until the rate of movement under the applied load has stabilised at

a rate of movement not exceeding 0.25 mm in 5 minutes. The anchor will be considered to have passed provided the total movement does not exceed 2.5 mm during the entire test period. The residual rock anchor movement, once all load has been removed, shall be recorded at the end of the test.

For Foundation Test Criteria – Design Load see **Appendix C**

2.6.7.5 Pressure grout injected anchors - test criteria

For an anchor in soils 1-3:

The design load shall be applied to the anchor during the test in appropriate increments to 50%, 75%, 90% and 100%, each for a minimum holding period of 5 minutes and finally, 100% for at least half an hour. Successive load increments shall not be applied, and the maximum test load shall be held until the rate of movement under the acting load has stabilised at a rate of movement not exceeding 1 mm in 5 minutes. The maximum test load shall also be held until the rate of movement under the applied load has stabilised at a rate of movement not exceeding 1 mm in 5 minutes. The anchor will be considered to have passed provided the total movement does not exceed 10 mm during the entire test period. The residual rock anchor movement, once all load has been removed, shall be recorded at the end of the test.

For an anchor in rock:

> The design load shall be applied to the anchor during the test in appropriate increments to 50%, 75%, 90% and 100%, each for a minimum holding period of 5 minutes and finally, 100% for at least half an hour. Successive load increments shall not be applied, and the maximum test load shall be held until the rate of movement under the acting load has stabilised at a rate of movement not exceeding 0.25 mm in 5 minutes. The maximum test load shall also be held until the rate of movement under the applied load has stabilised at a rate of movement not exceeding 0.25 mm in 5 minutes. The anchor will be considered to have passed provided the total movement does not exceed 3 mm during the entire test period. The residual rock anchor movement, once all load has been removed, shall be recorded at the end of the

For Pressure Grout Injection Anchors – Test Criteria see **Appendix D**

2.6.7.6 Proof load anchor/pile test requirements

General and test setup requirements:

1) Where instructed by the *Eskom Site Representative* or *Design Engineer*, the *Contractor* shall apply a construction proof load test equal to 70% of the design loading conditions to the completed anchor for the purpose of verifying the maximum working load capacity of the anchor.

To ensure quality assurance, anchor strength and construction integrity, the contractor shall execute proof load tests on a minimum of 5% of the anchors installed.

2) The *Contractor* shall prepare the test procedure and supply all equipment and personnel to perform the tests. The pile/anchor test procedure, based on the following requirements, shall be prepared by the *Contractor,* and submitted to the *Design Engineer* for acceptance prior to the execution of the tests.

3) The *Design Engineer* may request that the pile/anchor foundation be tested.

4) Pile/Anchor proof load tests shall be conducted in the presence of the *Eskom Site*

Representative.

5) Pile/Anchor foundations installed prior to acceptance by the *Design Engineer* of the pile/anchor test results will be subject to modification or replacement by the *Contractor* should the pile/anchor fail the test.

6) The test beam supports shall be placed outside the uplift influence zone of the pile/anchor to be tested and the distance from the outside of the pile/anchor (or pile/anchor group) to the test beam support shall not be less than "r".

$r = (l + c) \tan \varnothing$

where:

l = depth of pile/anchor (or pile/anchor group) with respect to the underside of the pile/anchor cap.

c = depth of pile/anchor cap excavation. and Ø = frustum angle.

7) Two dial gauge micrometres shall be placed on either side of the pulling rod, to eliminate errors due to rotation of the test pile/anchor. The datum frame supports shall also be positioned a similar distance from the test pile/anchor as the test beam supports above. The average reading of these gauges will represent the actual creep. Should this method, for any authentic reason prove impracticable, then a suitable approved alternative method may be used.

8) The load shall be applied to the anchor in appropriate increments to 50%, 75%, 90% and 100% of the proof test load, and then unloaded to 50% and again loaded to 100% of the proof test load, twice, i.e., during two further cycles of loading. The Contractor shall monitor anchor/pile movement along the guy slope or vertical slope in the case of vertical pile/anchors.

Successive load increments shall not be applied until the rate of creep is less than or equal to the measurements listed below:

a) Block guy anchors (deadman) = 2.5 mm/minute

b) Pile anchors = 0.1 mm/minute

c) Rock anchors = 0.05 mm/minute

The three cycles of loading from 50% to 100% shall each be of duration of not less than 5 minutes.

a) A guy anchors shall be considered acceptable if the total creep from 50% to 100% load over 3 cycles is less than 15 mm.

b) A pile anchor shall be considered acceptable if the total creep from 50% to 100% load over 3 cycles is less than 2 mm.

c) A rock anchor shall be considered acceptable if the total creep from 50% to 100% load over 3 cycles is less than 1 mm.

9) If the creep exceeds above criteria the anchor /pile foundation shall be modified or replaced by the *Contractor* and re-tested.

For Proof Loads see **Appendix E**

2.6.7.7 ole foundations

a) The *Contractor* shall provide equipment on site during the construction of the pole foundation capable of loading the pole foundation to two-thirds of the maximum design moment.

b) Where instructed by the *Eskom Site Representative*, the *Contractor* shall apply a construction proof load test of two-thirds the maximum design moment to the completed pole.

c) The pole foundation shall be loaded in increments of 50%, 75%, 90% and 100% and then unloaded to 50% in 3 cycles of 50% to 100% of the proof test. If creep exceeds 1 mm/minute at ground level, additional load shall be applied until the creep is less than the stated limit. The three 50% loads and three 100% loads shall each be maintained on the pole for 5 minutes. If the creep is less than 1 mm/minute, the final creep measurements shall be taken after each holding period. The pole foundation shall be considered acceptable if the total ground level creep from 50% to 100% load over 3 cycles is less than 30 mm. If the creep exceeds 30 mm, the foundation shall be modified or replaced by the *Contractor* and re-tested.

d) All pole foundation tests shall be conducted in the presence of the *Eskom Site Representative*.

2.7 owers

2.7.1 Tower Design

2.7.1.1 By the Contractor

a) The *Contractor* shall make use of his own design of tower(s), and these alternative tower designs must be submitted to the *Employer* for acceptance prior to manufacturing or use.

b) The *Contractor* shall be fully responsible for his designs and their satisfactory performance in service. Acceptance by the *Employer* does not relieve the *Contractor* of responsibility for the adequacy of the design, dimensions, and details.

c) Where the *Employer* provides general tower configurations, they act as a guide only to the *Contractor*. Electrical clearances, cover angles, minimum phase spacing, tower heights etc., shall be as shown on the conceptual drawings. The *Contractor* is encouraged to improve the towers with respect to mass and aesthetics.

d) Tower test loads will be provided. The towers shall be designed to withstand all the specified loads and shall be capable of withstanding construction loads during tower erection without special handling equipment.

2.7.2 Tower Manufacturing

2.7.2.1 Tower code numbers and marking

a) New and existing tower designs accepted for manufacture will be allocated a tower code number consisting of three digits, e.g., 422. This number is to be used in conjunction with the tower type letters and tower descriptions given in the schedules to form the titles of the various towers.

For example:

Suspension tower type 422 A

0° - 15 ° Angle strain tower type 422 B

These titles are to be used on all correspondence, drawings, test reports, etc., relating to a

tower.

b) Each tower member shall be allocated an identifying number, which shall correspond, to the number on the appropriate tower erection and manufacturing drawing.

c) The tower code number and the tower type letter are to be clearly stamped on every member of the tower as a prefix to the member mark number. All steelworks shall carry a manufacturer's identification marking consisting of a maximum of three letters. This shall be of the same letter height as the number code. Acceptance of the marking shall be obtained prior to usage. These marks shall be stamped before hot dip galvanizing and be clearly readable after hot dip galvanizing and erection, e.g.: on back-to-back members these markings shall be on the flange without stitches.

d) Marking shall be done by stamping the marks into the metal with numerals or letters of 10mm minimum height. The marking shall be consistently in the same relative location near the ends on all pieces. No other marking shall be used.

e) See also the requirements in 7.2.9 "Anti-theft measures and marking"

2.7.2.2 Tower steel standard

a) Structural steel for all tower members, including all stubs and cleats embedded in concrete shall conform to EN10025 Grade S355JR, and shall be hot dip galvanised after fabrication and marking.

b) Certified mill test reports of the chemical and mechanical properties of the steel for the full quantity required for fabrication shall be obtained from the steel supplier. Copies of these mill test reports shall be retained at the *Contractor's* works for review.

c) The *Contractor* shall, if so instructed, cut samples from deliveries of Grade S355JR steel, and conduct mechanical tests upon the samples to ensure that the steel is Grade S355JR. The frequency of testing shall be subject to acceptance by the Design Engineer.

d) Only structural shapes included in the latest edition of the "South African Steel Construction Handbook", published by the South African Institute of Steel Construction, shall be used. Ensuring the Availability of member shapes selected is the sole responsibility of the *Contractor*.

e) To facilitate the transport of tower members, these shall be limited to a maximum length of 12.5 m.

f) The steel selected for manufacturing purposes of poles and lattice structures should be suitable for hot dip galvanizing. In general, two steel types are acceptable namely "Aluminium Killed Steel" and "Silicon Killed Steel".

The chemical content of the steel should be within the following limits:

- For Aluminium Killed Steel: Silicon (Si) = 0.01 to 0.04% and Phosphorous (P) = 0.015% maximum.
- For Silicon Killed Steel: Silicon (Si) = 0.15 to 0.25% and Phosphorous (P) < 0.02% maximum.

2.7.2.3 General tower steel fabrication

a) All parts of structures shall be fabricated in accordance with the accepted shop drawings, and generally carried out in accordance with SANS 2001CS1. Workmanship and finish shall be equal to the best modern practice for transmission tower work. Pieces having the same markings shall be interchangeable.

b) All parts of the structure shall be neatly finished and free from kinks or twists. All holes, blocks and clips shall be made with sharp tools and shall be clean-cut without torn or ragged edges.

c) Shearing and cutting shall be neatly and accurately done. Cuts shall be clean without torn or ragged edges. Care shall be taken in the edge finish of plates subjected to large bending moments or large bends in fabrication.

d) Where necessary, to avoid distortion of the holes, holes close to the points of bends shall be made after bending of member. The use of a blow torch for cutting holes to size shall not be permitted. Plasma cutting machines can be used in combination with drilling or reaming to achieve final hole dimensions.

e) For material less than 10 millimetres in thickness - punching holes to full size, the diameter of the punch shall less than 1.5 mm than the diameter of the die.

f) For material greater than 10 millimetres but smaller than 18 millimetres in thickness -

punching holes to full size, the diameter of the punch shall less than 2.0 mm than the diameter of the die.

g) Sub punching for reamed work shall be such that after reaming, no punched surface shall appear in the periphery of the hole.

h) All holes shall be spaced accurately in accordance with the drawings and shall be located on the gauge or back mark lines. The maximum allowable variation in hole spacing for a bolt group, from that indicated on the drawings for all boltholes, shall be 1 mm. Miss drilled or miss punched holes may not be refilled by welding.

i) The *Contractor* may submit alternative manufacturing processes to the *Design Engineer* for approval before manufacturing commences other than those listed above.

For General Tower Steel Fabrication see **Appendix F**

2.7.2.4 Steel Bending

a) All forming or bending during fabrication, shall be only done according to methods accepted by the *Design Engineer*, such that it will prevent any embrittlement, cracking, or loss of strength in the material being worked.

The technical requirements for hot and cold forming are as follows:

1) The bending radius will be at least equal to 1.5 times the material thickness to be used.

2) When hot bending of steel needs to be performed, an accurately controllable form of

heating must be employed for both temperature and time.

3) The length of the section to be heated shall be clearly marked on the section, and heating equipment set accordingly.

4) The required bending tool shall be always ready on the bending press with checking jigs available. Checking jigs must be of high quality so that they do not deteriorate over time. Steel jigs should be used.

5) A dry run shall be made first to check that all systems are operational and that the proper tools are used.

6) Material shall be uniformly heated over the required length, to a temperature of between 750°C to 900°C. Oxidation of the material shall be minimised. An acceptable consistent means of temperature measurement of the steel temperature must be used.

7) Heated material shall be inserted into the bending press and formed while the temperature is still within the specified range. The bending process of a single bend must be done using a single action.

8) Formed material shall be checked immediately to ensure that they have been formed correctly.

9) Formed/bent material shall be left to cool naturally in open air. The use of any liquids or forced air to cool formed material is not acceptable.

10) Re-checks shall be made with the appropriate jigs when the material is cold.

b) If more than one bend is required on a section, the operation shall be repeated for each bend. Repeated heating of a bend position shall not be allowed.

c) New bends shall not deform the bend previously made.

d) For bending limitations on the flaring of flanges on angle sections, refer to the *Design Engineer*. Any other bending of angle sections shall be done hot.

e) For cold bending process, designs must consider that the neutral axis distance shall be 0.33 of the plate thickness for plates thicker than 2 mm.

2.7.2.5 Bolts, nuts, and washers

a) Bolts and nuts shall be at least Grade 6.8 and manufactured in accordance with DIN EN ISO 898-1, and shall be hot dip galvanised to SANS 121 / ISO 1461.

b) After hot dip galvanizing, bolt holes shall be not less than 1.2 mm larger in diameter than the corresponding bolt diameter.

c) Bolts of different diameters can be used on the same tower (if so required by the approved tower drawing), provided that bolt sizes are not mixed in any one connection or plate. The minimum diameter size of bolt shall be 16 mm.

d) The threaded portions of all bolts shall project through the corresponding nuts by an amount not exceeding 15 mm and not less than 3 mm after tightening.

e) No threaded portion of any bolt shall occur within the thickness of the parts bolted together. To ensure this a single washer of suitable thickness shall be placed under the nut so that in all cases the required clamping force can be achieved.

f) The minimum thickness of washers shall be 3 mm and the maximum thickness shall be 6 mm. g) No lock nuts or spring washers shall be used on the tower.

h) Where a pin-type connection is made at the top of masts on guyed structures, it shall be of a type secured by means of a bolt, nut and split pin. The split pin shall be of stainless steel (grade 304), with a minimum diameter of 20% of the bolt diameter. See also 7.2.6 (d).

i) As a general rule when hot dip galvanizing a threaded component or ISO metric fastener, the galvanizing of one thread either internal or external requires an extra clearance of four times the coating thickness. In practice it is normal for standard bolts from stock to be fully galvanized, but for nuts to be galvanized as blanks and then tapped up to 0.38-0.42 mm oversize with the threads lightly oiled. When assembled the nut thread is protected by contact with the coating on the bolt.

j) Further to the requirements as stated above, if protection of bolts, nuts and washers by means of a specialised thermal diffusion zinc coating is specified in the relevant line specification, then additional clearances on the nut may be required as both bolt and nut threads will remain zinc coated to the required zinc coating thickness and easy fitment of nut and bolt must still be retained.

k) All tower and hardware bolts will be manufactured with standard thread sizes so that they can be inspected with a go/no-go gauge prior to hot dip galvanizing. Bolts should be threaded according to SANS 1556-1: ISO Metric screw threads.

l) Hot dip galvanizing should be done according to SANS 1461 by which the suggested mean coating thickness for centrifuged articles with a diameter of more than 20 mm will be 55 µm and for articles with a diameter less than 20 mm will be 45 µm.

m) When use is made of a thermal diffusion zinc coating process the minimum coating thickness will be 70 µm and the thread cut should accommodate this.

n) Undersize cutting of the male thread (i.e., Bolt) before hot dip galvanizing will not be allowed as the quality inspection before hot dip galvanizing cannot be done with a standard go/no-go gauge.

2.7.2.6 hackles and extension links

a) The *Contractor* is to provide each tower with shackles and extension links (where applicable) for insulator string attachments of a size and strength suitable for attaching the conductor insulator assemblies, and earth conductor hardware assemblies to the tower at the appropriate positions.

b) Shackles, split pins, and extension links shall be designed and fabricated according to the relevant Eskom and/or international standards.

c) Shackles for insulator string attachments shall be of the correct length and strength, to connect the insulator hardware supplied to the attachment point on the tower.

d) The shackles shall be of the type secured by means of a bolt, nut, and split pin. Design of the shackles are not limited to classic straight leg shackles and can also be of the "hinge pin" type. The split pin shall be of stainless steel. The nominal diameter of split pins shall be a minimum of 3 mm for bolts up to and including 19 mm; 5 mm for bolts up to and including 28 mm; and 6 mm for bolts larger than 28 mm.

e) The orientation of shackles shall be as far as practically possible as follows:

- Suspension shackle for earth and phase conductors: When viewed on the transverse face, the legs of the shackle are to be in the vertical plane and at right angles to the direction of the line.
- Strain shackle for earth and phase conductors: When viewed on the transverse face, the legs of the shackle are to be in the vertical plane parallel to the direction of the line.
- In all cases the relevant tower drawings should be consulted to ensure correct orientation.

