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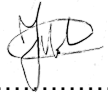
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TX254	1	First issue	November 2012
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## 1. INTRODUCTION

The scope of work of the tender is to construct overhead powerlines bearing in mind that certain line components are supplied free issue from Eskom.

The scope will include construction of new overhead powerlines and certain turn-ins and line deviations. Line refurbishment projects (such as major maintenance, re-insulation, upgrading and uprating etc.) will also be considered.

This document describes the technical specifications for setting up Line Contractors for an incubation program for 132kV, 275kV, 400kV, and 765kV overhead powerlines. Please refer to Appendix H entitled "List of Returnables."

It should be noted that Technical (also called Engineering) weighs 35% of the overall score. The pass threshold for Technical is 70%.

Table 1-1: Project Details

Project Description	The attributes in the following table are typically designed for.
Conductor	<b>The typical phase conductors that are used within the Eskom network:</b> <ul style="list-style-type: none"><li>• Tern</li><li>• Kingbird</li><li>• Bersfort</li><li>• Other conductors as required by each project</li></ul>
Ground wire	<b>The typical conductors that are used as ground wires (shield wires) within the Eskom network :</b> <ul style="list-style-type: none"><li>• Steel wire 19/2.7</li><li>• Optical Ground Wire (OPGW) ( 48 core )</li><li>• Other conductors as required by each project</li></ul>
Insulators	The typical insulator types used are: <ul style="list-style-type: none"><li>• Glass cap and pin</li><li>• Composite long rod</li></ul>
Hardware	Standard I-assembly and strain structure hardware. Standard I- assembly and V-assembly suspension structure hardware. (As per SANS 10280:2017) with live line fittings.

<b>Towers</b>	<p>For 132 kV:</p> <ul style="list-style-type: none"> <li>- Self-supporting lattice towers, guyed towers, steel poles, wood poles</li> <li>- Common tower codes: 245, 247, 248, 255, 273</li> </ul> <p>For 275 kV:</p> <ul style="list-style-type: none"> <li>- Self-supporting lattice towers, guyed towers, steel poles</li> <li>- 433, 434 ,436 ,438</li> </ul> <p>For 400 kV:</p> <ul style="list-style-type: none"> <li>- Self-supporting lattice towers, guyed towers, steel poles</li> <li>- 515, 517, 518, 520B, 528, 529</li> </ul> <p>For 765 kV:</p> <ul style="list-style-type: none"> <li>- Self-supporting lattice towers, guyed towers, steel poles</li> <li>- 701, 702, 703, 705</li> </ul> <p align="center">Multi-circuit and other towers will be introduced at project stage.</p>																		
<b>Foundations</b>	<table border="1"> <tr> <td>Soil types:</td><td>Type 1, 2, 3, 4, soft rock and hard rock</td></tr> <tr> <td>Soil nominations:</td><td>Conducted by the Contractor and reviewed for acceptance by LES. Must be conducted by an engineering geologist/geotechnical engineer that is professionally registered with the South African Council for Natural Scientific Professions (SACNASP) or Engineering Council of South Africa (ECSA)</td></tr> <tr> <td align="center" colspan="2">Foundation types, self-supporting towers</td></tr> <tr> <td>Spreader type:</td><td>Pad and Pier foundations (Conventional foundations)</td></tr> <tr> <td>Pile type:</td><td>Augered piles (vertical only), micro piles, grouted driven piles etc.</td></tr> <tr> <td align="center" colspan="2">Foundation types, guyed type towers</td></tr> <tr> <td>Spreader type:</td><td>Pad and Plinth (small pier) mast foundations (Conventional foundations)</td></tr> <tr> <td>Buried block:</td><td>Deadman Anchors and Rock Anchors (Conventional foundations)</td></tr> <tr> <td>Pile type:</td><td>Grouted driven piles, micro piles, augered piles (vertical only for augered pile)</td></tr> </table>	Soil types:	Type 1, 2, 3, 4, soft rock and hard rock	Soil nominations:	Conducted by the Contractor and reviewed for acceptance by LES. Must be conducted by an engineering geologist/geotechnical engineer that is professionally registered with the South African Council for Natural Scientific Professions (SACNASP) or Engineering Council of South Africa (ECSA)	Foundation types, self-supporting towers		Spreader type:	Pad and Pier foundations (Conventional foundations)	Pile type:	Augered piles (vertical only), micro piles, grouted driven piles etc.	Foundation types, guyed type towers		Spreader type:	Pad and Plinth (small pier) mast foundations (Conventional foundations)	Buried block:	Deadman Anchors and Rock Anchors (Conventional foundations)	Pile type:	Grouted driven piles, micro piles, augered piles (vertical only for augered pile)
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Pile type:	Grouted driven piles, micro piles, augered piles (vertical only for augered pile)																		

	Special requirements:	All foundations to be raised a minimum of 650 mm above ground due to dune sands
	<b>Additional comments:</b> <ul style="list-style-type: none"> <li>Prior to installation of any foundations on site, the Contractor must have submitted soil nomination lists with accompanying soil profiles, concrete mix designs, grout mix designs and all foundation design drawings for LES acceptance.</li> <li>Concrete mix design to consider Alkali Silica Reaction</li> </ul> <p>Establishment of on-site laboratory for the curing and testing of concrete cubes using calibrated equipment.</p> <ul style="list-style-type: none"> <li>Slump tests to be done during every pour. Soil Compaction tests to be done for every backfilling operation @ minimum of 93% Mod AASHTO.</li> </ul>	
<b>Jumpers</b>	Jumper conductor:	Same as phase conductor unless stipulated
	No. of conductors:	Same as phase conductor unless stipulated
	Bundle spacing (mm):	Same as phase conductor unless stipulated
	Spacer type:	Rigid spacer
	Minimum spacer requirement:	Minimum 4 per jumper
<b>Corrosion Protection</b>	<ul style="list-style-type: none"> <li>All tower members, fasteners and hardware components shall be protected by galvanizing in accordance with SANS 121 and SANS 10684.</li> <li>Typical galvanizing for towers and hardware for inland application is 85 µm and for coastal application is 105 µm</li> </ul>	
<b>As built requirements</b>	<p>As Built information to be provided as per Eskom requirements, (As-Built Document 240-72252925)</p> <p>This must include ALS (Aerial Laser Survey) which must also cover the substations. (Aerial Laser Survey, 240-75909189)</p> <p>Final Lidar Scan of the constructed Powerline for the verification of designed clearances and the compilation of as-built drawings for submission to Eskom.</p> <p>Infra-Red Scan – to pick up “hotspots” when powerline is energised.</p>	
<b>Line labels</b>	<p>Line is to be labelled as per Eskom transmission spec 240-120804300. Line labels must be manufactured according to the Substation and Network Equipment Label Specification, 240-75660336.</p> <p>Install High Voltage danger signs for towers.</p>	

<b>Bush Clearing</b>	For bush clearing guidelines, refer to Eskom specification entitled "Vegetation Management and Maintenance within Eskom Land, Servitudes and Rights of Way (unique identifier 240-70172585)" and to relevant environmental documents such as the Environmental Assessment(EA), Environmental Impact Assessment(EIA), Environmental Management Plan (EMP) and Construction and Operation EMP.
<b>Line Impedance Measurement</b>	Measurement of electrical line parameters for positive and zero sequence and the full impedance matrix. Line Impedance Measurements to be done prior to energising utilising specification 240-143268945
<b>Anti – Theft Measures</b>	<p>Anti-theft specification 240-75884508 &amp; technical instruction 12TI-013</p> <ul style="list-style-type: none"> <li>• Anti-climb devices to be installed on all towers.</li> <li>• Anti-climb devices as per manufacturing drawings (palisade type)</li> <li>• All anti-vandal bolts must be the swage type as per the anti-vandal specification, all members will be fitted with minimum of two anti-vandal bolts - one on each side of every member.</li> <li>• All plates below the anti-climb device should contain anti-vandal bolts for at least 60% of total number of bolts.</li> <li>• All anti-vandal bolts to be installed before stringing on guyed type towers.</li> <li>• Weld the bolts and nuts of the shackles of U-bolts of the guyed towers (529A) to prevent theft as per anti-theft specification where applicable.</li> <li>• All steel members shall be stamped with the word "ESKOM" at 300 mm – 500 mm intervals as mentioned in the towers section.</li> </ul>
<b>Anti-bird perch devices</b>	The contractor must supply and install anti-bird perch devices in accordance with the Eskom specification 240-147885960 and installation guideline 240-156074235.
<b>Fall Arrest Systems</b>	Any temporary fall arrest system installed by the contractor during construction must be removed after construction. Make use of horizontal fall arrest system in beam of towers.
<b>Risk Matrix</b>	A General HV Line Construction Risk and Mitigation Plan (risk matrix) is supplied in <b>Appendix G</b> of this specification.
<b>Environmental</b>	The number of berms required will be commented by the LES Civil Engineer, Design Leader will coordinate this meeting between the Environmental Practitioner and the LES Civil Engineer.
<b>Tower footing</b>	<ul style="list-style-type: none"> <li>• Resistance Target will depend on voltage level of powerline</li> <li>• Device to measure should have a filter and high current features to enable valid earth testing in difficult situations.</li> <li>• Earth resistance range of 0.010 Ohms to about 19.99 kilo Ohms</li> <li>• Contractor to provide specification for the equipment that will be used for testing</li> </ul>

### 1.1. TOWER DRAWINGS

Typical tower outline drawings can be found in **Appendix B**

### 1.2. HARDWARE DRAWINGS

Typical examples of hardware drawings can be found in **Appendix C**. The breaking load naming under strength rating corresponds to the different breaking loads as stipulated in the hardware drawings.