2.7.2.7 Anti-climbing devices

a) Anti-climbing devices shall be designed and installed for each tower. These are to be attached at a height of approximately 3.5 m above ground level as per the relevant tower drawing. Swaged bolts should be used for attaching the anti-climbing devices to the tower.

b) Anti-climbing devices should be of palisade type as specified per Eskom issued tower drawings. Razor wrap-type is required only for refurbishment type of projects where barbed wire was originally installed or where tower drawings have not been converted to palisade type.

c) Razor wire anti-climbing devices shall be formed by stringing onto projecting steel supporting members, fencing wire consisting of 2.5 mm double-strand uni-directional twist pattern, galvanised steel razor wire. Spacing between strands shall not be more than 100 mm centres, the first wire being not more than 100 mm from the tower face and forming an overhang of not less than 500 mm beyond the outer face of the tower. This overhang distance shall be maintained at the tower corners. On small anti-climbing devices such as on legs of guyed "V" towers, twin single strand razor wire may be used.

d) The strands of razor wire shall be secured at intervals, not exceeding 2 m, by spacers formed by pieces of the same razor wire bound to the strung barbed wire by galvanised binding wire. Where razor wire other than galvanised steel is specified, the spacers and binding wire shall be compatible.

e) Where the design of the towers is such that they can be climbed on the inner face, a similar anticlimbing device shall extend from the inner face of the tower inwards.

2.7.2.8 Safety Step bolts

a) The *Contractor* shall install all safety step bolts. All these bolts shall be punched and painted as for normal tower bolts.

b) Safety step bolts are for connecting a safety harness onto when working at heights. One leg of each tower shall be equipped with safety step bolts at minimum bolt spacing of 350 mm centres, starting immediately above the anti-climbing devices, and extending to the highest cross arm or earth wire peak of the tower. The bolts shall be fixed to the main leg members of the tower by means of two hexagonal nuts. Holes for safety step bolts shall be on all leg extensions from ground level up. No safety step bolts shall be installed below the anti-climbing device except for construction purposes.

c) The safety step bolts shall be uniformly spaced continuous and in line over gusset plates on main members only at a minimum bolt spacing of 350 mm on each flange of the main member. The connection of this bolt shall be ignored when calculating the number of bolts required. The orientation of the safety step bolt is with the eye in the vertical plane.

d) For double circuit towers, two diagonally opposite legs shall be equipped with safety step bolts and shall extend to the underside of the top cross arm or earth wire peak.

2.7.2.9 Anti-theft measures and marking

Anti-theft measures include the use of swaged bolts and the marking of members together with the appropriate anti-climbing device(s). All members, at least up to anti-climbing device level, must be fitted with swaged bolts in all holes. In addition, the same members must be marked with the words "ESKOM" every

300 to 500 mm. The normal member identification marking as detailed in section 2.7.2.1 "Tower code numbers and marking" should remain at the end of all members.

2.7.2.10 Galvanising

Hot dip galvanizing of all steel members shall be in accordance with SANS 1461. All possible care shall be taken to avoid damaging the zinc coating in transit or on site. Any material found to be damaged is to be made good or replaced by the *Contractor*. When hot dip galvanizing needs to be repaired only materials endorsed by the Hot Dip Galvanizing Association or other material approved by the *Design Engineer* may be used. Zinc-rich epoxy paint (of at least 100 microns) can be used. Cold galvanising or galvanising paint

may not be used. Consideration can also be given to galvanising thermal spray as a method of repair on site.

2.7.2.11 Welding

For components of sufficient complexity to require welding, permission shall first be obtained from the *Design Engineer*. If permission is granted, the *Contractor* shall submit his manufacturing and welding procedure to the *Design Engineer* for acceptance before manufacturing commences.

2.7.2.12 Testing and inspection

a) The *Employer* reserves the right for the *Design Engineer* to inspect the work, and witness tests at any stage during manufacture.

b) Witnessed tests to SANS 50025 1 to 6 / EN10025 1 to 6 may require samples of steel from the *Contractor's* stockpile.

c) The *Design Engineer* or the SA Bureau of Standards may make tests, to ensure satisfactory quality of the hot dip galvanizing.

d) Certificates shall be obtained proving compliance with all aspects of material quality, manufacture, and hot dip galvanizing.

2.7.3 Guy ropes and guy attachments

2.7.3.1 Guy ropes

a) Guy ropes shall conform to SANS IEC 61089.

b) Samples of guy ropes together with the relevant guy grip attachments, as well as representative anchor link attachments and tower attachments shall be tested as a complete system prior to use to confirm conformance to requirements.

2.7.3.2 Guy attachments

a) All guy rope attachments shall conform to Eskom standard NWS 1074 – Guy strand grips for transmission lines.

b) The guy attachments shall be capable of developing the minimum breaking strength of the guy rope.

c) The thickness and contour of tower and guy anchor attachment points shall be co-ordinated with the guy attachments, to ensure that excessive bending forces or stress concentrations (for example inadequate chamfering of anchor link holes) are not transferred to the guy grips.

d) The grip connecting the guy rope to the anchor shall provide continuous adjustment, parallel to the guy rope, of 450 mm. After final tightening, an adjustment length of 300 mm shall be available for future adjustment for guyed type towers and masts to increase the tension of the guy. This remaining adjustment length is not applicable to cross rope type towers. Once the tower has been erected, plumbed, and the conductors strung and sagged, the adjustment shall be sealed or locked to avoid the possibility of tampering. The grip connecting the guy rope to the tower at the top may be similar in design, but non-adjustable.

e) Final acceptance shall be obtained from the *Design Engineer* for the types of guy attachments selected. Test reports, certifying the results of ultimate strength tests, cycle load tests, vibration tests and impact tests as well as material and fabrication standards, tests and drawings are to accompany requests for acceptance.

f) The guy ropes, guy fittings, shackles etc. shall be included as part of the complete tower.

g) For the cross-rope type towers, three of the guys of the tower shall have no adjustment

whatsoever. Only one of the four guys shall have tension adjustment, at the bottom connection only. In case mast rotation occurs due to incorrect guy lengths, consideration can be given to tension adjustment devices in more guys.

h) After installation of the mast foundations and anchors, the position and elevation of each tower shall be measured, and the required length of the guys shall be calculated with respect to the known height of the tower as per the tower drawing. Then the four guys shall be cut and the end fittings installed.

i) The tolerance for the complete length of the guys (calculated distance between centres of top and bottom attachment points) shall be ±20 mm from the calculated length. All guys shall be permanently marked, including the number of the tower and the pre-established position of each guy in each tower.

j) The contractor shall propose convenient rigging holes in the foundation anchor link to accommodate tensioning equipment for the correct tensioning of the guy rope during construction.

k) All ropes with compression end fittings shall be tested individually to a tensile load equal to 83% of the ultimate tensile strength of the steel rope in each case. Due to the testing, which causes permanent stretch, a reduction of 0.2% of total length shall be applied to the calculated manufacture length of all ropes, which are to be tested.

2.7.3.3 Fall protection systems

a) The *Contractor* must ensure that a temporary fall protection system is installed on all structures at the required positions (vertical access and horizontal movement) for the duration of all construction activities. The system installed should conform to the necessary safety requirements and standards and be in line with good construction practices. The safety step bolt can form part of the temporary fall arrest system. After all construction activities are completed, the system shall be removed excluding the safety step bolts which will be utilized for future maintenance.

b) Safety step bolts should be installed on all lattice towers, as per standard Eskom drawing.

c) The *Contractor* must ensure that the applicable workforce undergo the required training in using the temporary fall protection system and are equip with the correct safety gear for the task at hand.

2.7.4 Tower erection

2.7.4.1 General

The *Contractor* to supply detailed safe work procedures (for each tower type to be used on the project) of tower assembly, erection, and dressing in accordance with the guidelines provided in the Line Specification.

2.7.4.2 Tower material handling and storage

a) Tower steel in storage shall be supported off the ground with enough blocks to prevent bending or warping of individual members.

b) Tower steel shall be handled with the use of nylon or fabric slings. The use of unprotected wire rope slings is not permitted.

c) Material shall not be dumped or dropped from trucks but shall be carefully unloaded and stacked.

d) Material shall not be dragged on the ground.

2.7.4.3 Assembly and erection of towers

a) The applicable type of tower shall be erected on the completed foundation. Towers shall not be erected until the foundation concrete had at least 14 days to cure and the concrete 7-day cube strength tested above 15 MPa, the minimum 7-day cube strength requirement.

b) All towers shall be vertical within 2 mm in 1 metre in both the transverse and longitudinal directions when erection of the tower is completed unless a different tolerance is specified.

c) Steel towers shall be assembled and erected so as not to overstress structural members, bolts, or foundations. The structural assemblies shall be erected with the members supported in their proper relative position. Structural assemblies that are not sufficiently rigid to be raised in one piece shall be stiffened by means of temporary bracing during tower erection.

d) All towers shall be assembled in strict accordance with the drawings. The size and length of all bolts, washers, nuts, ring fills and plate fills shall be as specified on the erection or manufacturing drawings.

e) Contact surfaces of plates at the joints shall be cleaned of foreign materials and dirt before assembly. Wherever possible, bolts shall be installed with threads and nuts to the outside, and bolt heads to the inside of columns and trusses. Surfaces that are horizontal after erection shall have bolt heads down and nuts up.

f) A reasonable amount of drifting will be allowed in the assembly of members but driving of bolts to correct mismatched holes will not be allowed.

g) If blind or partially blind holes, missed clips, or other minor miss-fabricated steel members are discovered in the field, the *Contractor* shall notify the *Eskom Site Representative* and receive his acceptance of the proposed repair measures prior to effecting field repairs.

h) Where drilling, punching, or clipping is done in the field, all exposed steel surfaces shall be coated with materials endorsed by the Hot Dip Galvanizing Association or other material approved by the *Design Engineer*.

i) Suitable ladders shall be used wherever necessary during erection of towers. Such ladders and any temporary step-eye bolts shall be removed when erection work is not in progress.

j) After final tightening of all nuts, they shall be fixed in position by punching three indentations at approximately 120-degree intervals around the threads with a round pointed centre punch. The nuts and exposed bolt thread shall be painted with a single pack waterborne anti corrosive primer with a life expectancy of 20 years.

k) After erection, all towers shall be cleaned of all foreign matter or surplus paint.

2.7.4.4 Erection of guyed towers

a) Provision shall be made for the erection of guyed towers on terrain with various ground slopes.

b) The guy grips shall be installed in strict accordance with the manufacturer's recommendations, to ensure complete holding power of the guy grips.

c) Guy grips of the adjustable U-bolt design shall be carefully tightened to ensure equal loading of the two legs of the U-bolt. Neither nut shall be tightened more than 6 mm differentially without equalising the load on the nuts, nor when the desired tension is achieved. The nuts shall be even, with the nut faces parallel and at the same level before locking.

d) The guy rope will be cut to a length that will allow projection to just beyond the bottom of the U-bolt, and tied to obviate opening of the strands, effectively closing the open area of the U-bolt. The orientation of U-bolts shall be such that the legs are vertical (one on top of the other) with reference to the ground plane. This will prevent livestock from getting stuck in the U-bolts.

e) At the time of tower erection, all guys shall be tensioned to the value as indicated in the relevant tower outline drawings. This shall be the tension in the guy after all fittings have been attached and all rigging used for tensioning the guy has been removed. The Contractor shall be responsible for establishing a suitable method of determining installed tensions in the guy rope.

f) Guy ropes shall be tensioned to hold the towers plumb and perpendicular to the line as soon as the towers are erected. Towers shall not be more than 2 mm in 1 m out of alignment from vertical in both the transverse and longitudinal direction, and the cross arms shall be perpendicular to the line within 0.3° of arc. In case of cross rope masts, a tolerance of not more than 3 degrees will be allowed for mast rotation.

g) The guys shall remain properly tensioned so that the tower remains plumb during, and after conductor stringing and clamping. Conductor stringing operations shall be halted if any guy becomes slack during the regulating operation of a section.

h) During erection, if it becomes necessary to leave the guys at reduced tension for longer than twenty-four hours, the *Eskom Site Representative* shall be informed immediately.

i) The *Design Engineer* shall accept the method of locking the guy grip and guy guard at the anchor end of the guy wires. The guy guard shall not be locked over the guy grip until the *Eskom Site Representative* has inspected and accepted the guy grip installation and the presence of adequate locking.

j) All U-bolts of guys on ground level will be fitted with anti-vandal caps or other suitable methods subjected to Eskom's approval, to ensure that the bolts cannot be loosened.

2.7.4.5 Tower labels

Tower labels are to be manufactured and installed as in "TSP41-604 – Design, manufacturing and installation standard for transmission line labels".

2.7.5 Tower dressing

a) Before any tower dressing can commence the tower must have been inspected and signed off by either the *Eskom Site Representative* or *Design Engineer*, indicating that the assembly and erection has been done in accordance with the relevant tower drawing(s) and method statement(s).

b) All rope assemblies, hardware assemblies, vibration dampers, aircraft warning spheres, bird flight diverters, bird guards and other assemblies must be installed in strict accordance with the supplier or manufacturer instructions or guidelines.

c) In the case of hardware assemblies, sample assemblies must be assembled in the *Contractor's* camp according to the approved assembly drawings and inspected by the *Design Engineer* prior to starting dressing operations. This includes phase conductor assemblies, earth wire assemblies and OPGW assemblies for every tower type to be used on the project.

d) All tower dressing operations shall be made according to the accepted relevant method

statement(s).

e) When assemblies are lifted into position or hoisted up towers, winches shall be used and not wheeled vehicles.

2.8 Stringing

2.8.1 Material supply

2.8.1.1 By the Employer

Quantities and delivery shall be as per the agreed schedules between *Employer* and *Contractor*.

2.8.1.2 By the Contractor

a) The *Contractor* is to establish the correct quantities of all stringing materials required to complete the *Works*.

b) The *Contractor* is to provide off-loading and secure storage facilities and shall be held responsible for the proper protection and safekeeping of all material like conductor, earth wire and OPGW until the completion date. The *Contractor* shall be held responsible for any loss or damage to material after delivery.

c) Special lay-down areas are to be made especially for wooden packaging (wooden drums and crates) to prevent direct contact with soil. The lay-down area must be on sufficient high ground to

prevent any material standing in water after rain or other wet conditions.

d) The *Contractor* is to verify and confirm the quantities of material supplied by the *Employer*. Conductor use is to be optimised to obviate excessive waste. A nominal amount (dependant on

the terrain - max. 3%) of phase and earth conductor will be allowed for sags and jumpers. Off-cuts and waste shall be returned to the *Employer* upon completion of the works as scrap.

e) All other surplus material shall be returned to the Employer upon completion of the works.

2.8.2 Installation of phase and earth conductors

2.8.2.1 General

All come-along clamps must be colour-coded to indicate the difference between clamps suitable for aluminium conductor and clamps suitable for steel wire. A silver colour is to be used for aluminium and brown for steel wires.

2.8.2.2 Changes in phase configuration

Where stringing through towers requires changes between horizontal, vertical or delta phase configurations, the *Contractor* shall confirm the alignment of the phases with the *Design Engineer* to ensure that the minimum phase clearances are maintained as well as the correct phase orientation(s).

2.8.2.3 Crossings, notices and permits

a) Substantial temporary conductor supports shall be used, or equally effective measures taken, to prevent encroachment of statutory clearances, or other clearance requirements stated in the permits, between the conductor being strung and other power or communication lines, roads or railways being crossed.

b) Suitable structures under each phase will be erected to protect all fences from conductor damage during stringing.

c) Temporary changes in poles, fixtures or conductors of lines being crossed will only be carried out if accepted by the *Eskom Site Representative*. The *Contractor* shall indicate any changes considered necessary and the *Eskom Site Representative* will co-ordinate any changes with the owner of the service.

d) The *Contractor* shall notify the *Eskom Site Representative*, at least 45 days in advance, of the time he intends to make crossings of power lines, communication lines, major roads, or railways. This notification shall state the location of the crossing to be made, the approximate time of the permit, the length of time that will be required to affect the crossing, and the duration of permit requested. The *Eskom Site Representative* will endeavour to accommodate late changes to the stringing programme; however, the *Employer* will not be liable for any time delays or costs resulting from the late programme changes.

e) The *Employer* will endeavour to arrange that all crossings be made with the crossed line deenergised. The time of line outages shall be kept to the absolute minimum. If line outages are not possible, alternative arrangements for live crossings should be made. A method statement of how this power line crossing is intended should be submitted to the *Design Engineer* for acceptance before work commences. All preparatory work shall be done prior to the work permit coming into effect. Upon completion of the work, the *Contractor* shall immediately notify the *Eskom Site Representative* that the lines are clear and release his working permit.

f) Suitable crossing support structures shall be used when obstacles like line, road, rail and other crossings are to be crossed. These support structures shall prevent the conductors, earth wire or OPGW to be strung to come into contact with the obstacle to be crossed and always allow

safe working distances and clearances to be maintained under live conditions. Detailed method statements indicating type of structures, methodology and material to be used are to be sent to the Design Engineer for acceptance prior to constructing the crossing.