### 1.3. TECHNICAL TENDER EVALUATION CRITERIA

For the technical tender evaluation, the score sheet in **Appendix I** will be used with the given weighting criterion and weighting per discipline in multidisciplinary packages to evaluate each tenderer.

Safe work procedures focuses on equipment and equipment capacity to be used on the assembly, erection and stringing of all type of structures as well as the methodology used to bring together the different elements of the system. Any items marked as “mandatory” on the technical evaluation criteria are gatekeepers (non-compliance leads to disqualification).

Points will be provided and evaluated according to the matrices in **Appendix I** – technical tender evaluation form.

### 1.4. COMPLIANCE TO STATUTORY AND LEGAL REQUIREMENTS

This line must be in compliance to all relevant SANS standards and the OHS Act with the construction regulations abided by during construction of the line.

## 2. MECHANICAL SPECIFICATIONS

### 2.1. GENERAL LINE DETAILS

Table 2-1: General Line Details

Line voltage phase-to-phase	400 kV typical for transmission and 132kV typical for distribution
Three-phase; single or double circuit	Three Phase; Single circuit 400kV and 132kV typical 400kV double circuit and 400kV /132kV multi-circuit also used
Phase configuration	Flat typical
Number of conductors per phase	One or two for 132kV , three or four for 400kV , Six for 765kV
Number of earth conductors	Two typically with one normally an OPGW
Minimum clearance from lowest conductor to earth:	8.1m to 10m for 400kV typical, 15m for 765kV
Minimum clearance from conductor envelope to earthed metal:	
(a) Under still air conditions:	3.2 m and 5.5 m
(b) Under every day wind conditions to tower steelwork:	2.9 m and 5.2 m
(c) Under high wind conditions to tower steelwork:	1.0 m and 1.9 m
Dimensions of hardware assembly:	See separate hardware drawing

#### 2.1.1. Wind Loading

A 10-minute wind speed of 29 m/s at a height of 10 m will be used with recurrence interval of 150 years and terrain category B, to determine the pressures on the components of the line. A reliability level of 2 will be used.

## 2.2. CORROSION PROTECTION

### Towers:

See Appendix K for further details.

### Conductor, Earth Wire, Guy wires and OPGW

The conductor, jumpers, earth wire, guy wires and OPGW may need to be greased in accordance with IEC61089 a typical level is Case 2 greasing. Only the Eskom approved grease may be used



## 2.3. PHASE CONDUCTOR AND GROUNDWIRE DETAILS

### 2.3.1. Phase Conductor

The phase conductor used on most 400kV lines will be the Tern ACSR conductor. At times Bersfort conductor will be used. Certain IEC and other conductor types will be introduced on a project-by-project basis. Typical parameters for Tern and Bersfort are shown below. The conductor will be supplied by Eskom on a free issue basis.

Table 2-2: Tern Conductor Details

Conductor type	"Tern" ACSR, IEC Code 403.77-A1S1A-45/3.38-7/2.25
Conductor overall diameter (mm)	27.00
Area aluminium (mm <sup>2</sup> )	403.77
Area Total (mm <sup>2</sup> )	431.6
Aluminium wires (mm)	45/3.38
Steel wires (mm)	7/2.25
Conductor linear mass (kg/km)	1340,00
Ultimate Tensile strength (kN)	98.7
Resistance dc @ 20 °C (ohms/km)	0.0718
Modulus elasticity final (GPa)	66.6
Coefficient of Linear expansion (1/°C)	21.12 x 10 <sup>-6</sup>
Drum length (m)	3000
Matched sets	Yes
Greased conductor requirements – level of greasing	Non-greased – N/A

Table 2-3: Bersfort Conductor Details

Conductor type	3 x Bersfort ACSR, IEC Code 686.50-A1S1-48/4.27-7/3.32
Conductor overall diameter (mm)	35.56
Area aluminium (mm <sup>2</sup> )	686.5
Area Total (mm <sup>2</sup> )	747.1
Aluminium wires (mm)	48/4.27
Steel wires (mm)	7/3.32
Conductor linear mass (kg/km)	2369.00
Ultimate Tensile strength (kN)	180
Resistance dc @ 20 °C (Ohms/km)	0.0421
Modulus elasticity final (GPa)	66.6

Coefficient of Linear expansion (1/°C)	21.12 x 10 <sup>-6</sup>
Greased conductor requirements	Non-greased

### 2.3.2. Earth Wire

The earth wire used may be “Horse” ACSR conductor.

Table 2-4: Horse Earth Wire Details

Conductor type	Horse ACSR, IEC Code 73.36-A1S1A-12/7/2.79
Conductor overall diameter (mm)	13.95
Area aluminium (mm <sup>2</sup> )	73.36
Area Total (mm <sup>2</sup> )	116.16
Aluminium wires (mm)	12/2.79
Steel wires (mm)	7/2.79
Conductor linear mass (kg/km)	541.00
Ultimate Tensile strength (kN)	60.70
Resistance dc @ 20 °C (Ohms/km)	0.3939
Modulus elasticity final (GPa)	108.00
Coefficient of Linear expansion (1/°C)	15.84 x 10 <sup>-6</sup>
Short circuit current rating for 1 s (kA)	10.1
Short circuit current rating for 0.5 s (kA)	14.2
Greased conductor requirements	Non-greased

### 2.3.3. OPGW

48 Core OPGW will be used of various fault current capabilities. This could change on a project-to-project basis. An example of a 12 kA OPGW than can be used is shown below

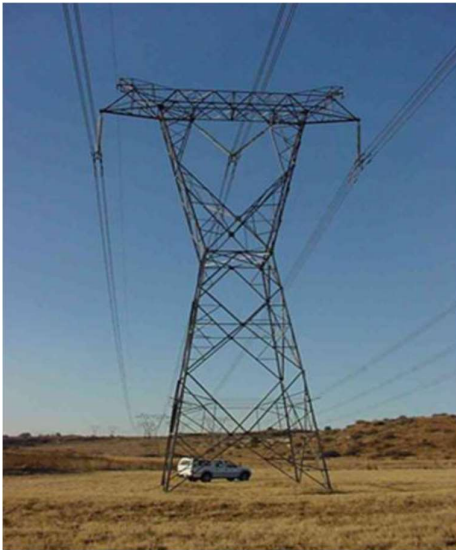
Table 2-5: OPGW Details

Short circuit current rating for 1 s (kA)	12
Cable diameter (mm)	14 – 15.9
Cable mass (kg/m)	0.496 – 0.697
Cable ultimate tensile strength (kN)	54 – 107.8
Resistance dc @ 20 °C (Ohms/km)	0.27 – 0.4
No. of fibres	48
Greased conductor requirements	Non-greased

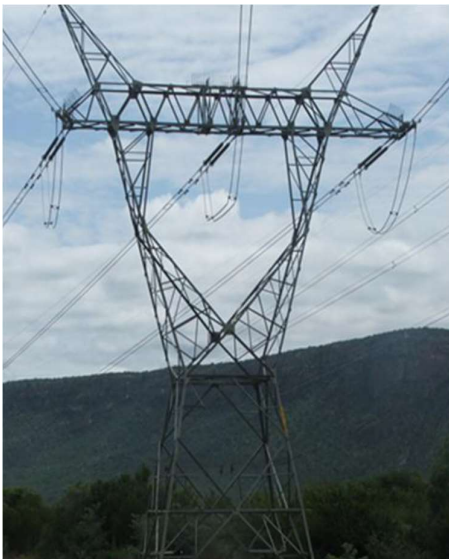
## 2.4. DETAILS OF TOWERS TO BE USED

### 2.4.1. Details of Suspension and Strain Towers for 518 Series

(As per original the design specification for 518 tower series)



**Figure 1 Self Support Suspension**



**Figure 2 Self Support Strain**

Table 2-6: 518 Series Tower Details

Nominal design span:	450 m
Final phase conductor sag at 50°C for design span:	14 m
Minimum clearance from lowest phase conductor to earth:	10.0 m
Height of lowest phase conductor attachment point above earth:	18 m
Minimum clearance from conductor envelope to earthed metal:	
(a) Under still air conditions:	3.2 m
(b) Under 15° swing conditions to tower steelwork:	2.9 m
(c) Under 55° swing conditions to tower steelwork:	1.0 m
Design angle of swing of single suspension assembly from vertical:	n/a
Dimensions of V suspension assembly for phase conductors:	See hardware drawing, Appendix C
Length of strain insulator assembly:	See hardware drawing, Appendix C
Design maximum swing angle from vertical of jumpers at strain towers or clearance checks:	15°
Length of earth conductor suspension hardware assembly:	
a) Maximum	0.425 m
b) Minimum	0.1 m
Maximum cover angle at tower in still air from vertical through earth conductor to line through earth conductor and outer phase conductor:	15°
Maximum cover angle at tower in still air from earth conductor to inner phase conductor:	60°
Maximum angle of swing of earth conductor either side of vertical	30°
Vertical angle between the phase conductor and the horizontal at the attachment point for which clearance to earthed metal should be checked:	
a) Above the horizontal:	5°
b) Below the horizontal:	15°
Jumper clearances on 0° terminal tower to be provided for the following conditions:	
a) angle between the normal to the tower cross-arm and incoming line:	0°
b) angle between the normal to the tower cross-arm and closing span:	35°

#### **2.4.2. Characteristics of Standard Cross-Rope Suspension Towers**

The Cross-rope suspension 529A is shown in drawing 0.69/529A/1. All masts have common extremities, and five mast extensions of 3.0 m, 4.5 m, 6.0 m, 7.5 m and 9.0 m are required to complete all mast lengths.

The composition of masts using these extensions for all tower heights is also shown in drawings 0.69/529A/1. Guy wires shall be stranded wire, with a minimum UTS of 391.3 kN. Refer to Drawings 0.69/529A/1. The crossrope must have a minimum UTS of 318.4 kN.

Ladder system to be used where working platform is installed on mast where joints are located.

The tower type has been designed for Triple Bersfort conductor to the following wind/weight spans:

**Table 2-7: Original Design Criteria for 529A Tower**

<b>Tower type</b>	<b>Wind span (m)</b>	<b>Weight span (m)</b>	<b>Dev angle</b>
Suspension	500	600	0

Clearances and safety distances indicated are from the outside of members and not from member axes. Slope of guys in the transverse and longitudinal planes are constant for all tower heights.

**Table 2-8: 529A Tower Details**

<b>Nominal design span:</b>	500 m
<b>Minimum clearance from lowest conductor to earth:</b>	10 m
<b>Distance from top of tower (mast apex) to attachment point of lowest conductor, approximately:</b>	13.8 m
<b>Minimum clearance from conductor envelope to earthed metal:</b>	See Drawing 0.69/529A/1 Rev 12
<b>(a) Under still air conditions:</b>	3,2 m
<b>(b) Under every day wind conditions to tower steelwork:</b>	2,9 m
<b>(c) Under high wind conditions to tower steelwork:</b>	1,0 m



**Figure 3 Guyed Cross Rope Suspension**



**Figure 4 Guyed Cross Rope Suspension Compact**



**Figure 5 : Guyed V suspension**

#### 2.4.2.1. Spacer Rope

The spacer cable shall be a single piece of cable in each case, with a compression fitting or a preform type fitting at each end. All spacer cables with compression end fittings shall be tested individually to a tensile load equal to 83% of the ultimate strength of the cable. Due to the testing, which causes permanent stretch, a reduction of 0.2% of total length shall be applied to the calculated length of all ropes which are to be tested. The minimum UTS of the spacer cable must be 237 kN A first off sample for both preform type and/ or compression type will be sent for tensile load testing to an approved test facility in accordance with IEC 61089.

#### 2.4.2.2. Cross Rope

The cross rope shall be a single piece of cable in each case, with a compression fitting or a preform type fitting at each end. All cross-rope cables with compression end fittings shall be tested individually to a tensile load equal to 83% of the ultimate strength of the cable. Due to the testing, which causes permanent stretch, a reduction of 0.2% of total length shall be applied to the calculated length of all ropes which are to be tested. The minimum UTS of the spacer cable must be 318 kN A first off sample for both preform type and/ or compression type will be sent for tensile load testing to an approved test facility in accordance with IEC 61089.

#### 2.4.2.3. Guy Strands and Guy Attachments

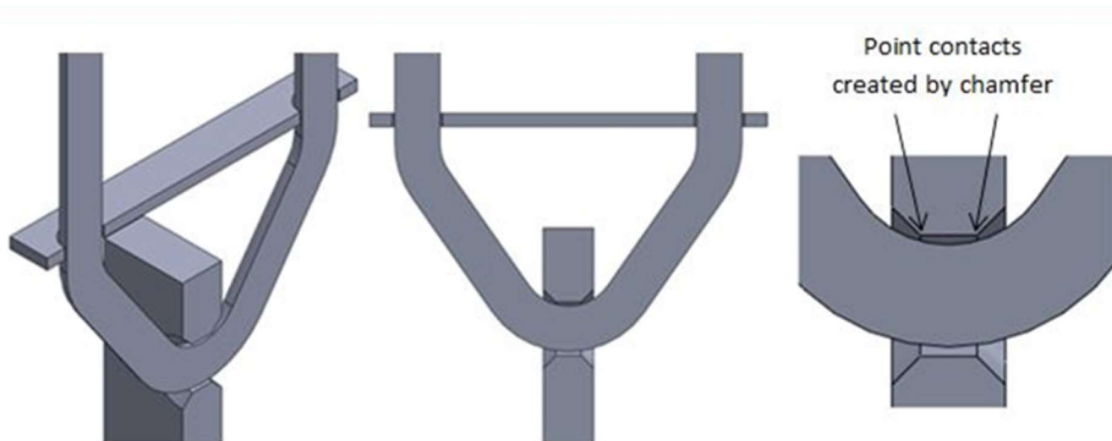
As part of the towers the steel guy strands (single strands), end fittings, shackles, etc shall be included for the installation of the suspension towers. There are two types of assemblies for guys for the Cross-rope suspension towers, the first is the pre-cut type with compression end fittings, these shall all be installed prior to testing and shipping of the guys to site (Witness by an Eskom design engineer is required). The second type is the wedge type guy assembly where testing is only required on one assembly which also needs to be witnessed by an Eskom design engineer.

For the 529 series it is not essential that all guys are adjustable. For the 529A three of the guys of each tower shall have no adjustment whatsoever. Only one of the four guys shall have tension adjustment, at the bottom connection only. 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 drawing 0.69/529A/1. Then the four guys shall be cut and the end fittings installed.

The bidders shall propose convenient attachment configurations between guys and tower, and guys and anchor rods. The adjustable end on the fourth guy shall be simple. It is suggested that a U-bolt be connected to the end of the anchor rod, and that a steel plate be installed on the U-bolt for guy-length regulation. This plate would have a transverse hole, to which the guy end fitting would be connected by means of a bolt, nut and split pin.

The objective of the guy link attachment plate interface is to mitigate any stress concentration contact points as shown in **Figure 2.2-6** and **Figure 2-7.2**.

When a U-bolt is connected to the guy link the interface needs to be filleted to match the radius of the U-bolt as shown in **Figure 2.2-8**. When connecting the bolt (straight) end of a shackle to the guy link the interface needs to be that of a straight drilled/punched hole as shown.