2.8.2.4 Handling and stringing of conductors

a) All phase and earth conductors shall be tension strung using the accepted sag and tension tables for the relevant phase and earth conductor(s).

b) The equipment and methods used for stringing the conductors shall be such that the conductors will not be damaged. Care shall be always taken to ensure that the conductors do not become kinked, twisted, or abraded in any manner.

c) Stringing shall be done in daylight hours only.

d) The *Contractor* shall make suitable arrangements for temporary staying of towers and anchoring of conductors when necessary. Conductors may not be anchored to any portion of any tower, except strain towers, and then only at the points designed for conductor attachment. Temporary anchoring to footings and guy anchors will not be permitted. Where temporary anchoring is required, suitable temporary anchors shall be provided. Installation and removal of temporary anchors will be the *Contractor*'s responsibility.

e) Matched conductor drums, marked with the same number followed by the suffix A, B, C etc., shall be used for each pull of multiple conductors per phase to ensure even sag characteristics and a minimum number of joints. The Contractor shall select the most suitable sets of matched conductor drums for each stringing position to minimise wastage of conductor. The Contractor shall keep an accurate record of the phase and earth conductor drum numbers and their position in the line. On Completion a copy of these records shall be supplied to the *Design Engineer* and *Eskom Site Representative*.

f) Where multiple conductors per phase are used, these shall be attached to a single running board and strung simultaneously to ensure matched sags. The individual conductors shall be attached to the running board by auxiliary clamps that will not allow relative movement of strands or layers of wire and shall not over tension or deform individual wires.

g) Running boards shall pass through running blocks smoothly without hanging, catching, or causing wide variations in pulling tensions, damage to the running blocks or over stressing of towers. The pulling line shall be a non-rotating type, which will not impart twist or torque to the running board or conductors. Swivels shall be used to attach the pulling line and conductors to the running board. Swivels shall be small enough to pass through the running blocks without damage to either and shall have ball bearings and be free turning under load.

h) All conductors shall be strung by the controlled-tension method by means of rubber faced, double bull wheel-type tension stringing equipment. This equipment shall be so designed that there shall be no conduction of the heat generated by the braking action, to the bull wheels. There shall be appropriate mechanical braking on the reels to prevent loose conductor between the reels and the bull wheels, but sufficient tension to pull the conductor in between layers remaining on the reel. Brake controls shall be positive and fail-safe to minimise the danger of brake failure.

i) The tension shall be controlled individually on each conductor, and when the desired tension is obtained, the same constant tension shall be held so long as the brakes are left at this setting. Tensions, while pulling, shall be sufficient to clear all obstacles safely without damage to the conductor. At no time shall the pulling tension exceed the tension shown on the sag charts. Pulling of more than one drum length of conductor shall be subject to the *Eskom Site Representative's* acceptance.

j) Adequate protection shall be provided where there is danger of conductors being damaged or scratched, to limit corona on conductors. Conductors shall not be left in contact with the ground, vegetable matter or any conducting or semi-conducting material. Wood lagging or similar material shall be used to protect the conductor when working at ground level. Ensure all materials in contact with the conductor are free of nails and other deleterious substances.

k) Radio communications shall be used to relay information and instructions between the conductor tensioning station, intermediate check points, mobile stations, and the pulling station always during a stringing-tensioning operation. An outage of radio communications at any station will require immediate stopping of conductor pulling operations.

l) The placement of tensioning and pulling equipment shall be such that the vertical angle of pull-on a cross arm during stringing operations shall not be more than 20° relative to the horizontal. Conductors shall not be pulled around angles that exceed 20° from the normal direction when pulling the conductor. With tandem-mounted running blocks, the pulling angle shall not exceed 40°. With triple mounted running blocks, the pulling angle shall not exceed 60°. The centre running block shall be adjustable and aligned so that all three running blocks contribute equally to reducing bending on the conductor.

m) The sheaves shall conform to the conductor manufacturer's recommendation as to diameter, and to size and shape of groove for the size of conductor used. Sheaves shall have a minimum diameter of fifteen times the conductor diameter at the base of the groove. Sheave surfaces that will be in contact with the conductor shall be coated with neoprene or rubber. This covering shall be kept clean and free of materials that might damage the conductor surface. The conductor sheaves shall have a separate groove for the pulling line. The pulling line shall not run on the rubber covered conductor grooves. The sheaves shall be inspected for damage or contamination before each usage. The Contractor shall not use any sheaves rejected by the *Eskom Site Representative* due to damage or excessive wear. The *Contractor* shall immediately remove such sheaves from the site.

n) During stringing operations and before regulating, if it becomes necessary to leave the conductor in the blocks for longer than eighteen hours, the conductor shall be left at a much-reduced tension, and the *Eskom Site Representative* immediately notified. This reduced tension must be recorded in Newton or kg together with the ambient temperature. The percentage of sag, spans involved, time interval, and correction for creep shall be noted, and records forwarded to the *Eskom Site Representative*.

In no case shall conductors be left with less than the following clearances:

- Cultivated or open country: 6 metres,
- Roads and rails: 8 metres,
- Railroad tracks: 9 metres.

o) Bird caging of the conductor and/or earth conductor during stringing shall be avoided by the appropriate positioning of conductor drums relative to the tensioning equipment, as well as other means necessary to minimise conductor/earth conductor bird caging.

2.8.2.5 Joints

a) Before stringing commences, the *Contractor* will be required to compress sample phase and earth conductor mid span joints, as well as phase conductor dead/end assemblies on site in the presence of the *Eskom Site Representative*, using the matched and numbered dies and

compressors intended to be used on the line during stringing. The length of conductor between any two fittings on the sample shall be not less than 100 times the overall diameter of the conductor. Note that for OPGW, the contractor shall make a sample assembly and subject the assembly to the same test procedure as detailed in the next paragraph.

At an acceptable testing authority, a tensile load of about 10% of the breaking load of the conductor shall be applied and the conductor/earth wire/OPGW 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 (as per SANS IEC 61089) increased to 90% of the breaking load and maintained for 1 min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1 min and no failure of the fitting. The conductor/earth wire/OPGW shall then be loaded to failure, and the joint shall again withstand a minimum load of 95% of the minimum breaking strength of the conductor for it to be deemed acceptable. If the sample joint fails this test, a further three (3) sample joints shall be tested and will all be required to pass the above. If any one or more of these sample joints fail, no stringing shall commence until the *Design Engineer* is satisfied that the jointing equipment is acceptable. A copy of the test report shall be forwarded to the *Design Engineer* prior to stringing. The test report should include the project name and all relevant measurements such as “across-flat” widths, length of samples, etc.

b) As far as possible, complete drum lengths of conductor and earth conductor shall be used to reduce the number of joints. Joints shall not be closer than 15 metres to the nearest suspension tower or 30 metres from the nearest strain tower. Joints shall not be installed in spans crossings railways, proclaimed roads, power or important communication lines. In no case shall more than one joint be installed in a given span, nor shall a joint be installed in a span dead-ended at both ends. The minimum distance between joints shall be 300 metres.

c) Whenever joints or dead ends are made, auxiliary erection clamps and hauling devices shall not be placed closer than 8 m to the point of joint or dead-end. The auxiliary erection clamps shall not allow relative movement of strands or layers of wire, and shall not birdcage, over tension or deform individual wires.

d) The conductor shall be cut with a ratchet or guillotine cutter to produce a clean cut, retaining the normal strand lay and producing minimum burrs. The aluminium strands shall then be stripped from the steel core by using an acceptable stripper. Under no circumstances shall high tensile hacksaw blades be used to cut conductor.

e) The conductor shall be laid out for 15 metres and straightened at the ends before preparation for installation of joints or dead ends. Compression jointing shall be carried out on a clean tarpaulin or jointing trailer. The lay of wires shall be tightened before the first compression is made. The conductor strands shall be cleaned by wire brushing and an accepted non-oxidising paste applied. Compression joints shall be carefully made so that the completed joint or dead-end is as straight as possible. To minimise distortion, the joint should be rotated 180° between each compression operation, with the joint and conductor being fully supported in the same plane as the compression jaws. If, required by the Eskom Site Representative, the completed joint or dead-end shall be straightened on a wooden block by using appropriate tools. Any damaged joints or dead ends shall be replaced.

f) After compression joints have been completed, all corners, sharp projections, and indentations resulting from compression shall be carefully rounded. All other edges and corners of the fitting that have been damaged shall be carefully rounded to their original radius. Nicked or abraded surfaces shall be carefully smoothed. Tape, tape residue and filler paste shall be removed from fittings and conductors.

g) Sufficient notification shall be given to *Eskom Site Representative* prior to the installation of compression fittings. Unless previously agreed all joints and dead ends shall be installed in the presence of the *Eskom Site Representative*.

h) Under no circumstances shall compression joints be allowed to pass over the running blocks.

i) During the progress of the stringing, the *Contractor* shall keep an accurate record of the spans in which conductor and earth conductor joints are made, the date of assembly onto the conductor. A copy of these records shall be supplied to the *Design Engineer*.

2.8.2.6 Preparation of metal-to-metal contact surfaces

All current carrying connections, contact surfaces, clamps, conductor, and terminals shall be prepared as follows:

- wipe the mating surfaces free from grease and dirt (except the bores of compression sleeves)
- apply 1 mm thick coating of approved jointing compound to the surfaces using a non-metallic spatula or similar tool
- scrub all the coated surfaces thoroughly with a wire brush which is new, or which has been used solely for this purpose
- wipe off the jointing compound
- apply a fresh 1 mm thick coating of compound; and
- After a period of not more than one minute make the connection in the normal manner and remove excess extruded compound.

NOTE: No jointing compound squeezed out by clamping pressure shall be used in making further joints. The *Contractor* shall apply such compound as necessary for making the connections by the method outlined above. On bolted connections care shall be taken during the tightening to avoid overstressing the bolts or components of the clamps. A torque wrench shall be used for tightening each bolt to the required torque.

- Tighten all bolts and U-bolts to their specified torque.
- Leave clamps for 24 hours to allow aluminium conductor to expand and contract.
- Check all bolts to ensure that they are still at the required torque as stipulated on the components or hardware assembly drawings.
- Ensure "NORDLOK" or Belleville washers are installed on all jumper flags.

2.8.2.7 Conductor repairs

a) Damage caused by the *Contractor* shall be repaired in a manner determined by the *Eskom Site Representative*. Damage is any deformity on the surface of the conductor that can be detected by eyesight or by feel. Damage includes, but is not limited to nicks, scratches, abrasions, kinks, bird caging, and popped out and broken strands.

b) Depending upon the severity of the damage and the length of damaged section, the repair shall be made by careful smoothing the deformity with extra fine sandpaper, covering with preformed repair rods, installing a compression-type repair sleeve, or by cutting and splicing.

c) Kinked, bird caged, or severely damaged sections of conductor shall be cut out. When there is repeated damage in the same span, or in consecutive spans, the entire conductor in such spans shall be replaced.

d) All damage caused by auxiliary erection clamps or other gripping devices shall be repaired or cut out, as instructed by the *Eskom Site Representative* before the conductor is sagged.

e) Preformed repair rods shall be installed if no more than one strand is broken or nicked deeper than one third of the strand diameter, or when several strands are reduced in area not exceeding the area of one strand. Not more than two sets of preformed repair rods shall be installed on any one conductor in any given span.

f) A compression-type repair sleeve shall be installed, if not more than one third of the outer strands of the conductor are damaged over a length of not more than 100 mm, or not more than three strands are broken in the outer layer of conductor and the area of any other damaged strands is not reduced by more than 25%.

g) Compression-type repair sleeves shall not be installed on one conductor in each span if it already contains a conductor splice, conductor dead-end or another compression-type repair sleeve.

h) If damage exist in the outer and inner aluminium layers but no damage exists on the steel centre core for ACSR conductors, then a preformed type line splice can be considered. Details of the proposed repair should be provided to the *Design Engineer* for final acceptance.

i) Damage to the steel strands or aluminium strands, exceeding the stated limits for repair sleeves, shall be cut out and spliced by means of a compression type mid-span joint.

j) Any foreign matter such as pitch, paint and grease placed on the conductor and fittings by the *Contractor* shall be removed by methods accepted by the *Eskom Site Representative* prior to regulating.

2.8.2.8 Regulating

a) To have better quality control on stringing, the *Contractor* must submit a schedule of how he intends stringing the strain sections and give locations of puller and tensioner used for the *Eskom Design Engineer* to review for acceptance. The tensioner must be behind the tower to be strained off. Should there be a deviation from this process, then the *Contractor* must supply a detailed method statement to demonstrate how he can safely execute the stringing operation. This deviation must be sent the *Eskom Design Engineer* for acceptance prior to commencement of any stringing operations. The *Contractor* is to ensure that appropriate equipment and accompanying hardware is selected for the specific application.

b) The *Contractor* shall string all conductors and earth conductors to the appropriate sags and tensions as determined from the conditions specified in this *Works* Information. The calculation of clamping offsets shall be the responsibility of the *Contractor*. Such calculations shall be submitted to and accepted by the *Design Engineer* prior to regulating. The appropriate conductor temperature to be used for sagging shall be determined by means of a Celsius thermometer inserted in the end of a suitable length of conductor or earth conductor from which a 150mm length has been removed from the centre strand, or other accepted method. The wire with the thermometer inserted shall be hung at cross arm level for at least two hours before the temperature is read.

c) The length of a section of phase and earth conductors to be regulated at any one time shall be limited to that length that will assure attainment of correct sag based upon terrain and obstructions.

d) Where there are many suspension towers between strain towers, regulating of phase and earth conductors shall be done at intervals of 3 to 5 spans. In hilly country the conductors may require to be temporarily anchored one span away from the spans being regulated. The sag spans chosen shall be near each end of the section pulled for single conductor lengths, and near each end and at the middle for double conductor lengths. In addition, the sags shall be checked in all spans over 500 metres. In unusual situations, the *Eskom Site Representative* may require additional checks.

e) The *Contractor* shall provide, and maintain in good condition, suitable dynamometers, sag boards or other accepted apparatus for the proper checking of the work. Dynamometers shall read in Newton and shall be tested and recalibrated at regular intervals. The *Contractor* shall keep dynamometer calibration certificates at the site office.

f) The *Contractor* shall notify the *Eskom Site Representative* at least twenty-four hours prior to any planned regulating operation. No regulating shall be done except in his presence, unless otherwise authorised. The *Contractor* shall provide labour and equipment, for signalling and climbing purposes as requested by the *Eskom Site Representative,* to facilitate his inspection of the sag.

g) In pulling up the conductor, caution shall be used to avoid pulling the conductor above sag height.

h) The maximum elapsed time from the beginning of the pulling operation to the completion of the regulating operation shall not exceed seventy-two hours, nor shall the maximum elapsed time between the completion of the regulating operation and the completion of the clamping operation exceed seventy-two hours. Conductor remaining in the blocks longer than the established limits shall be subject to inspection and, if damaged, replaced. The *Contractor* shall provide labour and equipment as requested by the *Eskom Site Representative* for this purpose, as well as for inspection in the event of sudden windstorms.

i) No minus regulating tolerance will be allowed. A plus regulating tolerance of 0.01 times the theoretical sag, but not exceeding 150 mm will be allowed, provided all conductors in the regulating span assume the same relative position to true sag. Sags of conductors in the same bundle shall not vary more than 35 mm relative to one another. Sag variances between phases shall not be apparent to the naked eye.

j) When finally adjusting the sags of conductors and earth conductors, the sag shall be checked with sag boards, or other accepted methods in spans where the levels of the two towers are approximately the same, and the span length is approximately equal to the equivalent span length of the strain section. Upon completion of this regulating operation, as many successive spans as can be observed from the sag board position shall be checked for uniformity of sag.

k) All conductors, except for conductors in sag sections over flat terrain, shall be plumb-marked at each structure for the complete section regulated before clamping-in or dead-ending of the conductor is begun. Conductors shall be marked with paint crayon or wax pencil - not with metal objects.

l) Insulator strings on three suspension towers adjacent to a new section to be regulated shall be clamped to the conductor before temporary anchors are removed and regulating of the new section begins. These insulators shall remain in the plumb position upon completion of regulating of the new section and during plumb-marking.

m) Regulating operations shall be conducted during daylight hours only. Regulating operations shall be suspended at any time, when in the opinion of the *Eskom Site Representative*, wind or other adverse weather conditions would prevent satisfactory regulating.

n) Records of temperature sag and tension for each section regulated shall be kept by the *Contractor*, and a copy supplied to the *Design Engineer*.

n) On completion of regulating of a section of the line, the *Contractor* shall measure and record all clearances over roads, power lines, communication lines, railways etc. along the route. A copy of these clearance records is to be submitted to the *Design Engineer*. The Eskom Site Representative is to be notified immediately of any discrepancy found between the actual clearance and that shown on the profiles.

2.8.2.9 Clamping of conductors

a) The conductors and earth conductors shall be clamped-in by the *Contractor* after the *Eskom Site Representative* has accepted the regulating operation as being in full compliance with the standards and stringing data. Where offsets are required, the conductors shall be accurately adjusted in accordance with the offset clamping information developed by the *Contractor*.

b) All conductors in a sag section shall normally be clamped-in, beginning at the second structure from the forward end of the pull, and shall progress structure by structure, until the conductors at all structures are clamped-in.

c) The *Contractor* shall exercise extreme care in moving the phase and earth conductor from the stringing blocks to the suspension clamps.

d) Where armour rods or conductor clamps incorporating armour rods are called for, they shall be installed in strict accordance with the manufacturer's recommendations. Armour rods shall be centred in each suspension clamp in such a manner that the clamp is not more than 50 mm from the centre of the rods. Variations between the ends of the individual rods shall not exceed 12 mm. Aluminium rods shall be handled with the same care as the conductor.

e) Properly calibrated torque wrenches shall be used to tighten suspension clamp and dead-end bolts to the manufacturers' specified torque values. U-bolts shall be drawn up evenly to torque values. Bolts shall not be tightened excessively. Proof of calibration shall be submitted to the *Eskom Site Representative*.

f) All conductor support assemblies shall be installed such that the insulator string will hang in a vertical plane through points of insulator string attachment to structure, with the structure properly aligned.