**Figure 2.2-6: Stress concentration points caused by incorrect guy link interface**



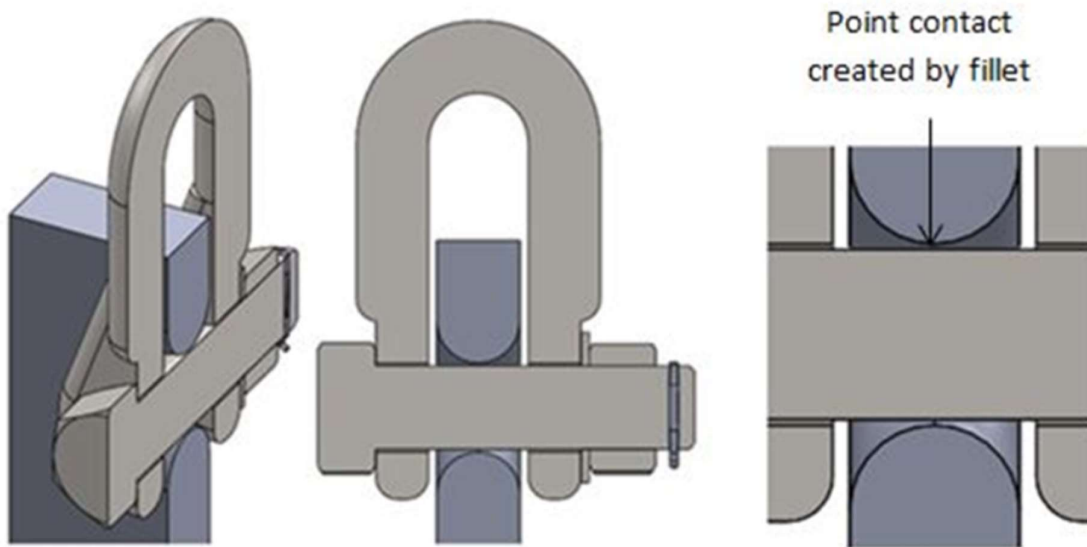


Figure 2-7.2: Stress concentration points caused by incorrect guy link interface

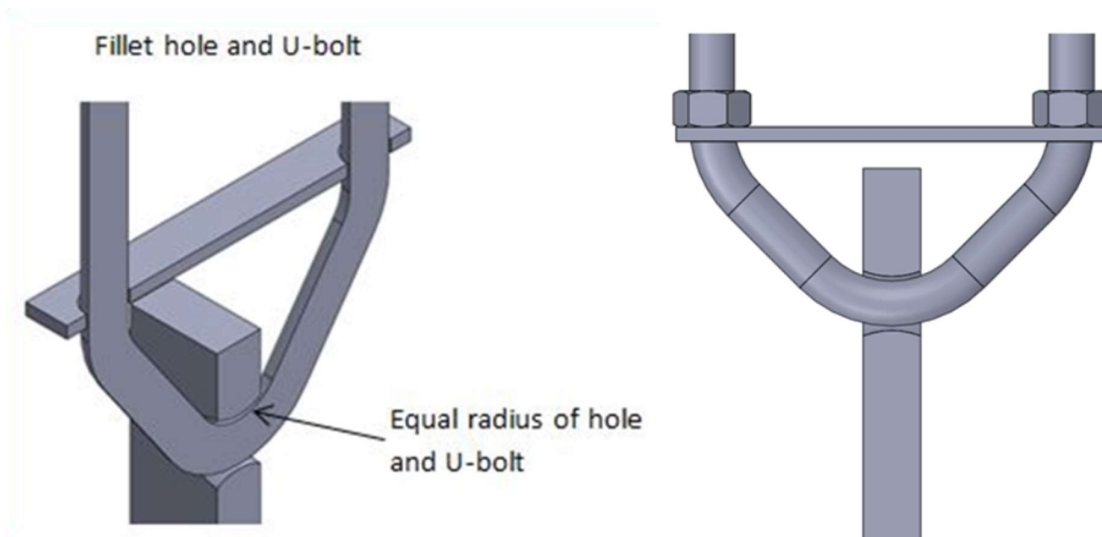


Figure 2.2-8: Correct interface when connecting a U-bolt to the guy link plate

## Straight hole and shackle

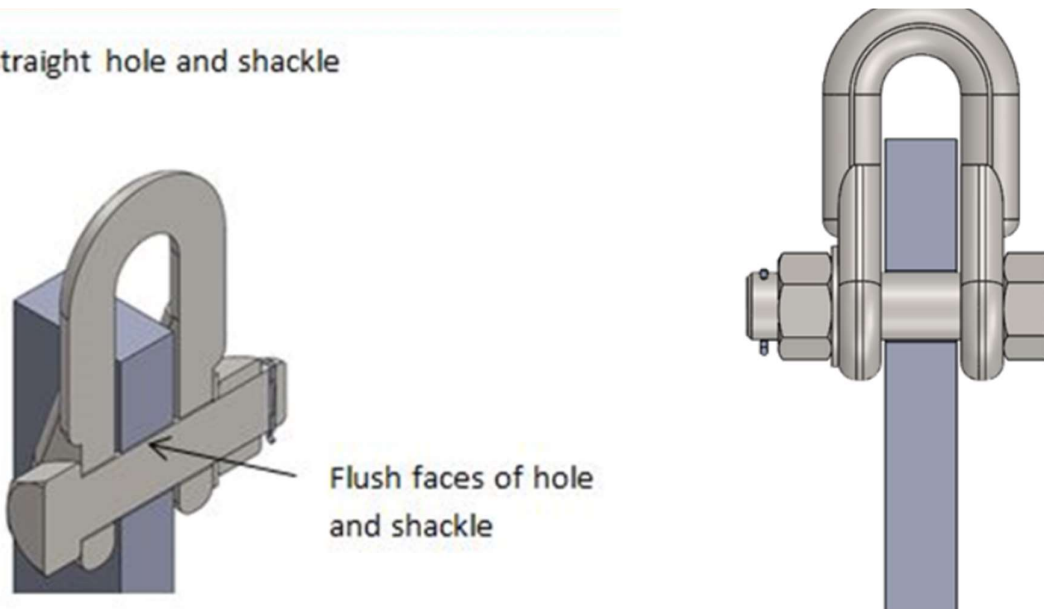


Figure 2.2-9: Correct interface when connecting a shackle to the guy link plate

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.

The minimum required breaking strength of the guy ropes is 391 kN. Further information is provided in **Appendix D**.

#### 2.4.2.4. Testing of Compression and Preform Fittings

The contractor shall submit proposals to Eskom for acceptable test procedures, test equipment and recording devices. The contractor shall communicate in writing to Eskom, in good time, the site and the date of the tests according to SANS 61089.

No testing of cables shall take place without a representative from Eskom being present. The contractor shall identify each individual cable and shall keep records of all the test results. Copies of these records shall be submitted to Eskom.

#### 2.4.2.5. Tower Installation

According to the Test and Inspection Plan witnessing of the first installation of each tower type is necessary and must be witnessed by an Eskom design engineer. Safe working procedures of erection and stringing for the installation of each of the towers need to be developed and submitted at the tender stage.

### 2.4.3. Characteristics of Standard Guyed-Vee Suspension Towers

Table 2-9: 520B Tower Details

Nominal design span:	400 m
Final phase conductor sag at 50°C for design span:	12,6 m
Minimum clearance from lowest phase conductor to earth:	10 m
Height of lowest phase conductor attachment point above earth:	21,0 m
Minimum clearance from conductor envelope to earthed metal:	
(a) Under still air conditions:	3,2 m
(b) Under 15° swing conditions to tower steelwork:	2,9 m
(c) Under 55° swing conditions to tower steelwork:	1 m
Design angle of swing of single suspension assembly from vertical:	n/a
Dimensions of V suspension assembly for phase conductors:	See hardware specification
Length of strain insulator assembly:	See hardware specification
Design maximum swing angle from vertical of jumpers at strain towers or clearance checks :	15°
Length of earth conductor suspension hardware assembly:	0.425 m
Maximum cover angle at tower in still air from vertical through earth conductor to line through earth conductor and outer phase conductor:	15°
Maximum cover angle at tower in still air from earth conductor to inner phase conductor:	60°
Vertical angle between the phase conductor and the horizontal at the attachment point for which clearance to earthed metal should be checked:	
a) Above the horizontal:	5°
b) Below the horizontal:	15°
Jumper clearances on 0° terminal tower to be provided for the following conditions:	
a) angle between the normal to the tower cross-arm and incoming line:	0°
b) angle between the normal to the tower cross-arm and closing span:	45°

#### 2.4.3.1. Guy strands and guy attachments

As part of the towers the steel guy strands (single strands), end fittings, shackles, etc shall be included for the installation of the suspension towers. For the 520B the four guys shall have

tension adjustment, at the bottom connection only. The stays and the assembly fittings shall have minimum UTS of 596 kN.

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 drawing 0.69/520B/1. Then the four guys shall be cut and the end fittings installed.

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

The bidders shall propose convenient attachment configurations between guys and tower, and guys and anchor rods. The adjustable and non-adjustable end on the guys shall be simple. It is suggested that a U-bolt be connected to both ends of the rope. The guys shall be installed at a pre-tension of 10% of UTS before stringing.

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.

#### 2.4.3.2. Tower installation

For the 520B a pilot installation is necessary. Safe work procedures of assembly, erection and stringing for the installation of tower are to be provided by the contractor for review.

### 2.5. TESTING OF GUYS

The contractor shall submit proposals to Eskom for acceptable test procedures, test equipment and recording devices. The contractor shall communicate in writing to Eskom, in good time, the site and the date of the tests.

No testing of cables shall take place without a representative from Eskom being present. The contractor shall identify each individual cable and shall keep records of all the test results. Copies of these records shall be submitted to Eskom.

## 2.6. PROFILING DETAILS

The typical profiling details of the 400kV towers used are as follows:

**Table 2-10: Wind and Weight Spans as per Profile**

DESCRIPTION OF TOWER TYPE	TOWER TYPE NAME	MAXIMUM WIND SPAN (m)	MAXIMUM WEIGHT SPAN (m)	MAXIMUM UPLIFT SPAN (m)
Self-Supporting Single Circuit 0°-35° Angle Strain	517E	500	2050	200
Self-Supporting Single Circuit 35°-60° Angle Strain & 0° Terminal	517F			
a.) 35°-60° Angle Strain		500	2050	200
b.) 0° Terminal		375	900	200
Suspension, Cross Rope	529A	560	670	-
Suspension, Self-Supporting	518H	600	900	-
Suspension, Self-Supporting Transposition	518E	500	1040	-
0°-45° Angle Strain	518C	500	1200	200
45°-70° Angle Strain & 0° Terminal	518D	500	1200	200
Suspension, guyed Vee	520B	500	1200	-

The table above shows the wind and weight spans used in the profiles. The spans in the table above reflect the allowable wind and weight spans for the conductor and earth wire chosen.

A margin of safety has been applied in the determination of these spans, but it is the contractor's responsibility to check the loads applied during his erection and stringing procedures to ensure that the test loads are not exceeded, including his safety margin, which should not be less than 1.5.

## 2.7. TOWER TEST LOADS

The typical structure test loads are shown in the table below and should be used for calculating back-stay requirements.

Note: The structure loads below for transverse, longitudinal and vertical loads should not be applied simultaneously at any given time. These loads represent the maximum loads applied during different load cases and was never applied all at once on any structure. If additional

information is required, it is advised that the design engineer be contacted for further information.

**Table 2-11: Tower Test Loads**

TOWER TYPE	Transverse (kN)	Longitudinal(kN)	Vertical(kN)
518H Earth wire	15.18	30	18.3
Conductor	91	74.31	159
518C Earth wire	37.32	28.1	15
Conductor	290.2	218	128
518D Earth wire	25.9	25.3	11.3
Conductor	214	196	96
518E Earth wire	12.72	30	8.74
Conductor	75.4	74.2	95
520B Earth wire	9.97	30	8.74
Conductor	75.4	76.8	71.6
529A Earth wire	9.91	17.77	6.2
Conductor	47.86	51.21	30.6
517E Earth wire	32.76	29	14.98
Conductor	163.05	143.33	71.15
517F Earth wire	45.46	29	14.99
Conductor	204	132.88	98.38

## 2.8. TOWER SHACKLES FOR TOWER ATTACHMENTS

The shackles shall be of the bolted type and shall be provided with a stainless-steel split pin fitted to the bolt to prevent the nut from working loose. **All tower shackles are considered part of the tower and must be supplied with the tower. The tower shackle supplied shall be the straight leg shackle not a standard (bowed leg) shackle.** These are indicated in the table below:

**Table 2-12: Tower Shackle Details**

TOWER TYPE	CONDUCTOR	CAPACITY	BOLT DIAMETER
<b>518H</b>	Earth conductor	120 kN	16 mm
	Phase conductor	300 kN	24 mm
<b>518C</b>	Earth conductor	210 kN	20 mm
	Phase conductor	450 kN	30 mm
<b>518D</b>	Earth conductor	210 kN	20 mm
	Phase conductor	450 kN	30 mm
<b>518E</b>	Earth conductor	120 kN	16 mm
	Phase conductor	300 kN	24 mm
<b>520B</b>	Earth Conductor	120 kN	16 mm
	Phase Conductor	210 kN	20 mm
<b>517E</b>	Earth conductor	210 kN	20 mm
	Phase conductor	450 kN	30 mm

<b>517F</b>	Earth conductor	210 kN	20 mm
	Phase conductor	450 kN	30 mm
<b>529A</b>	Earth Conductor	Special assemblies rated as 120 kN	N/A
	Phase Conductor	Uses inverted suspension clamp – 210 kN	N/A

## 2.9. FEATURE CODE LIST AND CLEARANCES

Typical clearances that are maintained when designing a 400kV power lines from existing infrastructure.

Table 2-13: 400 kV clearance table

Feature Description	Req. Vert. Clearance 400 kV (m)
11 kV power line	4.2
22 kV power line	4.2
Public Roads, non-electrified railways, (excluding farm tracks)	9.7
33 kV power line	4.2
Communication lines & power lines	4.2
Buildings, structures not part of power lines (including Transnet owned structures)	6.0
Vegetation canopy	7.0
66 kV power line	4.2
Railways (statutory clearance requirements)	9.7
Transnet owned single supply	13.1
Transnet owned multiple supply and single supply line crossings, level crossing	14.6
Transnet owned railways – conductor	5.4
Transnet owned railways – structures	5.9
Transnet footbridges	7.6
88 kV power line	4.2
WATER COURSE/RIVER – EDGE	8.5
Navigable WATER	21.6
132 kV power line	4.2
Ground	10.0 (10.5 for populated areas)
220 kV power line	4.2
275 kV power line	4.2
400 kV power line	4.2
PIPELINE	8.5
FENCE	6.0
Telephone lines	4.2
533 kV DC line	4.7
765 kV power line	6.5



## 2.10. LINE CROSSINGS

Typically a list of crossings would be provided these would need to be considered in the stringing methodology as different risk mitigations would be required for crossing different obstructions. . The clearances required are as follows for the different line voltages:

**Table 2-14: Required line crossing clearances**

No.	Description	132 kV	275 kV	400 kV	765 kV
1	Phase clearance to earth wire on another line under steady conditions. Also applies to phase conductor on another line with upper line at templating temperature and the lower line conductor not exceeding 15°C	2.0 m	3.1 m	3.8 m	6.1 m
2	Vertical phase clearance required to structure under swing conditions	3.8 m	4.9 m	5.6 m	8.5 m
3	Horizontal phase clearance required to structure under swing conditions	3.0 m	3.0 m	3.2 m	5.5 m
4	Conductor clearance required to conductor on another line under swing conditions	1.45 m	2.5 m	3.2 m	5.5 m

The criteria for clearance checks are listed below:

- Higher conductor at templating temperature & lower conductor at lowest temperature (15 °C EDT)
- Higher conductor at templating temperature & lower conductor at max swing
- Higher conductor at moderate swing & lower conductor at max swing

A example list of line crossings is shown below with detailed line crossings for specific crossings with clearance or constructability issues.

**Table 2-15: List of crossings along the line**

From tower	To tower	Crossing type(s)
1	2	22 kV line
2	3	Dirt road
42	43	Dirt road crossing
50	51	River crossing
53	54	Seasonal water courses
54	55	Dirt road crossing
57	58	Seasonal water courses
61	62	Dirt road crossing
62	63	Seasonal water course

70	71	Seasonal water course
77	78	Seasonal water course
96	97	Seasonal water course
107	108	Dirt road crossing
124	125	Dirt road
125	126	River/water course
128	129	Dirt road
136	137	Dirt road
172	173	Dirt road (R359) and Dx line
176	177	Dx line
178	179	River
180	181	River
184	185	Dx line
185	186	Orange river
186	187	Dx line
187	188	Dx line
190	191	Dirt road
194	195	N14 road
199	200	Oasis – Taaipit No.1 132 kV line
201	202	Railway line
203	204	Dirt road
204	205	Dirt road
209	210	Dirt road
213	214	Dirt road
247	248	Dirt road
257	258	Dirt road
267	268	Dirt road
269	270	Telephone line
287	288	Seasonal water course
292	293	Water course
299	300	Dirt road
301	302	Oasis – Oranje Switching station No.1 132 kV line and tar road
309	310	Dirt road
310	311	Telephone line

For 11 kV and 22 kV lines the suggested crossing method to be used is H-poles under dead conditions. The contractor should still consider live-line methods of crossing if outages are not attainable. For the 132 kV line crossing, the crane and net method should be considered. For all road crossings, it is suggested that H-poles be used. Checks should also be done by the contractor to ensure that clearances under blowout are maintained to crossing structures such as H-poles when Dx lines are being crossed.

## **2.11. STAKING TABLE**

The staking table will be available as a separate document. Ensure that this document is read on its own to establish requirements for insulated earth wire points, proposed joint box positions, special cross arm requirements and general construction comments.

**2.12. BOM**

The BOM will be available as a separate document.

**2.13. TOWER OFFSET POSITIONS**

Any special offset requirements will be mentioned in the specification. Refer to 240-47172520 for standard offset requirements of bend towers.

**2.14. TOWER ORIENTATIONS**

All terminal towers are to be located perpendicular to the line direction. The angles indicated on the PLS-CADD profiles represent the deviation angles and not the orientation of the terminal towers. Should the terminal tower be required to be orientated away from being perpendicular to the line, this will be clearly indicated on the profiles and staking table by means of appropriate text.

Should structures be located out of the bisector of an angle, this will be represented by means of an orientation angle displayed on the line profiles. A positive value indicates a deviation in the clockwise direction of the tower away from the bisector angle. Exact angles are shown on the profile.