2.8.2.10 Vibration dampers

a) Where vibration dampers are specified, these shall be installed at each suspension and strain point.

b) The number of dampers to be installed per span shall be as recommended by the manufacturer. The spacing from the mouth of the strain clamp or the centre of the suspension clamp shall be in accordance with the manufacturer's recommendations.

c) If the use of armour rods makes it impossible to meet this spacing, the first damper shall be positioned at the end of the armour rods, and any additional dampers shall then be spaced from the first damper. Dampers shall be located within 25 mm of their correct position.

d) Vibration dampers shall be installed when clamping the conductor, but only after the conductor has been securely fastened in the conductor support assembly.

e) Stockbridge type vibration dampers shall be installed so that they hang directly under the conductor.

f) The installation of vibration dampers shall be in accordance with the manufacturers' recommendations.

2.8.2.11 Multi-conductor spacers and spacer dampers

a) On lines employing more than one conductor per phase, spacers, or spacer-dampers, shall be installed to separate the individual conductors of each phase.

b) Conductor spacers or spacer dampers shall be installed immediately after clamping the

conductors, but in no instance shall conductors be allowed to remain without spacers installed for longer than seventy-two hours after clamping.

c) Notwithstanding the allowed times between stringing, regulating, clamping, and fitting of vibration dampers, spacers or spacer dampers, the overall time for these operations shall not exceed six days (144 hours).

d) Conductor spacers or spacer dampers shall be installed within 1 000 mm of the positions as specified by the manufacturer in a staggered (non-equal) spacing distance between spacer dampers, as per the manufacturers' installation instructions or spacing chart.

e) Conductor spacer carts used by the *Contractor* to move his men along the conductor shall be furnished with neoprene or rubber lined wheels to support the carts on the conductors. The carts shall be equipped with an odometer, which shall run on one sub-conductor and indicate distances in metres. The odometer shall be set in such a manner, as to give the distance from the suspension clamp to all cart positions along the span on the centre phase from which all the hardware on the three phases will be aligned perpendicular to the centre line of each span. Spacer-dampers will also be installed perpendicular to the sub-conductors of each phase along the

catenary.

2.8.2.12 Jumpers

a) The jumpers shall be formed to provide the maximum amount of clearance from earthed hardware, and tower steelwork. Their positioning shall comply with the clearances stated under the specified displacements.

b) The *Contractor* shall supply labour and equipment to assist the *Eskom Site Representative* in measuring clearances from jumpers to earthed hardware if requested.

c) Jumpers not meeting the required clearances shall be removed and replaced.

2.9 Insulators

2.9.1 General

The *Contractor* will adhere to the guidelines below regarding insulators.

2.9.2 Receiving

a) Check all paperwork and package markings for compliance.

b) Inspect crates for damage upon delivery to site.

c) Any packaging damage must be:

1) Reported immediately to the *Eskom Site Representative*.

2) Each insulator from the crate must be visually inspected for damage.

3) Damaged insulators units must be marked to prevent inadvertent later use.

2.9.3 Storage

a) Insulators must be stored in their original crates.

b) Insulators in their crates must preferably be stored indoors.

c) Crates stored outdoors must be in pressure treated lumber rather than regular lumber or cardboard boxes.

d) Crates should be stored off the ground.

e) Stacking of boxes/crates must not cause squashing of lower boxes/crates. In the event of damage, point 3) in the "Receiving" section 2.9.2 above must be followed.

f) Heavy material must not be stored on top of boxes/crates due to potential damage.

g) If insulators are to be stored out of boxes/crates, care must be taken to protect them from damage:

1) They must not be stacked on top of each other.

2) Other material must not be placed on top of them.

3) Accepted storage methods include using designated bins, suspension hooks, PVC pipes or builders' tubes

h) Storage locations must avoid:

1) Water ingress into the boxes/crates or areas of standing water.

2) Contact with petrochemical products.

3) Possible rodent damage.

2.9.4 Loading and off-loading

a) Care must be exercised when using forklifts, so as not to penetrate boxes/crates and damage the insulators. Damaged boxes/crates will be subjected to point 3) in the "Receiving" section 2.9.2 above.

b) Any nails or screws left exposed on removal of the box/crate lid, or internal batons, must be removed prior to removing insulators from the crate to prevent damage.

c) For polymer insulators shipped in plastic protective covers, the cover should be cut at the end only and not along its length.

2.9.5 Transport to site

a) Where possible, insulators must be transported in their original boxes/crates.

b) For the transport of unpacked insulators:

1) PVC pipes and builders' tubes can be used.

2) If protective coverings cannot be used, then the insulators should be stacked side-by-side.

3) Avoid placing objects on unprotected insulators.

4) Insulators should not be tied down using ropes, chains etc.

2.9.6 Insulator Handling

a) Insulators must not be dragged on the ground.

b) Insulators must not be thrown on the ground or lie where inadvertent vehicle damage may occur.

c) Polymer insulators must not be bent or twisted.

d) A polymer insulator less than 2.5 m in length can be carried by one person holding the core at a central point.

e) A polymer insulator longer than 2.5 m in length must be carried by two persons, each holding the insulator 0.5 m from each end.

f) Bending must be kept to within a 300 angle from the horizontal when carrying long insulators.

g) For post insulators, slings must be placed around the end fittings for lifting and moving.

h) Under no circumstances must slings be attached to the shed areas of polymers.

2.9.7 Installation

a) Prior to raising the insulators must be inspected visually for damage.

b) For cap and pin units, the correct installation of cotter keys must be checked.

c) A ground sheet must be provided for the assembly of insulators and hardware.

d) Corona rings must be fitted correctly, according to the supplier's drawing and instruction sheets.

e) Sleeves can be used to prevent polymer shed or glass damage.

f) For polymer insulators, ropes or lifting lines must be attached around the metal end caps and not the shed areas. The ground line must be controlled by a ground-based lineman to prevent the insulator colliding with the structure.

g) For glass insulators, ropes and lifting lines must not be connected in between discs to prevent loading and damage to the split pins.

h) Working platforms, bucket trucks, tools etc., must not come into contact with the insulator during and after installation.

i) The climbing and walking on both polymer insulators and corona rings are not permitted.

j) Insulators may not be used as anchoring points for pulleys, tools, safety belts and/or any other equipment.

k) No bending or twisting of the polymer is permitted during attachment of hardware.

2.9.8 Post Installation

A final visual inspection on the installation should be done to determine:

a) Any signs of damage, including torsional loading.

b) Signs of bending or deflection.

c) Incorrectly applied insulators or hardware, including corona rings.

2.9.9 Visual Inspection of Insulators

Insulators must be visually inspected for damage prior to installation by the *Contractor* and *Eskom Site Representative*.

For polymer insulators, the following can be inspected:

a) Bonding of the rubber to the fibreglass rod and end fitting area.

b) Cracks or splits on the sheds and sheath.

c) Knife cuts.

d) Poor hot dip galvanizing or corrosion on the end fittings.

e) Mould accumulation. A method for mould removal should be suggested by the *Eskom Site Representative.* Preferably use water and a cloth to clean. Do NOT use solvent/oil-based detergents or abrasive materials to clean.

f) Unclipped sheath sections

g) Rodent damage.

For glass insulators, the following can be inspected:

a) The clarity of the glass and streaks or cracks developing.

b) The porosity of the cement.

c) Poor hot dip galvanizing or corrosion of the end fittings.

2.9.10 Tests

For each requirement there should be an equivalent test unless the tests are already covered in the relevant normative reference(s).

2.10 Marking, labelling, and packaging

Where applicable, the *Contractor* shall ensure that all marking, labelling, and packaging must conform to the relevant standards.

2.11 Spares

Where spares-holding is a requirement, it must conform with the relevant standards.

2.12 Impedance measurements

Line impedance measurements shall be carried out for all new transmission lines built. The measurement shall be carried out as per the latest revision of specification number.

474-9428, Transmission Line Impedance Measurement Specification. As per the requirements of the test, the measurements must be done after construction completion but before the line is energised. In addition, the contractor needs to provide the As-Built information

2.13 Photographic and Video Records

Photographs shall be taken on all critical stages of the line construction. Where applicable, videos must be taken of the rigging and stringing activities.

2.14 Siting

2.14.1 Site Characteristics

The new 11 kV OHL must be designed with careful consideration of site conditions that may affect the ratings of equipment.

The following environmental conditions must be considered:

2.14.1.1 Topography

The surface topography of the Kriel area is typical of the Mpumalanga Highveld consisting of a gently undulating plateau. The flood plains of the local streams are at an average elevation of ± 1540 meters above mean sea level and drainage generally is a northerly direction.

2.14.1.2 Temperature

January is normally the hottest month with an average daily maximum temperature of 27°C. Winter average daily temperatures vary from 18.5°C maximum to -1°C minimum and a mean daily temperature of about 16°C.

2.14.1.3 Wind

Winds are generally light to moderate except during thunderstorms. During daytime, the prevailing winds are from the north-western direction and during night-time, the prevailing winds are from the north-eastern direction. The highest wind speeds are recorded from the Southeast with an average speed of 14km/H.

2.14.1.4 Rainfall

The average annual precipitation is about 750-mm falling almost entirely during the months of October to April. January is statistically the highest rainfall month with an average monthly rainfall of about 130-mm. June has the lowest rainfall with an average monthly rainfall of about 7 mm.

2.14.1.5 Other climatic factors

a) Thunder occurs mostly from November to January with average of 35.7 days annually.
b) Hail occurs mostly in December with average of 2.8 days annually.
c) Fog occurs mostly in the winter months with an average of 19 days annually.
d) Snow rarely occurs
e) Cloud coverage is highest in the summer months with annual average as follows:
   - 08:00 = 2.8/8
   - 14:00 = 3.8/8
   - 20:00 = 3.1/8

f) Evaporation for the area is in rage of 75mm to 190mm per month. The highest evaporation occurs in December, and the lowest in June.
g) The atmosphere is normally dry and dusty with presence of fly ash and pulverized fuel.

2.14.2 Site Layout

The 11 kV overhead lines (OHL) [05-00AD01 & 05-00AD02] were constructed to supply substations on the Outside Plant and Common Plant. The substations that are supplied by the OHL are namely:

- Ash conveyor substation
- Contractor's yard
- Ash water return substation (AWR)
- Slurry Plant
- Ash dams (Duck Pond, Ape Pump, Flight Pumps and South Face Seepage pump)

The OHL achieves the supply to the loads using an H-Pole structure, H-Pole structure assemblies, insulators, isolators, links, surge arrestors and an ACSR conductors and XLPE cables.

The routing for the 11 kV line is colour coded Red in the figure on the next page.

Figure 1: Kriel Power Station proposed 11 kV routing.

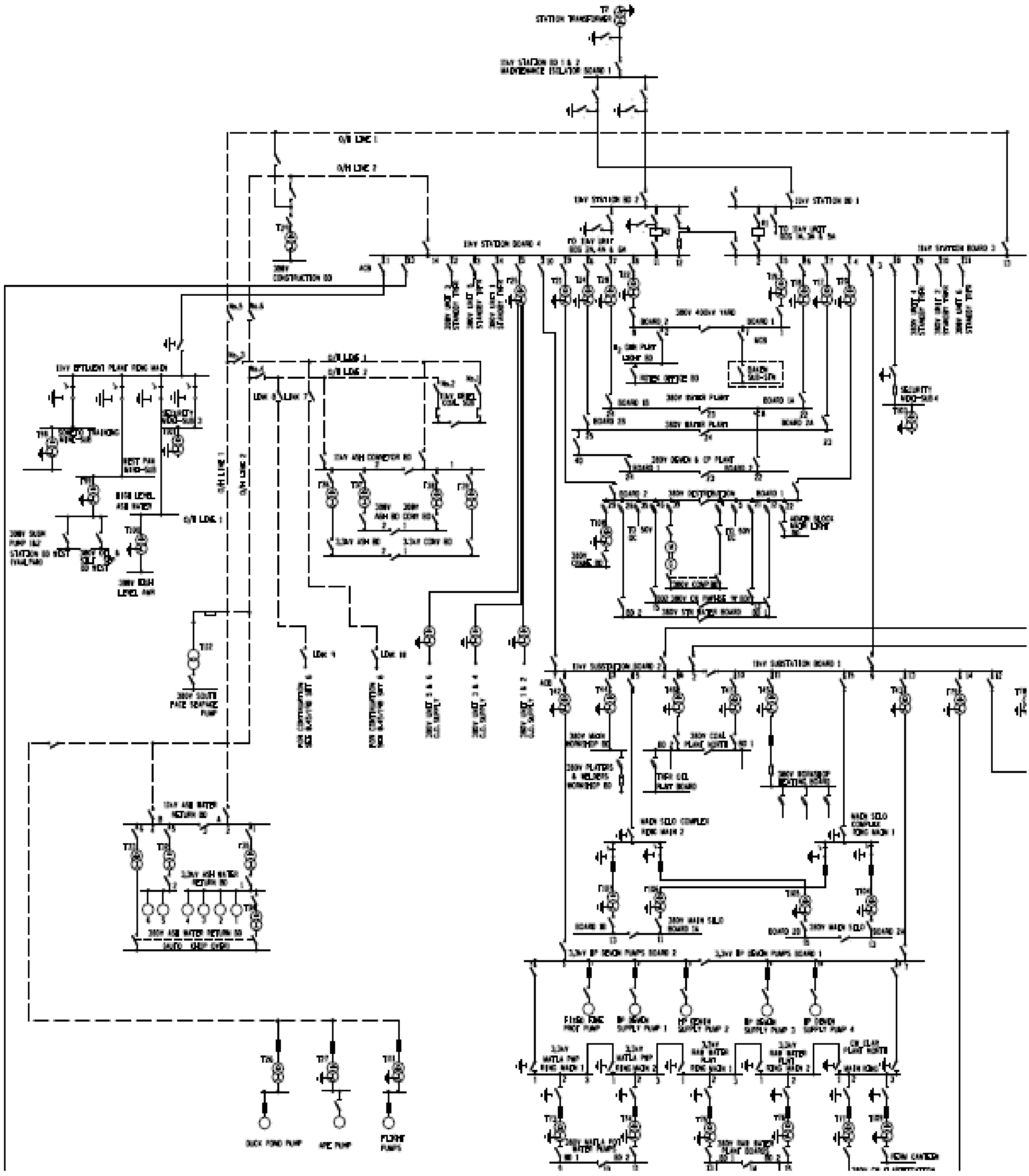


Figure 2: Kriel Power Station Common and Outside Plant Reticulation

2.14.3 Battery Limits

The table below shows the battery limits for the upgrade project:

PLANT	START	END	EXCLUSIONS	INCLUSIONS	P&ID DRAWINGS
11 kV Overhead Line	Line 1 - 11 kV Station Boar 3 Line 2 - 11 kV Station Board 4	Ash Water Return (AWR)	All *works* pertaining to substations and switchgear	1. Interfacing cables between both the 11 kV Station Boards and the two overhead lines (i.e., Line 1 & 2) 2. Additional 11 kV overhead line from links 5 & 6 to supply Ash Convey (Where the poles end) **Note:** The C*ontractor* will be responsible for sizing and installing of a cable from the station boards to the 11 kV overhead line (station boards to OHL first poles).	0.45/198

3 DOCUMENTATION AND CONFIGURATION MANAGEMENT

3.1 Document Management

All documents supplied by the *Contractor* shall be subject to the *Employer*'s approval. The language of all documentation shall be in English. All documentation shall be controlled and managed in accordance with Document and Records Management Procedure (32-6).

3.2 Document Identification

The *Contractor* is required to submit the Vendor Document Submission Schedule (VDSS) as per agreed dates to the delegated *Employer* Representative. The *Employer* will pre-allocate document numbers on the VDSS and send back to the *Contractor* through the delegated *Employer* Representative. The VDSS is revisable, and changes must be discussed and agreed upon by all parties. Changes in the VDSS can be additional documentation to be submitted, changes in submission dates or corrections in documentation descriptions, document numbers etc. The *Contractor's* VDSS shall indicate the format of documents to be submitted.

3.3 Document Submission

All project documents must be submitted to the delegated *Employer* Representative with transmittal note according to Project / Plant Specific Technical Documents and Records Management Work Instruction (240-76992014). In order to portray a consistent image, it is important that all documents used within the project follow the same standards of layout, style and formatting as described in the Work Instruction.

The *Contractor* is required to submit documents as electronic and hard copies and both copies must be delivered to the *Employer* Representative with a transmittal note. The *Contractor* submits all documents according to the accepted VDSS. The process for submission of documents shall be agreed before the design work commences.

In addition, the *Contractor* shall be provided with the following standards which must be adhered to:

- Project Plant Specific Technical Documents - Handover Works Instruction 240-124341168.
- Project Documentation Deliverable Requirement Specification 240-65459834.
- Technical Documentation Classification and Designation Standard 240-54179170.
- Project/ Plant Specific Technical Documents and Records Management Work Instruction 240-76992014.

3.4 Electronic Submission (SharePoint Transmittal)

Electronic submissions could be done using the SharePoint Transmittal Site functionality and route. This shall be done by executing the following:

- For bulk document submission, the following link can be used https://zendto.eskom.co.za/.
- Where applicable and contractually agreed, e-mail submissions can be used, as well as other submission methods employed in the relevant project e.g. Box; Norman Secure, etc.

3.5 Drawings format and layout

The creation, issuing and control of all Engineering Drawings will be in accordance to the latest revision of engineering drawing Standard 240-86973501. Drawings issued to the *Employer* will be a minimum of two hardcopies and an electronic copy that is editable. The *Contractors* are required to submit electronic drawings in Micro Station (DGN) format, and scanned drawings in pdf format. Drawings issued to the *Employer* may not be "Right Protected" or encrypted. The *Employer* reserves the right to use these drawings to meet other contractual obligations. The *Contractor* shall include the *Employer's* drawing number in the drawing title block. Drawing numbers will be assigned by the *Employer* as drawings are developed.