### 3. FOUNDATIONS, CIVIL AND GEOTECHNICAL SPECIFICATIONS

#### 3.1. GEOTECHNICAL

Standard Geotechnical Investigations i.e. Soil Nominations (as per the latest applicable version of Eskom specification 240-47172520: TRMSCAAC 6) are conducted. Soil Nominations are conducted by an engineering geologist/geotechnical engineer that is professionally registered with the South African Council for Natural Scientific Professions (SACNASP) or Engineering Council of South Africa (ECSA).

Should rock be encountered during soil nomination works, the rock depth and rock type must be proven to be competent by investigative drilling; particularly in areas where Hardpans/Dorbanks have been identified.

The Contractor makes provision for soil sampling and soil laboratory testing. A minimum of 10% of the powerline may be approximated for the evaluation of geotechnical soil properties. As required, soil/rock samples are taken upon the discretion of the professionally registered engineering geologist/geotechnical engineer; and/or suitably qualified practitioner. From observations of regional soil behaviours, the Contractor must, as a minimum, make allowance for problem soils behaviour with emphasis on erosive soils showing dispersive or collapsible structures. Soil resistivity tests are conducted per tower position.

For standard geotechnical investigations, the Contractor submits signed foundation-soil type nomination list and accompanying Contractor's soil profile log sheets (including laboratory results, where applicable) to LES for acceptance.

*Refer to document 240-47172520: "TRMSCAAC 6 The Standard for the Construction of Overhead Powerlines" for the full outline of the Standard Geotechnical Investigation works and associated deliverables.*

#### 3.2. FOUNDATION LOAD FACTORS

To ensure the reliability of the line as well as a predictable failure sequence in the unlikely event of a line support structure failure, factored loads (which include a geotechnical partial load factor) as supplied shall be applied to the strength of the foundations as listed.

Apart from what is a **factored load** as described above, the foundation designer shall, at his/her professional discretion, apply additional partial load factors in calculating the **Ultimate design load** to ensure satisfactory performance in service with respect to strength and durability requirements.

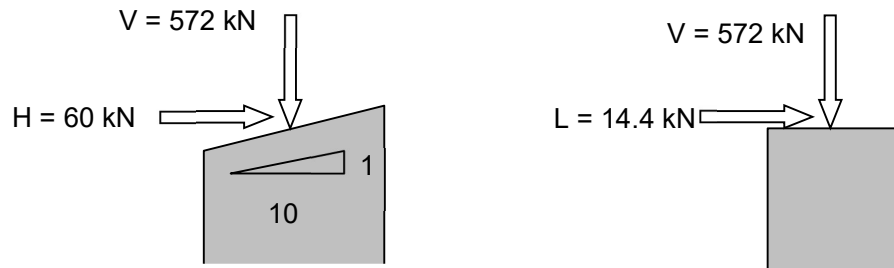
When considering the severe impact of foundation failure, the general objective is to ensure that foundations are designed to be the last component to fail in a power line. Additional load safety factors are incorporated for the new designs allowing for increased everyday loads and performance inconsistencies.

### 3.3. FOUNDATION LOADS

#### 3.2.1. The 529A Tower

Factored Foundation Reactions for Critical Loading Conditions:

##### a) *Mast foundation loads*

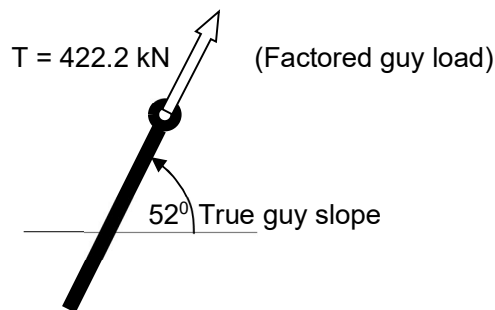


$V$  = Factored vertical component of mast load

$H$  = Factored horizontal component of mast load

$L$  = Factored horizontal shear load due to wind - can occur in any direction

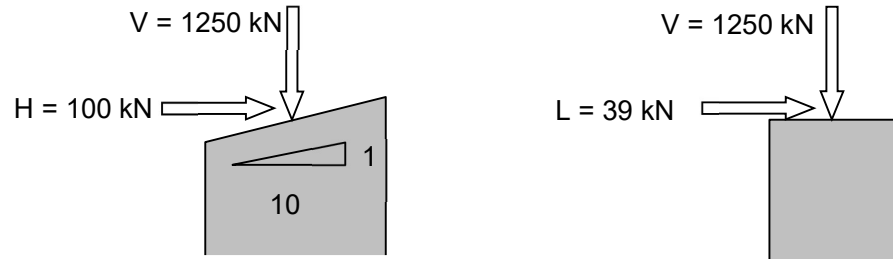
##### b) *Guy Anchor Foundations Loads*



### 3.3.1. The 520B Tower

Factored Foundation Reactions for Critical Loading Conditions:

#### a) Mast foundation loads

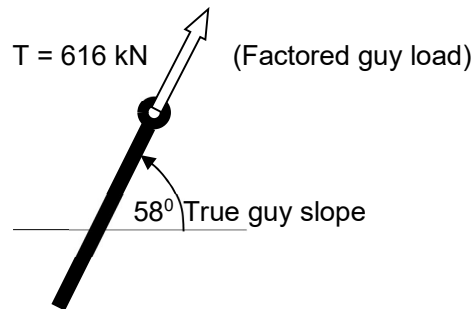


$V$  = Factored vertical component of mast load

$H$  = Factored horizontal component of mast load

$L$  = Factored horizontal shear load due to wind - can occur in any direction

#### b) Guy Anchor Foundations Loads



### 3.3.2. 518 self-supporting lattice series

#### a) 518 series with 0 m and +6 m body extension

Factored Foundation Reactions for Critical Loading Conditions

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)			
TOWER TYPE			
518C	518D / 518DR <sup>(1)</sup>	518E	518H
COMPRESSION			
C = 1608	C = 1792	C = 841	C = 754
X = 40	X = 92	X = 59	X = 30
Y = 29	Y = 68	Y = 38	Y = 25
UPLIFT			
U = 1337	U = 1573	U = 700	U = 592
Legs slope and stub size			
$\alpha_d = 17.982^\circ$	$\alpha_d = 19.292^\circ$	$\alpha_d = 11.968^\circ$	$\alpha_d = 15.480^\circ$
A = L 200x200X16	A = L200X200X18	A = L150X150X10	A = L120X120X12

<sup>(1)</sup> Loads preliminarily assumed to be same as 518D – still to be finalised. The stub of the 518DR tower forms part of the tower base

#### b) 518 series with +12 m, +18 m, +24 m body extensions

Factored Foundation Reactions for Critical Loading Conditions

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)		
TOWER TYPE		
518C	518D	518H
COMPRESSION		
C = 1729	C = 2590	C = 914
X = 99	X = 216	X = 92
Y = 72	Y = 138	Y = 91
UPLIFT		
U = 1393	U = 1900	U = 665
LEG SLOPE AND STUB SIZE		

$\alpha_d = 17.982^\circ$	$\alpha_d = 19.292^\circ$	$15.480^\circ$
A = L 200x200x16	A = L200x200x18	A = L120x120x12

C = Compression load acting in direction of tower

legU = Uplift load acting in the direction of the

tower leg

X = Horizontal residual shear load acting in the transverse

directionY = Horizontal residual shear load acting in

longitudinal direction

$\alpha_d$  = True angle of tower leg measured along the tower

diagonalA = Size of the tower stub angle section

For pad & chimney foundations the residual shear loads may be ignored for uplift stability checks, but shall be considered under compression stability checks.

Piled foundations shall be designed to resist the total horizontal base shears acting on the foundation, that is, the horizontal components of C or U plus X and Y in the respective transverse and longitudinal directions. This is applicable to both the compression and the uplift condition. The directions of X and Y shall be assumed in the same direction as the horizontal components of C and U respectively, that is, the most onerous horizontal load directions shall be assumed.

### 3.3.3. 517 self-supporting lattice tower series

#### Factored Foundation Reactions for Critical Loading Conditions

SELF-SUPPORTING TOWERS(ALL LOADS IN kN)	
TOWER TYPE 517E	TOWER TYPE 517F
COMPRESSION	
C = 1153	C = 1433
X = 55	X = 73
Y = 8	Y = 10
UPLIFT	
U = 964	U = 1214
LEG SLOPE AND STUB SIZE	
$\alpha_d = 16.15^\circ$	$\alpha_d = 18.091^\circ$



A = L 150x150x15

A = L150x150x18

C = Compression load acting in direction of tower

legU = Uplift load acting in the direction of the  
tower leg

X = Horizontal residual shear load acting in the transverse

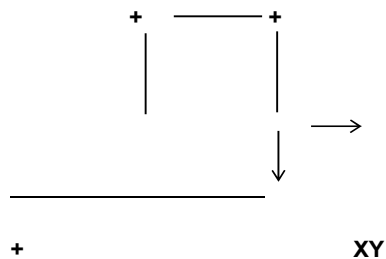
directionY = Horizontal residual shear load acting in  
longitudinal direction

$\alpha d$  = True angle of tower leg measured along the tower

diagonalA = Size of the tower stub angle section

For pad & chimney foundations the residual shear loads may be ignored for uplift stability checks but shall be considered under compression stability checks.

Piled foundations shall be designed to resist the total horizontal base shears acting on the foundation, that is, the horizontal components of C or U plus X and Y in the respective transverse and longitudinal directions. This is applicable to both the compression and the uplift condition. The directions of X and Y shall be assumed in the same direction as the horizontal components of C and U respectively, that is, the most onerous horizontal load directions shall be assumed.



### 3.4. GENERIC SPECIFICATION INFORMATION

Due to the presence of dune sand along the line route, it was recommended that the foundations be raised by 650 mm above the natural ground level for all towers.

Only HDPE pipe will be accepted for the encasing of the guy anchor link. The blue HDPE pipe is recommended provided that there won't be price difference.

Proof load tests must be conducted on a minimum of 10 % of all piles installed and 5% for all deadman anchors. The Contractor must supply a test plan to be accepted by LES before commencement of testing.

Where pile foundations are installed the piles must be tested prior to installation of the pile cap (note that this is included in the 10 percent test regime). A portion of the piles can be tested if they are offline, this will form part of the 10% testing (as mentioned above). Offline pile testing will be done to the discretion of the Contractors designer.

The Contractor's designer may install offline piles/ piling systems to verify frictional parameters that must be included in the design drawing submission to LES.

All foundations must protrude by a minimum of 650 mm above ground. Maximum to be determined by the contractor's designer (through submission of design drawings) should side slope be encountered

When designing piling/micro-piling foundation systems, the Contractors designer must take into account total shears.

All piling systems must be grouted option only.

It is compulsory for Contractors to price on conventional (pier and pad) and pile (augured, micropile, grouted driven pile, etc.) foundations. For piles ensure that the bill contains all six soil types and should indicate installed cost per tower type. Rock anchors and incorporation of rock as part of the foundation must be taken into consideration in the design. Under no circumstances must rock be removed without prior engagement with and acceptance by LES.

"Piled foundations shall be designed to resist the total horizontal base shears acting on the foundation, that is, the horizontal components of C or U plus X and Y in the respective transverse and longitudinal directions. This is applicable to both the compression and the uplift condition. The directions of X and Y shall be assumed in the same direction as the horizontal components of C and U respectively, that is, the most onerous horizontal load directions shall be assumed."

All foundations shall BE CONSTRUCTED in accordance with the latest applicable version of TRMSCAAC.

#### **4. EARTHING REQUIREMENTS**

On completion of installation of all towers, tower footing resistance shall be measured with an approved earth tester and the measurements must be submitted to the Project Manager. Resistance shall be measured when foundations and earth straps are all electrically connected which includes any counterpoise that may have been added. The footing resistance of the tower shall be measured before the overhead ground wires are connected to the tower or the overhead ground wires can be temporarily isolated. Reference must be made to 240-130615862 – “Earthing of Transmission Line Towers” standard for the method of testing to be employed.

##### **4.1. CONNECTIONS BETWEEN EARTH AND A SELF-SUPPORTING TOWER LEG**

For a self-supporting tower, a connection must be made at each block of the foundation system between the steel tower leg and the main reinforcing bar (rebar). That is, the connection between each of the four legs of a self-supporting tower and earth will be achieved with the use of a 19/2.7 steel conductor.

One end of the conductor must be bolted to the tower leg and the other end must be clamped to the foundation rebar. Both connections must be made before the foundation is cast and must be within concrete. The end of the conductor that is to be bolted must first be crimped onto a hole of a suitable lug before it can be bolted to a dedicated hole on the tower leg. **Figure 4.1** shows the crimped end of an earth electrode that must be bolted to a tower leg and the end that must be clamped to the foundation rebar.

A suitable lug with an 18mm-diameter hole must be crimped onto the loose end of the conductor. The lug must be bolted to the tower leg using a bolt of a minimum diameter of 16 mm.

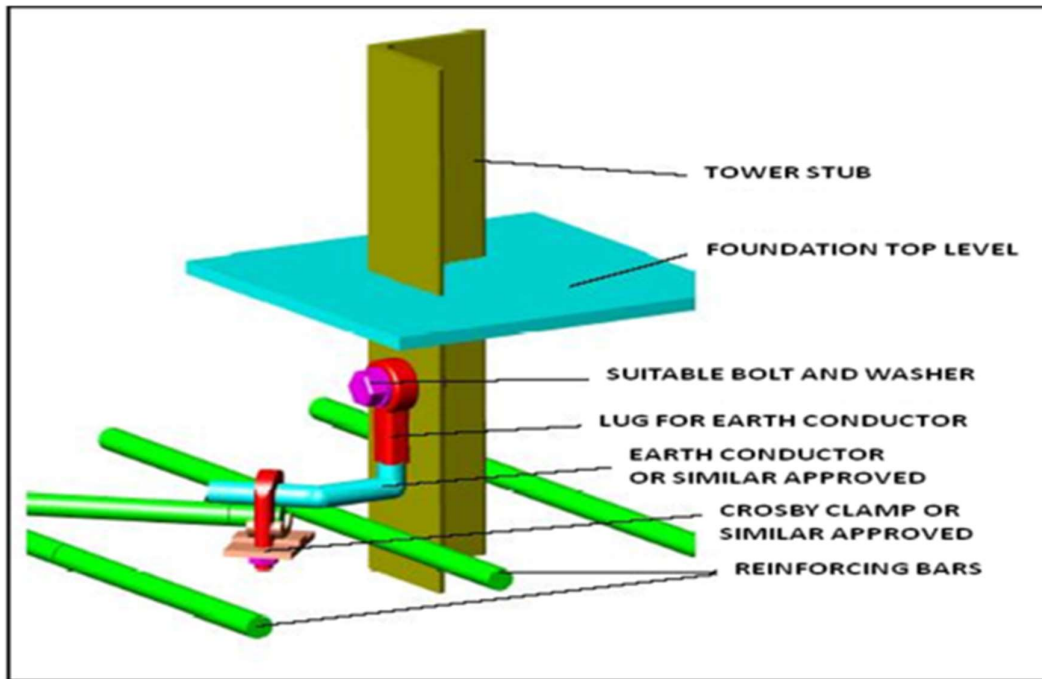


Figure 4-1: Connection between Self Supporting Tower Steel and Main Reinforcing Bar

#### 4.2. CONNECTIONS BETWEEN A TERMINAL TOWER AND A SUBSTATION

There must be an underground electrical connection between the terminal structure and the main earth-mat of a substation. The substation earth-mat consists of copper rods, thus the connection at each of the two legs of a terminal structure that are nearest to the substation must make use of two solid copper conductors, each with an approximate diameter of 10 mm.

The connection between the two conductors and the leg of a steel lattice terminal structure must make use of an earth-tail clamp as shown in **Figure 4.2**. The connection of each conductor to the tower must be in accordance with Eskom 0.54/393 drawings. The exposed part and the part extending to approximately 1m below ground of the conductor must be painted with two coats of a suitable bitumastic compound.

The connection of each of the conductors to the main earth-mat of the substation must make use of compression joints. The joints must be made using a 12 ton hydraulic compression tool. The tool must be of a type that will not release until full compression force is achieved. Each conductor must be buried 800 mm below the ground level.

The earth-wires (ground-wires) from the terminal structure are always bonded to the earth-peaks of a substation gantry.