4 CONFIGURATION MANAGEMENT

4.1 Plant Coding Allocation

Coding of the design shall be based on the latest revision of 240-131050729 Hybrid Coding Standard and the *Employer* shall undertake the coding in line with its standards. The AKZ coding shall be applied during the design review stage(s) and cross referenced to all arrangement drawings, schematics, instructions, and manuals and where practical to spare parts list/manuals. The *Contractor* shall be required to include allocated coding to the electronic design drawings.

4.2 Change Management

All design change management shall be performed in line with the *Employer* Project Engineering Change Management Procedure 240-53114026 and the *Employer* ensures that *Contractor* is provided with latest revisions of this procedure. Any uncertainty regarding this procedure should be clarified with the *Employer* and clarification updates should be reflected in updated versions of this procedure.

4.3 Design Review Documentation

The *Contractor* conducts design reviews as per the *Contractor*s official design review procedure. The *Contractor* further takes note of the *Employer's* Design Review Procedure 240-53113685 and participates in all design reviews as specified by the *Employer*. The *Employer* may "Accept"; "Accept with Comments" or "Reject". If required, the *Contractor* makes the necessary revisions on the documentation and ensures "Accepted" status is obtained from the *Employer*. The *Contractor* includes these design reviews as part of the schedule and suggests appropriate timing for such reviews.

4.4 Drawing Requirements

a) The *Contractor* provides drawings for the required scope. The *Employer* provides typical drawing template for tender purposes only and will form the basis for the design and formatting.
b) The *Contractor* supplies reproducible drawings according to the VDSS.

4.5 Design Review

a) The *Contractor* shall hold a design review as part of the compliance review of the plant, allowing the *Employer* to gain a clear understanding of the overall design.
b) The review shall be after the completion of the design and the preliminary outline drawings.
c) The *Contractor* shall make available the calculations and information for the detailed design verification. This part of the design review will take place in the *Contractor*'s design offices. The *Employer* shall advise on the appropriate venue.

4.6 Design Review Procedure

The *Contractor* is the Design Authority as defined in the Design Review Procedure (240-53113685). The *Contractor* is responsible for following this design procedure and conducts all the design reviews as specified in this procedure. The *Contractor* is responsible for conducting the following design reviews:

a) Design Freeze Review
b) Integrated Design Review
c) Construction Completion Review
d) Acceptance Testing Review

4.7 Engineering Change Procedure

The *Contractor* takes note of the *Employer's* Project Engineering Change Management Procedure (240-53114026). An engineering change includes any proposed change originating from engineering, *Contractor*s, project management or construction management.

5 PROCUREMENT

5.1 Plant and Materials

5.1.1 Quality

a) All Plant and Materials are new. All New Plant and Materials will be free from defects. No Reconditioned Plant and/or Materials are regarded as new under any circumstances.
b) The *Contractor* will not use Plant or Materials which are generally recognised as being unsuitable or otherwise to be avoided for the purpose for which they are intended.
c) Only components of high reliability will be utilised, with a proven operating history, to enable the Plant to achieve required reliability and availability. Plant and Material design, engineering and manufacture will accord with the best modern practice applicable to high-grade products of the type to be furnished, so as to ensure the efficiency and reliability of the Works and the strength and suitability of the various parts for the Works.
d) Plant and Materials withstands ambient conditions and the variations of temperature arising under working conditions without distortion, deterioration or undue strains in any part.
e) All parts are made accurately, and where practicable, to standard gauges so as to facilitate replacement and repairs. Like parts are interchangeable.
f) No repair of defective Plant and/or Materials will be permitted without the Project Manager's acceptance and any such repair, if accepted, will be carried out to the satisfaction of the Project Manager.
g) The *Contractor* ensures that co-ordinated and formally documented management system is in place for the assurance of quality as specified in ISO 9001, Quality management Systems – Requirements.
h) The *Eskom Site Representative* will specify hold and witness points during the installation and on-site testing stages of the project. The *Contractor* issues preliminary notification of such hold and witness points by fifteen working days advance notice to the *Project Manager* and confirms such hold and witness points at least seven days prior to the activity.

   Typical holding points are listed below:
   - Design Review
   - Factory Acceptance Test (FAT)
   - Delivery
   - Site Acceptance Test (SAT)
   - Installation
   - Commissioning
   - Optimization
   - All manuals and drawings (in the specified format)

i) In addition to maintaining appropriate inspection and test records to substantiate conformance to requirements, the following records are safely stored for a minimum period of seven years following the final completion of the works:
   - Installation, layout, and component approvals
   - Routine test certificates
   - Installation drawings and approvals

j) After this period, the *Contractor* offers these records to the *Employer* (in writing) and obtains a disposal instruction.
k) Documentation regarding quality procedures is submitted within thirty (30) days of contract award. The *Project Manager* will review and comment on the acceptability of these documents in a time frame as per the requirements of the contract for contractual correspondence. If controlled copies of these documents have been submitted to the *Project Manager*, then the controlled copy numbers may be quoted in the submission.

5.1.2 Plant & Materials provided "free issue" by the *Employer*

No plant and material shall be provided by the *Employer* as "free issue" for the project.

5.1.3 *Contractor's* procurement of Plant and Materials

a) Equipment availability and time of delivery will depend on the appointed *Contractor*. If the supplier or subcontractor does not manufacture the any equipment or its accessories locally, then it will be imported.
b) During transportation, packaging is done in such a way that damage is prevented. Components that are transported separately are marked accordingly and are easily identifiable.
c) The *Contractor* supplies the labelling for the Plant that forms part of the *works*. The *Contractor* provides labels for the Plant according to Kriel label specification. The *Contractor* makes use of the AKZ codes and descriptions provided by the Employer.
d) The labels are affixed in such a way that they are easily legible and not obstructed by the wiring or by other components.
e) The *Contractor* supplies the Project Manager, for verification and acceptance purposes, with a label list showing the text only. The *Contractor* shall ensure the positioning and designation of labels are correct.
f) The AKZ codes are used accordingly on documentation (e.g., drawings, manuals, equipment lists, cable schedules etc.) as a unique identification means. References to plant are accompanied by the relevant AKZ code for that item of plant.
g) Abbreviations to descriptions on the labels are generally not acceptable.

5.1.4 Spares and Consumables

a) The *Contractor* provides as part of the detail design, recommended Critical and Normal Running spares lists, including costs.
b) The *Contractor* provides 1x off set of critical spares as part of the *Works*.
c) The Employer is responsible for purchasing of recommended spares.
d) Each recommended spare is uniquely identified with a part number and respective supplier name, which can be cross referenced to a spares list and associated drawing.
e) The Project Manager prefers that support from the OEM or component supplier is available locally in South Africa. The *Contractor* is required to provide technical support for the design life of the Plant.

5.1.5 Tests and inspections before delivery

a) The *Contractor* provides and demonstrates the detail design logic for the devices and system, in their supply of the Works, to the Employer's representatives for acceptance.
b) The *Contractor* provides design documentation as per the Employer's VDSS, to the Project Manager for acceptance.

6 CONSTRUCTION

6.1 Temporary works, Site services & construction constraints

6.1.1 Employer's Site entry and security control, permits, and Site regulations

a) The *Contractor's* personnel are required to attend an Eskom Kriel safety induction, provided by the Project Manager, before allowed to enter and work on the site of Kriel Power Station. It is the responsibility of the Contractor to ensure that all required personnel have attended the safety induction.
b) The *Contractor* provides his/her safety file for acceptance by the Project Manager. The Project Manager and delegated safety personnel approves the safety file before the Contractor attends the Eskom Kriel safety induction.
c) Site access control to Kriel Power Station will be arranged with the Project Manager after successfully completing the safety induction.
d) Alcohol and drug testing will be conducted at any time on all personnel entering the Kriel Power Station site premises. Any personnel tested positive for alcohol or drug usage will not be allowed on site.

6.1.2 Site establishment

e) The *Contractor* complies with the environmental policy given in the Site Regulations. The *Contractor* provides, erects, and maintains for his own use adequate size office accommodation and stores together with such drainage, lighting, heating, and hot and cold-water services as may be required. Indoor storage space will be required for all switchgear panels, and control equipment since these materials are susceptible to damage if placed in an unprotected area.
f) After project execution the *Contractor* dismantles and clears the yard of all temporary structures and associated foundations and infrastructure. Proper storage of materials and equipment prior to installation will ensure each item's integrity and intended function.
g) Each *Contractor's* material control staff will ensure that all items stored at the project site are stored in accordance with manufacturer's requirements, engineering directives, and sound project practices

6.1.3 Restrictions to access on Site, roads, walkways, and barricades

h) All *Contractor* personnel vehicles comply with the National Road Traffic Act.
i) The *Contractor* applies for personnel site vehicle access, in their supply of the Works, for acceptance by the Project Manager.
j) The Project Manager and delegated safety personnel conducts Contractor personnel vehicle inspections at random.

6.1.4 People restrictions on Site; hours of work, conduct and records

k) The *Contractor* schedules hours of work, in their supply of the Works, in accordance with the site shift management at Kriel Power Station and with acceptance by the Project Manager.
l) Any incident or accident, in their supply of the Works is to be reported to the Project Manager within 24 hours. Any incident or accident, in the supply of the Works is to be investigated as defined in the Safety, Health and Environmental Requirements for Contractors RSR0001.

6.1.5 Title to materials from demolition and excavation

The *Contractor* requests permission and acceptance by the Project Manager, before removal of any items of Plant, Equipment or Materials found on site during execution of the Works. No material shall be disposed of side without the approval of project manager. The *Contractor* is required to dispose unused material in accordance with Eskom disposal procedure 32-1034 and Employer shall recover the cost of the disposed material.

6.1.6 Contractor's Equipment

a) The *Contractor* provides all Equipment that is required to complete the works.
b) The *Contractor's* Equipment does not impair the operation of plant and the access to the plant.

c) The *Contractor* provides of all, or any temporary or expendable materials required for the storage of equipment on site.
d) The *Contractor's* equipment, including testing equipment is validated and certified for use by the South African National Accreditation System.
e) The *Contractor's* equipment conforms to the applicable OHS Act safety standards and is maintained in a safe and proper working condition. The *Project Manager* has the right to stop the *Contractor's* use of any Equipment, which, in the opinion of *Project Manager*, does not conform to the foregoing.

6.1.7 Equipment provided by the Employer

No equipment will be provided by the *Employer* to the *Contractor.*

6.2 Site services and facilities

6.2.1 Supply of electricity

a) All points of supply requested by the *Contractor* are provided in terms of quantity and location at the discretion of the *Project Manager*.
b) There is no energy charge for electricity used for construction purposes.
c) No connection is made to the permanent installation at the Power Station without the prior acceptance of the Project Manager.
d) No guarantees of power supply quality are given, and power supply breaks of some duration may occur without warning. Planned outages are also a possibility. The *Contractor* decides at his own expense to improve continuity and quality of power supply where necessary for any reason and no claim of any nature relating to power failures is considered.

6.3 Design Requirements

6.3.1 Sequences of construction or installation

The *Contractor* must provide an installation plan for approval by the *Eskom Site Representative* and *Project Manager*. The *Contractor* uses the installation plan to schedule site activities and personnel required for installation, testing and commissioning activities.

6.3.2 Procurability Assessment

Equipment availability and time of delivery will depend on the appointed *Contractor*. If the *Supplier* or *Subcontractor* does not manufacture the assembly or its accessories locally, then it will be imported.

6.3.3 Constructability Assessment

An installation plan document will be developed during execution to guide the installation and commissioning process by the *Contractor*. The installation plan shall address the challenges that will occur during execution of the project, as there are no formal outages planned for the common and outside plant areas, and services supplied by substations on these plants are critical for production and legal requirements.

6.3.4 Transportation Plan

Each transportable unit she be safely transported. The *Contractor* must furnish the *Eskom Site Representative* with a transportation plan for all major equipment for approval.

6.3.5 Giving notice of work to be covered up

All intended activities must be captured in the *Contractor* scope of work, method statements and project schedule. The project schedule will be reviewed and updated by the *Contractor* and Project Manager.

6.4 Completion, testing, commissioning, and correction of Defects

6.4.1 Commissioning

a) Commissioning of the works is done by the *Contractor's* personnel with the Employer's delegated operations/commissioning staff (including Electrical Engineering, PTM, EMD, and Technical Support).
b) The *Contractor* submits a commissioning procedure and program for acceptance by the *Project Manager*.

c) Before plant and equipment is placed in service the *Contractor* certifies that it is in a suitable and safe condition. In addition, the *Contractor* provides a complete list of numbered schematics, wiring and cable diagrams which are a true record of the plant and equipment as installed and certifies that the works has been wired in accordance with these drawings.
d) Prior to the time when commissioning is to commence, the *Project Manager* will appoint a representative who will co-ordinate the commissioning of all plant and equipment forming an integral part of the system being commissioned. The *Contractor* is responsible for the commissioning of all the plant and equipment in their supply of the Works, to the requirements of this specification, in conjunction with the *Project Manager* and the *Employer's* representatives. Where various components are already in place or are supplied by the *Employer* to form an integrated system, the *Contractor* at the time of commissioning, carries the responsibility for the correct functioning of the whole system. The *Contractor* is responsible for providing a functional logic commissioning procedure for testing the applied logic and plant functionality in accordance to the new bus transfer system operating and control philosophy requirements. The functional logic commissioning procedure is developed with reference to the new bus transfer operating and control philosophy and is subject to the approval of *Project Manager* before functional testing commences.
e) In the event of incorrect functioning, the *Contractor* determines the cause and corrects the Defect if the Defect is within Plant and Equipment of their supply. The *Contractor*, at the time of commissioning, has the agreement, or alternatively, the attendance of the *Project Manager* involved in a particular phase, before proceeding with commissioning. Consequently, the *Contractor* must assure himself/herself as to the safety of his/her own Plant and Equipment, in respect of any commissioning test and in the event of damage, accept responsibility for such Plant and Equipment.
f) The *Contractor* commissions the works and ensures conformance to the Employer's performance requirements for the works.

6.4.2 Start-up procedures required to put the works into operation

a) The system is put in operation after safety clearance of all plant and systems and successful completion of functional testing of the *works*.
b) Sign off will be scheduled as per the project schedule on completion of each activity.

6.4.3 Take over procedures

Take-over/hand over will be scheduled as per completion of the *works* and acceptance by the *Project Manager*.

6.4.4 Access given by the Employer for correction of defects

The *Project Manager* arranges for the *Employer* to allow the *Contractor* access to and use of a part of the *works* which has been taken over if needed to correct a defect.

6.4.5 Performance tests after Completion

a) Acceptance tests shall be carried out to prove all the equipment guarantee figures provided by the *Contractor* in the technical schedules.
b) Where the results of the performance tests performed don't correlate with expected results and/or the control functions as per the operating philosophy do not meet the specifications guaranteed, the *Contractor*, at his own expense, carries out all necessary adjustments and modifications to the works required to obtain the required designed performance and operation requirements. Fully detailed proposals are submitted in writing to the *Project Manager* for approval before any adjustments and modifications are made and work in this respect is carried out when convenient to the *Project Manager*. All adjustments and modifications are subject to inspection and approval by the *Project Manager*.
c) When adjustments and modifications are completed, the *Contractor* advises the *Project Manager* in writing to this effect and applies for a further acceptance test. From the results obtained, and provided that the *Employer* is satisfied that it will be lasting, the works will be finally accepted by the *Employer*.

6.4.6 Training and technology transfer

a) The *Contractor* is to provide the following formal training to the *Employer's* personnel, including training material and manuals:

1. Operating
2. Maintenance
3. Engineering
4. Technical Support

b) The *Employer* will provide a list of personnel to undergo formal training, as part of the delivery of the Works.

6.4.7 Operational maintenance after completion

The Manufacturer's maintenance plan shall be incorporated with the station's Condition Monitoring (CM) and Planned Maintenance (PM) strategies to create a lasting reliable maintenance plan. The contract to be established with the supplier must incorporate maintenance services like training of maintenance personnel and repair of components unique to the OHL.

7 ACCEPTANCE

This document has been seen and accepted by:

NAME	DESIGNATION
R. Nelwamondo	Engineering Manager
G. Mthombene	Electrical Engineering Manager
R. Mahlaku	Senior Engineer
S. Msibi	Senior Engineer
N. Hadzhi	System Engineer
I. Mamabolo	Environmental Officer

8 REVISION

Date	**Rev.**	**Compiler**	**Remarks**
March 2023	0.1	MW. Masemola	Draft works information document

9 APPENDIX

9.1 APPENDIX A: Geotechnical Design Parameters

a) For rock

Parameters	Soft rock	Hard rock
Maximum toe bearing pressure at foundation depth	800 kPa.	2 000 kPa.
Rock Frustum angle	37º	45º
Skin shear friction - concrete to rock	135 kN/m²	350 kN/m²
SANS 10161 descriptions	(R1-R2) Indentations of 1-3 mm shown in the specimen with firm blows of the geological pick point. Can just be scraped with a knife.	(R3-R4)Handheld specimen can be broken with hammer end. Cannot be scraped or peeled with a knife.

b) For Soil types 1 and 2

Parameters	Type '1'	Type '2'
Maximum soil bearing pressure	300 kPa	150 kPa
Maximum toe bearing pressure	375 kPa	200 kPa
Frustum angle for suspension towers	30º	20º
Frustum angle for strain towers (factored)	30º x0.83=25º	20º x0.75=15º
Undrained shear strength (Interface friction concrete to soil)	80 kN/m²	40 kN/m²
Minimum dry Density	1700 kg/m³	1550 kg/m³
Density of reinforced concrete	2400 kg/m³	2400 kg/m³

Parameters	Type '1'	Type '2'
SANS 10161 descriptions	COHESIVE SOIL (S4-S5) Slight indentation produced by pushing Geologist pick point into the soil. Cannot be moulded by fingers. Hand pick required for excavation. COHESIONLESS SOIL Very high resistance to penetration of sharp end of geological pick. Requires many blows by a hand pick for excavation.	COHESIVE SOIL (S3) Sharp end of Geologist pick can be pushed into the soil up to 10mm. Can just be penetrated with an ordinary spade. COHESIONLESS SOIL Considerable resistance to penetration by sharp end of geological pick. Considerable resistance to shovelling.

c) For Soil types 3 and 4

Parameters	Type '3'	Type '4'
Maximum soil bearing pressure	100 kPa	50 kPa
Maximum toe bearing pressure	125 kPa	65 kPa
Frustum angle for suspension towers	0º	0º
Frustum angle for strain towers	0º	0º
Minimum dry Density	1400 kg/m^3	1000 kg/m^3
Density of reinforced concrete	2400 kg/m^3	1400 kg/m^3
SANS 10161 descriptions	COHESIVE SOIL (S2-S1) Sharp end of Geologist pick can be pushed into the soil 30 to 40 mm. Moulded by fingers with some pressure. No resistance to shovelling. COHESIONLESS SOIL Small resistance to penetration by sharp end of geological pick.	Type 4 is a condition i.e. waterlogged or submerged foundation conditions. This includes all soils below the permanent water table, including soils below a reoccurring perched water table, or permeable soils in low-lying areas subjected to confirmed (known) seasonal flooding.

NOTE: For maximum soil bearing pressure and maximum toe bearing pressure, use the tabled pressure or 80% of the ultimate tested bearing pressure determined from appropriate tests.

9.2 APPENDIX B: NaCl level in aggregate as a percentage by mass

CONCRETE TYPE	COARSE AGGREGATE	FINE AGGREGATE
Reinforced with OPC (Ordinary Portland cement)	0.05%	0.10%
Reinforced with SRPC (Sulphate resisting Portland cement)	0.02%	0.05%

9.3 APPENDIX C: Foundation Test Criteria – Design Load

FOUNDATION TEST CRITERIA - Design load				
DESIGN LOAD TEST	Load	holding period	movement	Rate of movement
BLOCK ANCHOR (Deadman)- Soil Type 1-2				
DESIGN LOAD TEST	%	minutes	mm	mm/minute
	50	5	3.75	0.75
	75	5	3.75	0.75
	90	5	3.75	0.75
	100	30	22.5	0.75
	Holding+ movement total		34	
Total Final Allowable movement			**50mm**	
PILE ANCHOR - FULL LOAD- Soil Type 1-2				
DESIGN LOAD TEST	Load	holding period	movement	Rate of movement
	%	minutes	mm	mm/minute
	50	5	0.75	0.15
	75	5	0.75	0.15
	90	5	0.75	0.15
	100	30	4.5	0.15
	Holding+ movement total		6.8	
	Total Final movement		**7mm**	
ROCK ANCHOR - Soft and Hard Rock				
DESIGN LOAD TEST	Load	holding period	movement	Rate of movement
	%	minutes	mm	mm/minute
	50	5	0.25	0.05
	75	5	0.25	0.05
	90	5	0.25	0.05
	100	30	1.5	0.05
	Holding+ movement total		2.3	
Total Final movement			**2.5mm**	

9.4 APPENDIX D: Pressure Grout Injection Anchors

PRESSURE GROUT INJECTED ANCHORS - TEST CRITERIA

FULL LOAD TEST	Load	holding period	movement	Rate of movement
SINGLE ANCHOR - Soil Type 1 -3				
FULL LOAD TEST	%	minutes	mm	mm/minute
	50	5	1	0.2
	75	5	1	0.2
	90	5	1	0.2
	100	30	6	0.2
	Holding+ movement total		9	
Total Final Allowable movement			**10mm**	

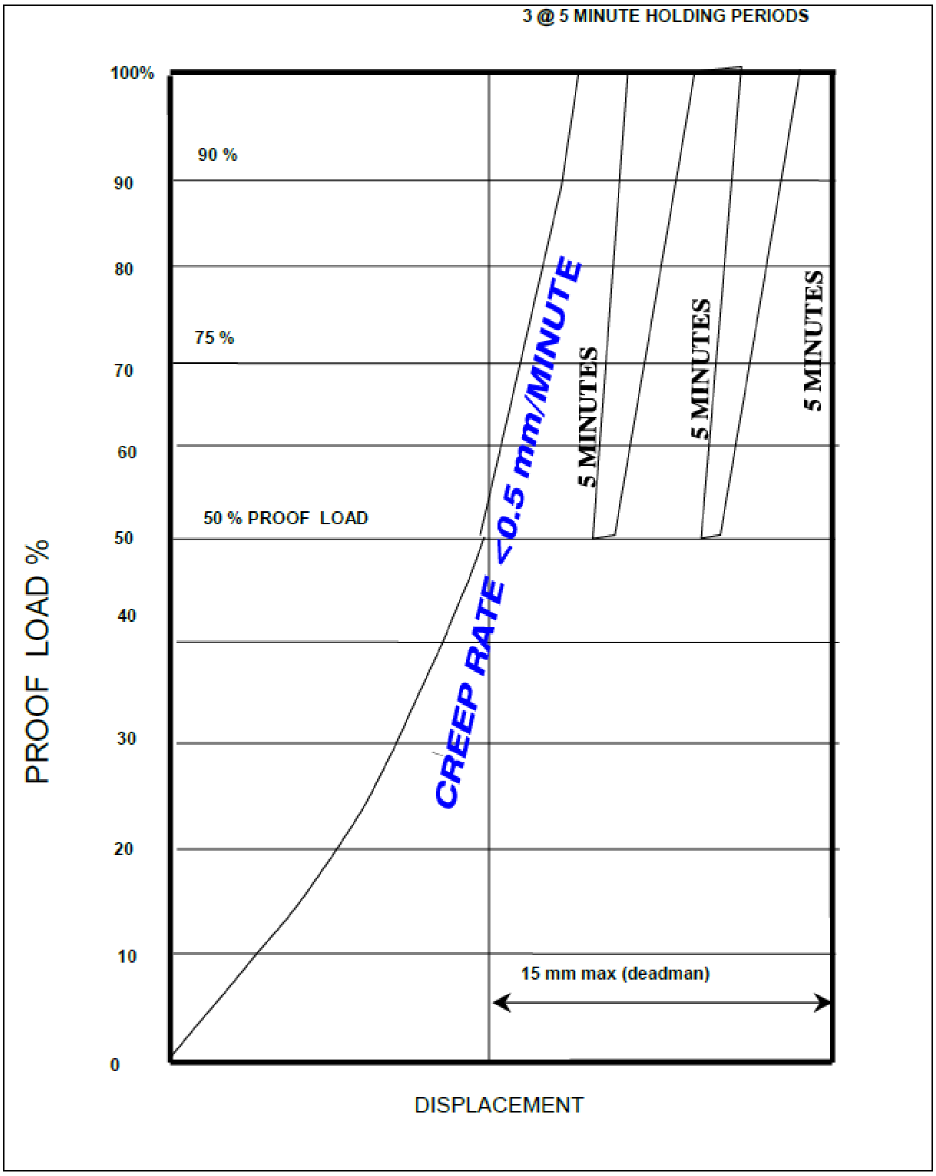
SINGLE ANCHOR - Soft /Hard Rock				
FULL LOAD TEST	Load	holding period	movement	Rate of movement
	%	minutes	mm	mm/minute
	50	5	0.25	0.05
	75	5	0.25	0.05
	90	5	0.25	0.05
	100	30	1.5	0.05
	Holding+ movement total		2.3	
Total Final Allowable movement			**3mm**	

9.5 APPENDIX E: Proof Loads

PROOF LOADS				
PROOF LOAD TEST	Load	holding period	movement	Rate of movement
BLOCK ANCHOR (Deadman)- PROOF LOAD				
PROOF LOAD TEST	%	minutes	mm	mm/minute
	50- 100	5	3.75	0.75
	50- 100	5	3.75	0.75
	50- 100	5	3.75	0.75
	Holding+ movement total		11.3	
Total Final Allowable movement			**15mm**	

PILE ANCHOR - PROOF LOAD				
PROOF LOAD TEST	Load	holding period	movement	Rate of movement
	%	minutes	mm	mm/minute
	50- 100	5	0.75	0.15
	50- 100	5	0.75	0.15
	50- 100	5	0.75	0.15
	Holding+ movement total		2.3	
Total Final movement			**3mm**	

ROCK ANCHOR - PROOF LOAD				
PROOF LOAD TEST	Load	holding period	movement	Rate of movement
	%	minutes	mm	mm/minute
	50- 100	5	0.25	0.05
	50- 100	5	0.25	0.05
	50- 100	5	0.25	0.05
	Holding+ movement total		0.8	
Total Final movement			**1mm**	



Proof load = 70% Ultimate foundation design loading

9.6 APPENDIX F: General Tower Steel Fabrication

OPERATION	ANGLES		PLATES / FLATS	
Straightness (after manufacturing)	Length of member = L (mm) Leg length = h (mm) For h ≤ 150 : Straightness = 0.4% L For 150 < h ≤ 200 : Straightness = 0.2% L			
Dimensions	Leg length = h (mm)	Permissible Variation (mm)	Flats	
			Width = b (mm)	Permissible Variation (mm)
	h ≤ 50	-1.0 to +1.0	b ≤ 35	-0.5 to +0.75
	50 < h ≤ 100	-1.5 to +1.5	35 < b ≤ 75	-0.8 to 1.0
	100 < h ≤ 150	-3.0 to +3.0	75 < b ≤ 100	-1.0 to +1.5
	150 < h ≤ 200	-3.0 to +3.0	100 < b ≤ 120	-2.0 to +2.5
			Thickness = t	
			t < 20	-0.5 to +0.5
			20 ≤ t ≤ 40	-1.0 to +1.0
			t > 40	-1.5 to +1.5
			Plates	
			Nominal thickness (t) (mm)	Permissible Variation (mm)
			4.5 ≤ t < 5	-0.3 to +0.9
			5 ≤ t < 8	-0.3 to +1.2
			8 ≤ t < 15	-0.3 to +1.4
			15 ≤ t < 25	-0.3 to +1.6
				-0.3 to +1.9

			25 ≤ t < 40 40 ≤ t < 80	-0.3 to +2.5

Punching of holes	Allowed up to ≤ 18 mm thick for full size diameter of hole. More than 18 mm thick then sub-punch and ream or drill to full size. Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 1 and 2 below.	Allowed up to ≤ 18 mm thick for full size diameter of hole. More than 18 mm thick then sub-punch and ream or drill to full size. Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 1 and 2 below.
Drilling of holes	Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 1 and 2 below.	Diameter of final hole = Bolt dia + 1.5mm. Tolerance of final hole dia = +0.5mm. See further tolerance requirements in Figure 1 and 2 below.
OPERATION	**ANGLES**	**PLATES / FLATS**
Bending Angle	Only for open and closed flanges as per relevant tower drawing(s). No cold bending allowed. Tolerance on final bending angle = ±1°	Cold Bending Plate thickness = t (mm) t ≤ 12 : Max angle = 14° 12 < t < 22 : Max angle = 7° Hot Bending Plate thickness = t (mm) For t > 22 mm Tolerance on final bending angle = ±1°
Backmark	Allowable offset from backmark = ±1 mm.	Allowable offset from backmark = ±1 mm.

Further tolerance requirement on holes:

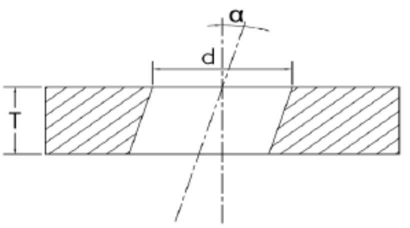


Figure 1

T = Plate or member thickness (mm)

T ≤ 16 : α = 4°
16 < T ≤ 20 : α = 3°
20 < T ≤ 25 : α = 2°

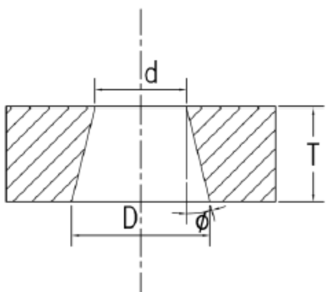


Figure 2

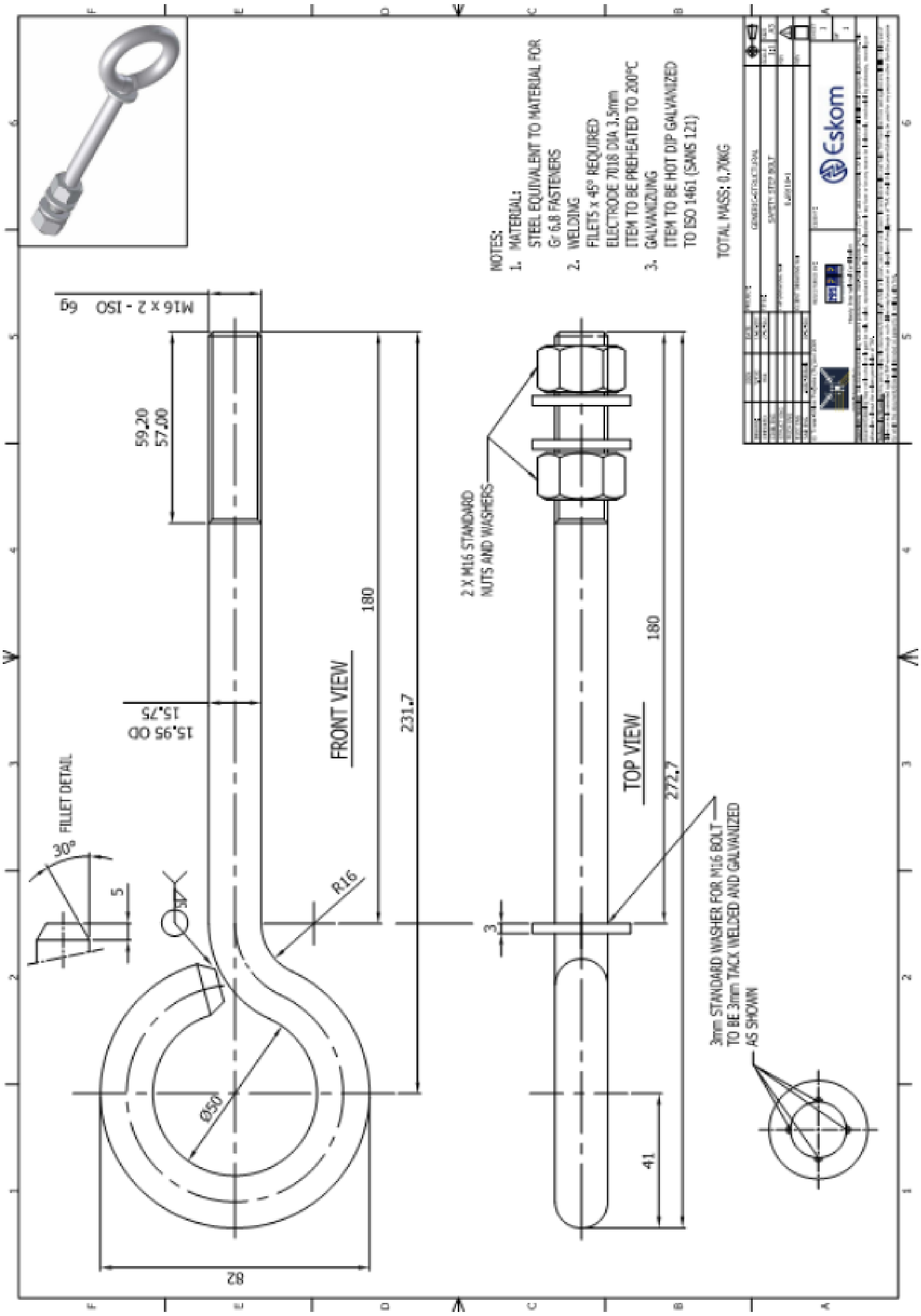
d = required diameter.

((D – d)/d) * 100 < 10%

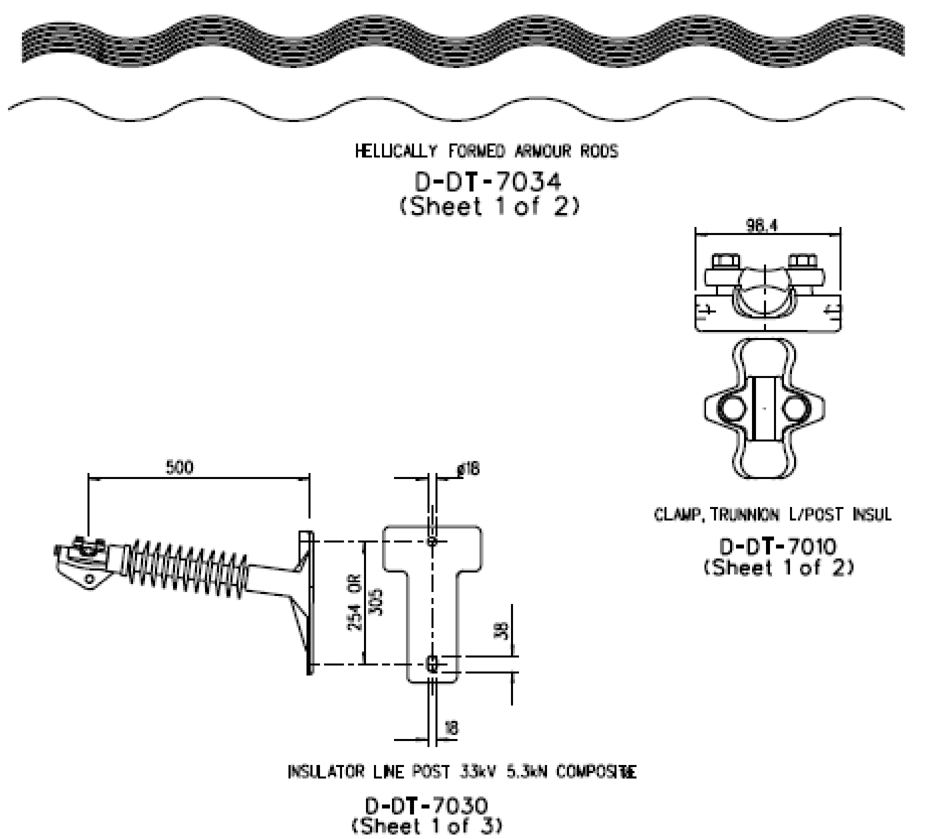
9.7 APPENDIX G: Bolt Tolerances

Bolts (All dimensions in mm)									With Hot dip galvanizing	
d/D	Toll	Pitch	M	es	Td	d_max	d_min	Galv	d_max	d_min
M16	6g	2	16	0.038	0.280	15.962	15.682	0.045	16.052	15.772
M18	6g	2.5	18	0.042	0.335	17.958	17.623	0.045	18.048	17.713
M20	6g	2.5	20	0.042	0.335	19.958	19.623	0.055	20.068	19.733
M22	6g	2.5	22	0.042	0.335	21.958	21.623	0.055	22.068	21.733
M24	6g	3	24	0.048	0.375	23.952	23.577	0.055	24.062	23.687
M30	6g	3.5	30	0.053	0.425	29.947	29.522	0.055	30.057	29.632
M36	6g	4	36	0.060	0.475	35.940	35.465	0.055	36.050	35.575
Nuts (All dimensions in mm)									Oversize Thread	
d/D	Toll	Pitch	M	EI	Td	D_1	D1_min	D1_max	D1_min	D1_max
M16	6H	2	16	0.000	0.375	13.835	13.835	14.210	14.255	14.630
M18	6H	2.5	18	0.000	0.450	15.294	15.294	15.744	15.714	16.164
M20	6H	2.5	20	0.000	0.450	17.294	17.294	17.744	17.824	18.274
M22	6H	2.5	22	0.000	0.450	19.294	19.294	19.744	19.824	20.274
M24	6H	3	24	0.000	0.500	20.753	20.753	21.253	21.393	21.893
M30	6H	3.5	30	0.000	0.560	26.211	26.211	26.771	26.961	27.521
M36	6H	4	36	0.000	0.600	31.670	31.670	32.270	32.530	33.130

9.8 APPENDIX H: Safety Step Bolt



9.9 APPENDIX I: Intermediate Stand-off Insulator Assembly (2ET14615)



ITEM	DESCRIPTION	D-DT No
1	INSULATOR LINE POST 33kV	7030
2	TRUNNION CLAMP	7010
3	ARMOUR ROD	7034

REV	REVISION DESCRIPTION	BY	CHKD	AUTH	DATE	

K ROZMIAREK	2003/02/17	Eskom Distribution	22/33KV INTERMEDIATE STAND-OFF INSULATOR ASSEMBLY
AUTHORISED	DATE		
K ROZMIAREK	2003/02/17		
CHECKED	DATE		
J LE ROUX	2003/01/15		
DRAWN	DATE	CAD REF:	
SCALE	NTS	FILE NAME:	
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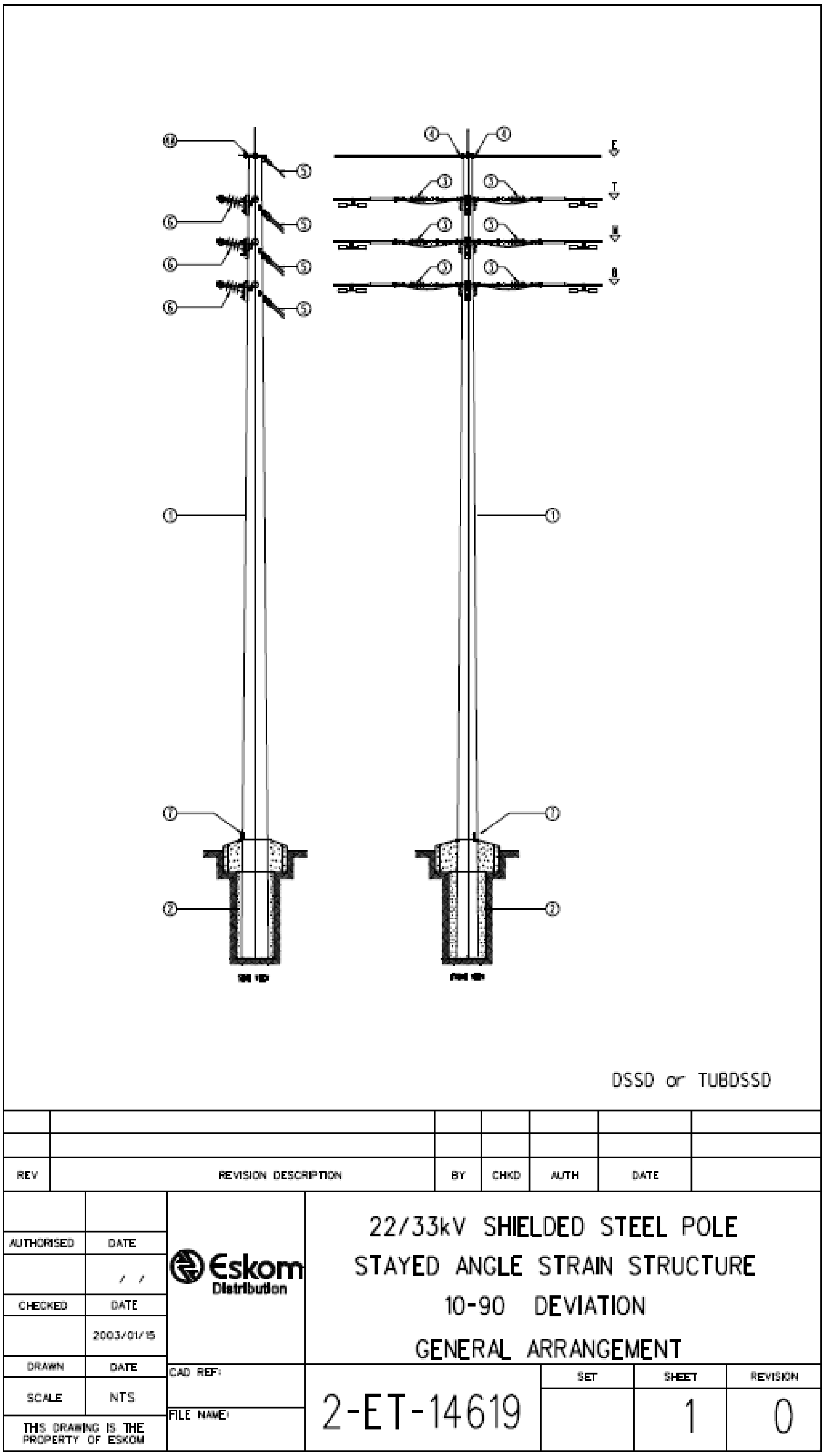
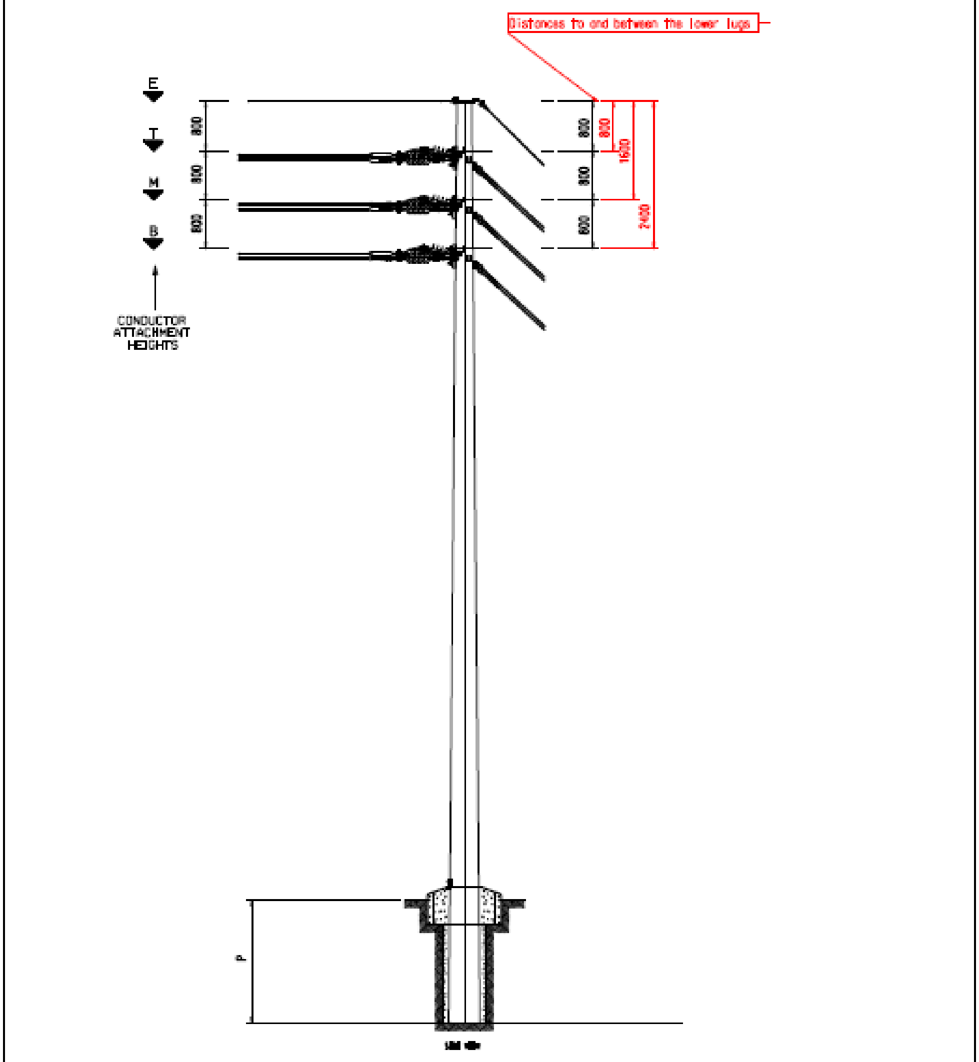
DRAWING No	SET	SHEET	REVISION
2-ET-14615	-	-	0

9.10 APPENDIX J: 22/33 kV Shielded Steel Pole Stayed Angle Strain Structure 10-90 Deviation (2ET14619 Sheet 1-3)

9.10.1 General Arrangement (Sheet 1)



9.10.2 Dimension Drawing (Sheet 2)



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	2003/01/15	
DRAWN	DATE	CAD REF:
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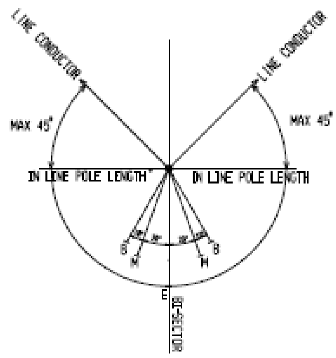
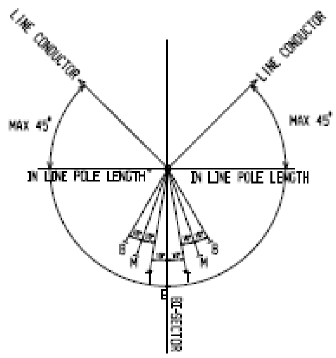
Eskom Distribution

22/33kV SHIELDED STEEL POLE
STAYED ANGLE STRAIN STRUCTURE
10-90 DEVIATION
DIMENSION DRAWING

	SET	SHEET	REVISION
2-ET-14619		2	0

9.10.3 Design Information (Sheet 3)





SCHEDULE FOR CONDUCTOR ATTACHMENT HEIGHTS (m)

POLE LENGTH m	PLANTING DEPTH m	CAH			
		E	T	M	B
11.1	1.7	9.4	8.6	7.8	7.0
12.1	1.8	10.3	9.5	8.7	7.9
13.1	1.9	11.2	10.4	9.6	8.8
14.1	2.0	12.1	11.3	10.5	9.7
15.1	2.0	13.1	12.3	11.5	10.7
16.1	2.0	14.1	13.3	12.5	11.7
17.1	2.0	15.1	14.3	13.5	12.7

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22/33kV SHIELDED STEEL POLE STAYED ANGLE STRAIN STRUCTURE 10-90 DEVIATION

DESIGN INFORMATION

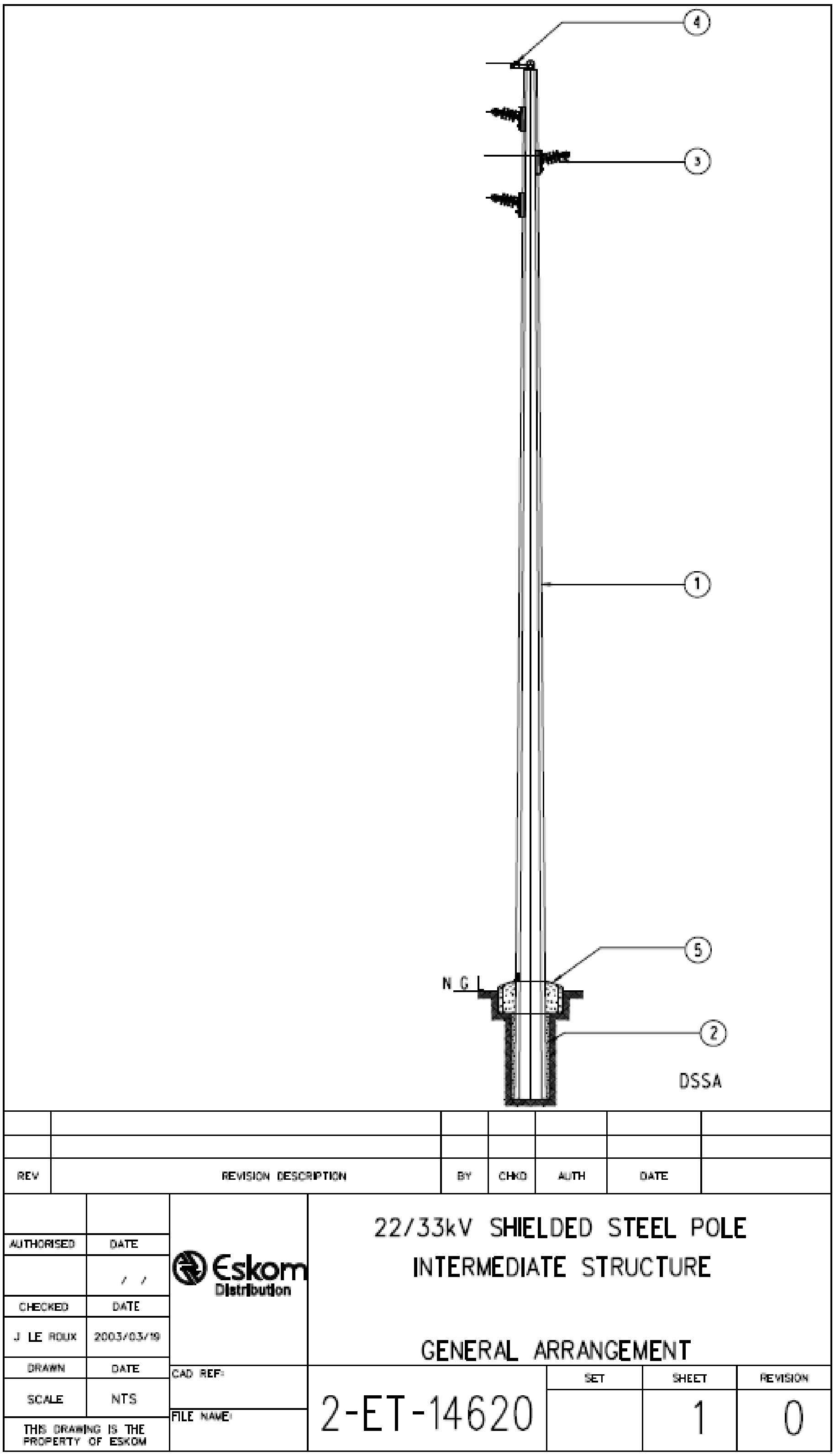
CAD REF:

FILE NAME:

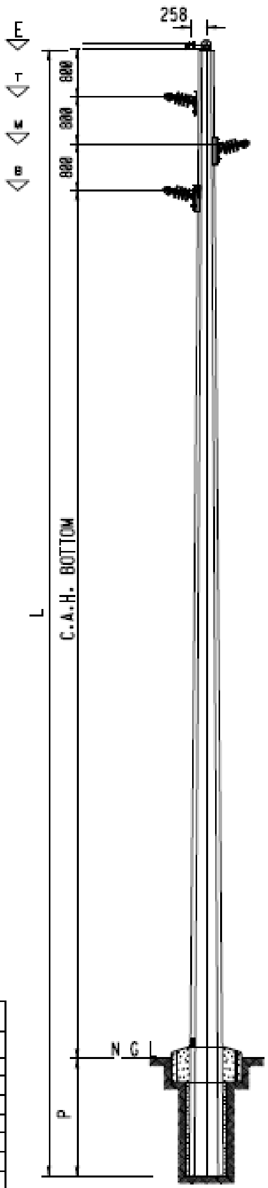
DRAWING NO.	SET	SHEET	REVISION
2-ET-14619		4	0

9.11 APPENDIX K: 22 kV Shielded Steel Pole Intermediate Structure (2ET14620 Sheets 1-2)

9.11.1 General Arrangement (Sheet 1)



9.11.2 Dimension Drawing (Sheet 2)



SCHEDULE FOR CONDUCTOR ATTACHMENT HEIGHTS (m)

POLE LENGTH m	PLANTING DEPTH m	C A H			
		E	T	M	B
12	1.8	10.2	9.4	8.6	7.8
13	1.9	11.1	10.3	9.6	8.7
14	2.0	12.0	11.2	10.4	9.6
15	2.1	12.9	12.1	11.3	10.5
16	2.2	13.8	13.0	12.2	11.4
17	2.3	14.7	13.9	13.1	12.3
18	2.4	15.6	14.8	14.0	13.2

REV	REVISION DESCRIPTION	BY	CHKD	AUTH	DATE

AUTHORISED	DATE
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CHECKED	DATE
J LE ROUX	2003/03/19
DRAWN	DATE
SCALE	NTS

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22/33kV SHIELDED STEEL POLE
INTERMEDIATE STRUCTURE

DIMENSION DRAWING

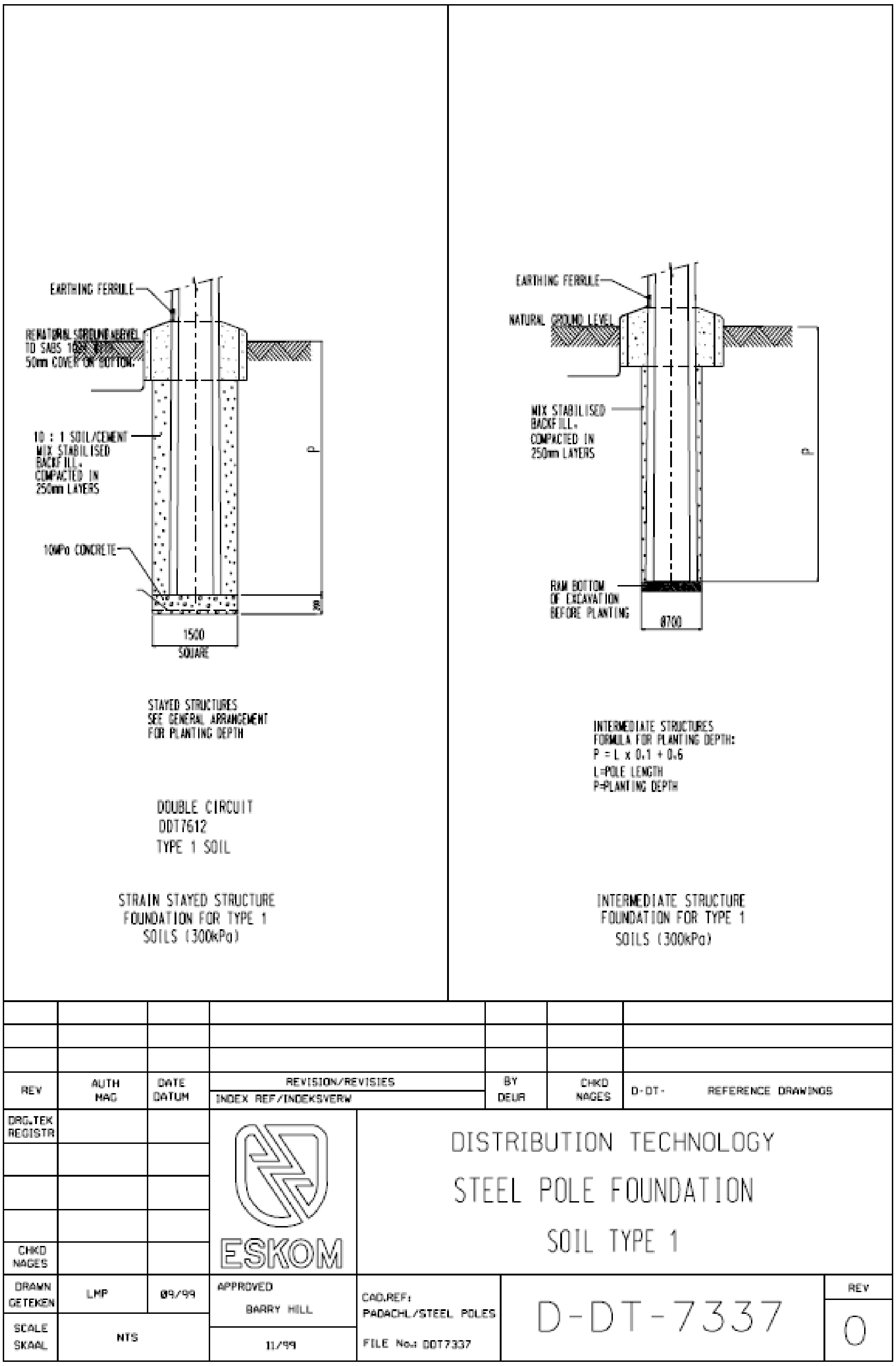
CAD REF:

FILE NAME:

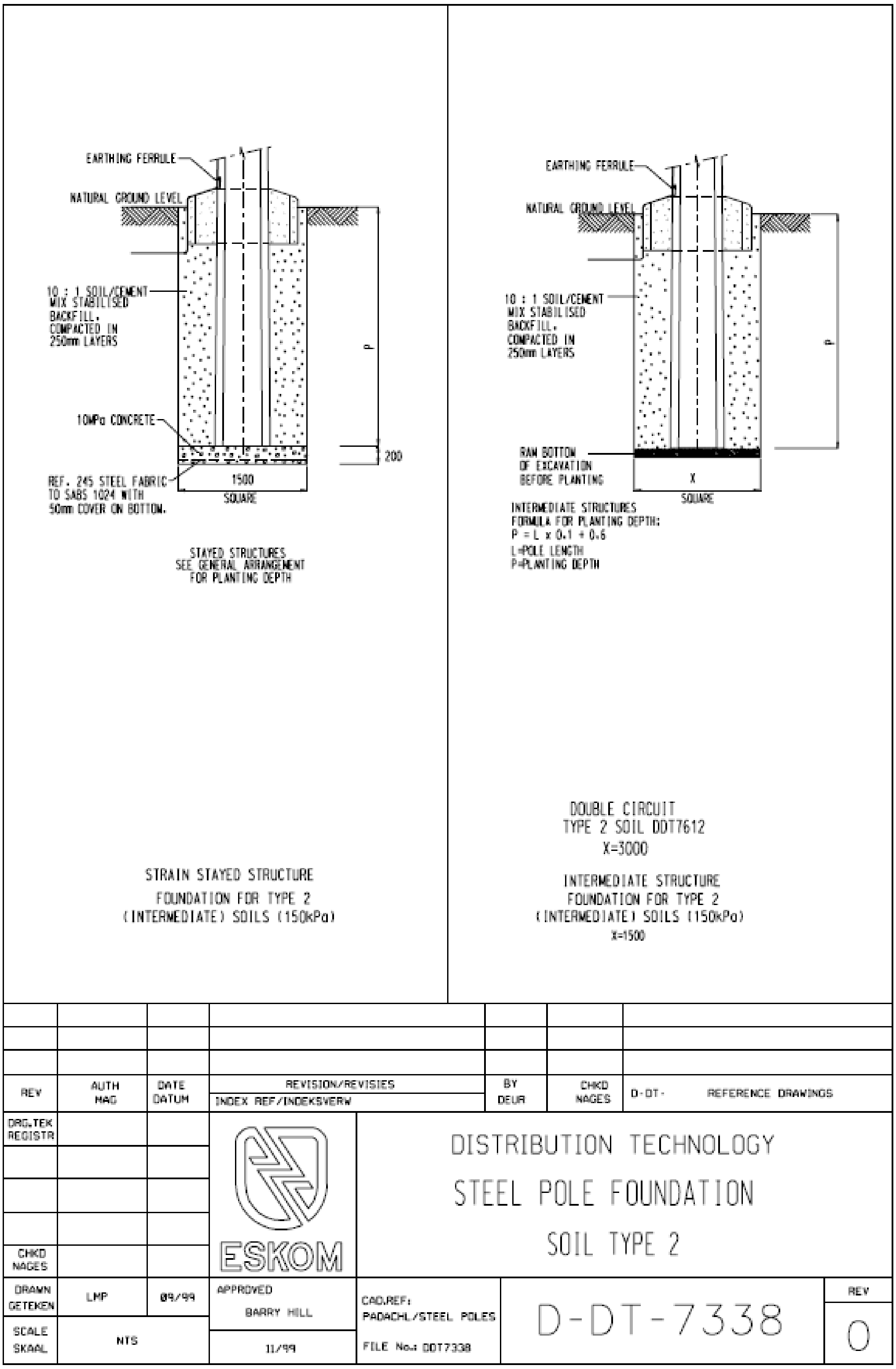
	SET	SHEET	REVISION
2-ET-14620		2	0

9.12 APPENDIX L: Steel Pole Foundation

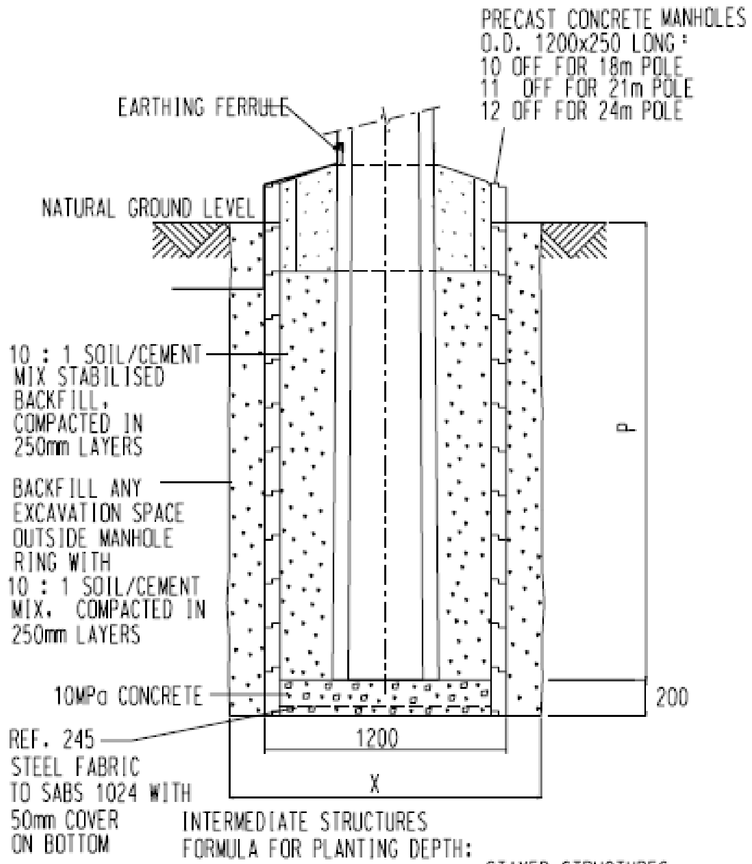
9.12.1 Soil Type 1 (DDT7337)



9.12.2 Soil Type 2 (DDT7338)



9.12.3 Soil Type 3 (DDT7339)



INTERMEDIATE STRUCTURES
FORMULA FOR PLANTING DEPTH:
P = L x 0.1 + 0.6
L=POLE LENGTH
P=PLANTING DEPTH

STAYED STRUCTURES
SEE GENERAL ARRANGEMENT FOR PLANTING DEPTH

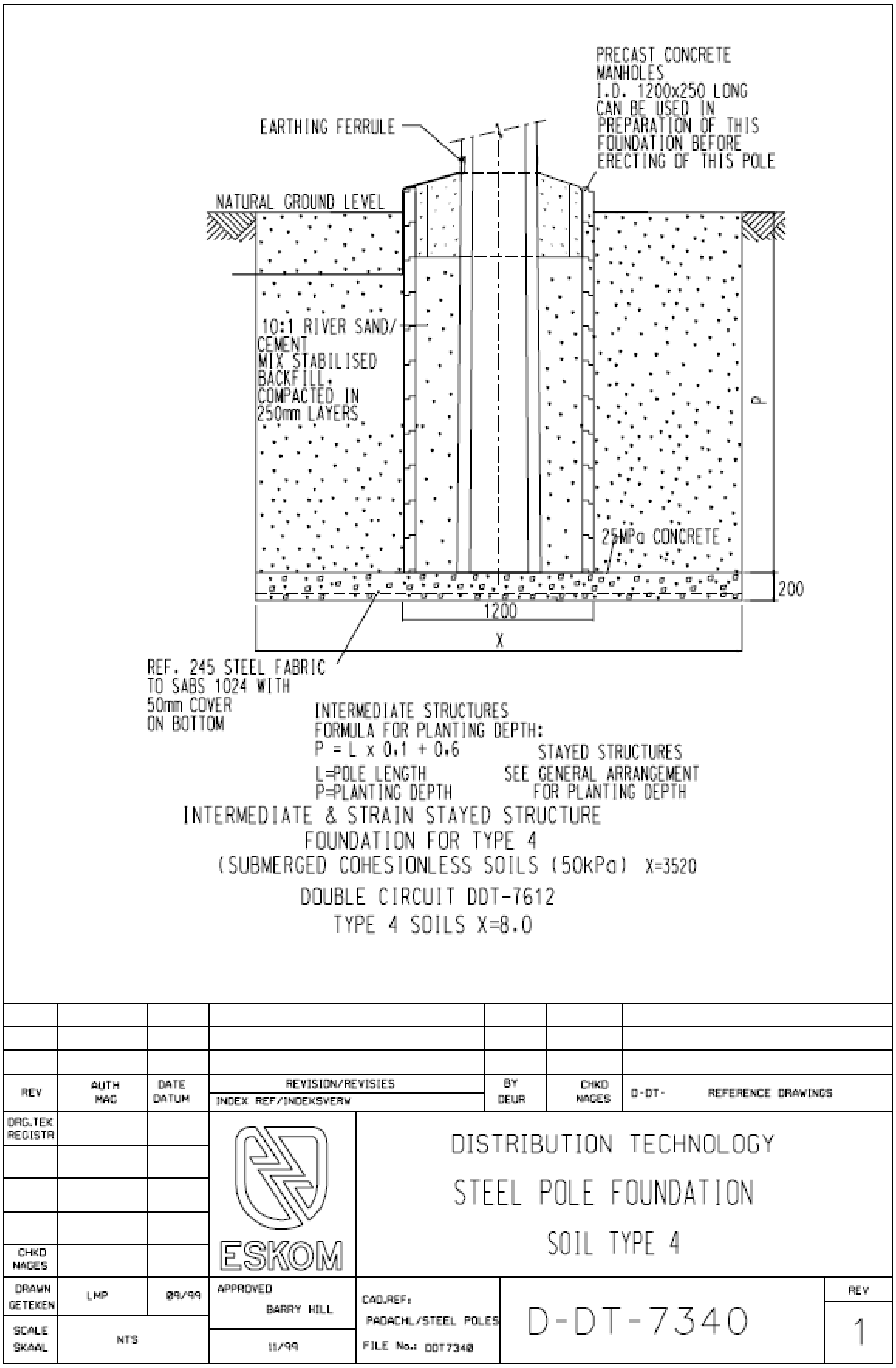
INTERMEDIATE & STRAIN STAYED STRUCTURE
FOUNDATION FOR TYPE 3
(SANDY, LOOSE COHESIONLESS) SOILS (100kPa) X=1700

DOUBLE CIRCUIT DDT-7612 TOWERS
TYPE 3 SOIL X=4.5m

REV	AUTH MAG	DATE DATUM	REVISION/REVISIES INDEX REF/INDEKSVERW	BY DEUR	CHKD NAGES	D-DT- REFERENCE DRAWINGS

DRG.TEK REGISTR		ESKOM — DISTRIBUTION TECHNOLOGY — STEEL POLE FOUNDATION — SOIL TYPE 3
CHKD NAGES		
DRAWN GETEKEN	LMP	09/99
APPROVED	BARRY HILL	11/99
SCALE SKAAL	NTS	
CAD.REF:	PADACHL/STEEL POLES	
FILE No.:	DDT7339	
DRAWING	D-DT-7339	REV 0

9.12.4 Soil Type 4 (DDT7340)



9.13 APPENDIX M: Kriel Power Station 11 kV Overhead Line Routing

11 kV Overhead
Line Routing.pdf

9.14 APPENDIX N: Bill of Quantities & Material (Vol. 3-4)

Volume 3 - BOQ -
Kriel 11kV Kingbird I

Volume 4 - BOM -
Kriel 11kV Kingbird I

9.15 APPENDIX O: Overhead Line Construction Handbook

Line Construction
Handbook.doc