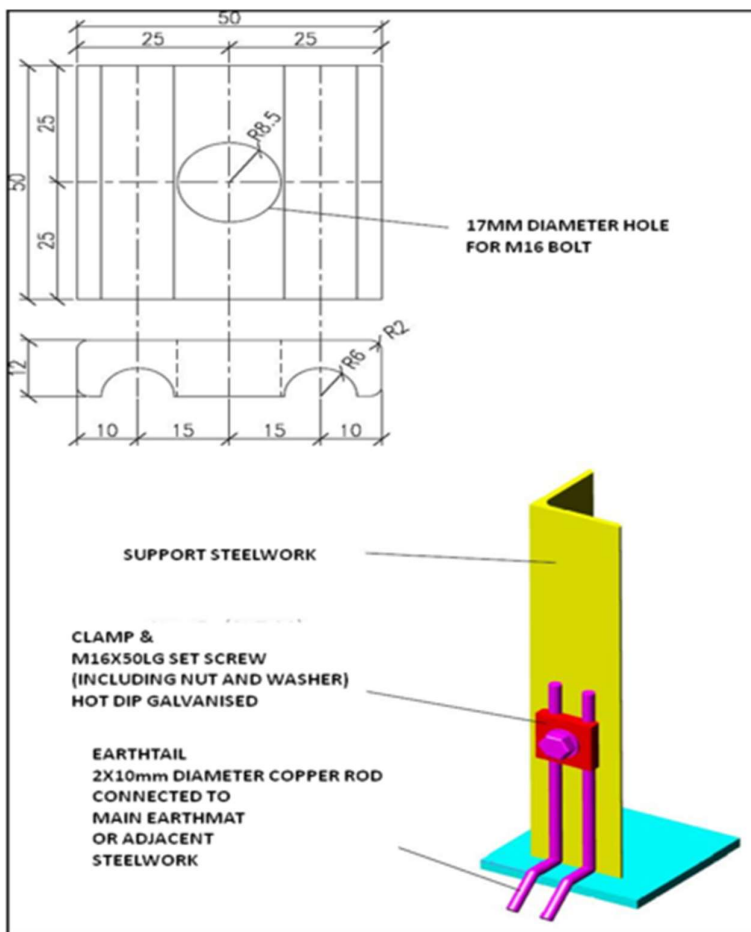
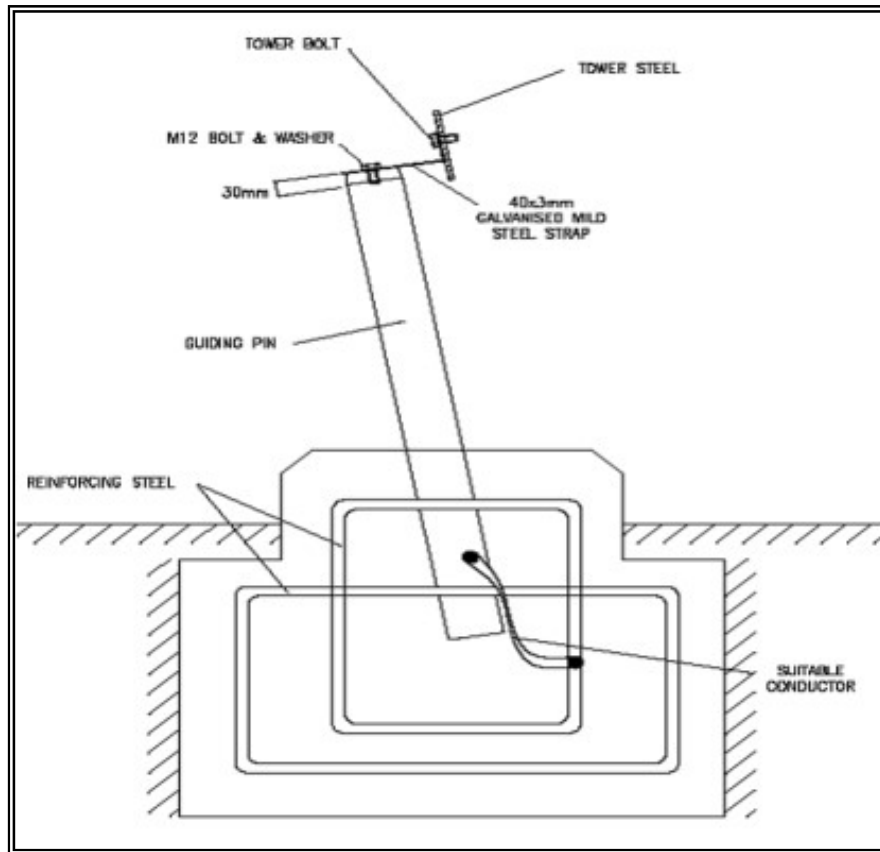


Figure 4-2: Terminal Tower Leg and Copper Conductor Connections

#### 4.3. CONNECTIONS BETWEEN EARTH AND A CROSSROPE TOWER LEG

For a crossrope tower, there should be a connection between a tower leg and the top of a locating pin and there should be another connection within concrete between the cast-in end of the locating pin and the main foundation re-enforcing bar (rebar). **Figure 4.3** shows the connections between the tower leg, the locating pin and foundation rebar.



**Figure 4-3: Tower Leg, Locating Pin and Foundation Rebar Connection**

The connection between the tower leg and the top of the locating pin should be made with the use of a galvanised mild steel strap with dimensions of 40 mm × 3 mm such that the strap is bolted to the tower leg. The top of the locating pin, which protrudes from the foundation, should be tapped with a 12 mm hole to be a depth of 30 mm.

The connection between the cast-in end of the locating pin and the main foundation rebar should also be made with the use of a 19/2.7 steel conductor. The conductor should be connected to the locating pin with a lug and should be connected to the rebar with a Crosby clamp.

For guy anchors, a proper connection shall be made at each foundation between the link and the reinforcing steel. The earth electrode that is recommended to be used for the connection is a 19/2.7 steel conductor. The conductor should be bolted to the link and it should be connected to the reinforcing steel using a Crosby clamp.

#### 4.4. CONNECTIONS BETWEEN EARTH AND A GUYED-VEE TOWER LEG

For a Guyed Vee tower, a connection shall be made within concrete between the main foundation rebar and one of the anchor bolts as shown in **Figure 4.4**. The connection shall be made using a 19/2.7 mm steel conductor, which will be fastened to the anchor bolt and to the foundation rebar using Crosby clamps. The two masts of a guyed vee tower will be bolted together using a 40 mm x 3 mm galvanised mild steel strap.

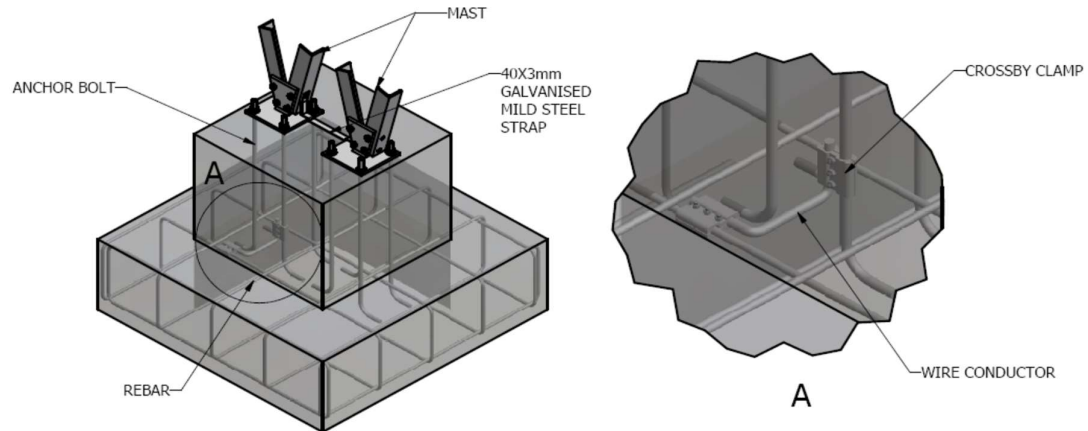


Figure 4-4: Tower Leg (Guyed Vee) And Rebar Connection

#### 4.5. EARTHING ARRANGEMENTS FOR TUBULAR STEEL STRUCTURES

The standard earthing system to be installed on bolted footings will incorporate a single electrical connection between the holding down bolt arrangement and the foundation reinforcing (where present).

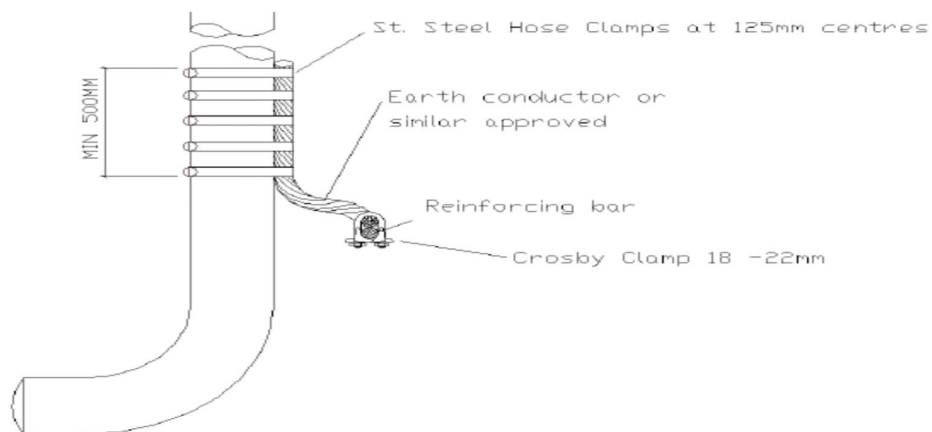
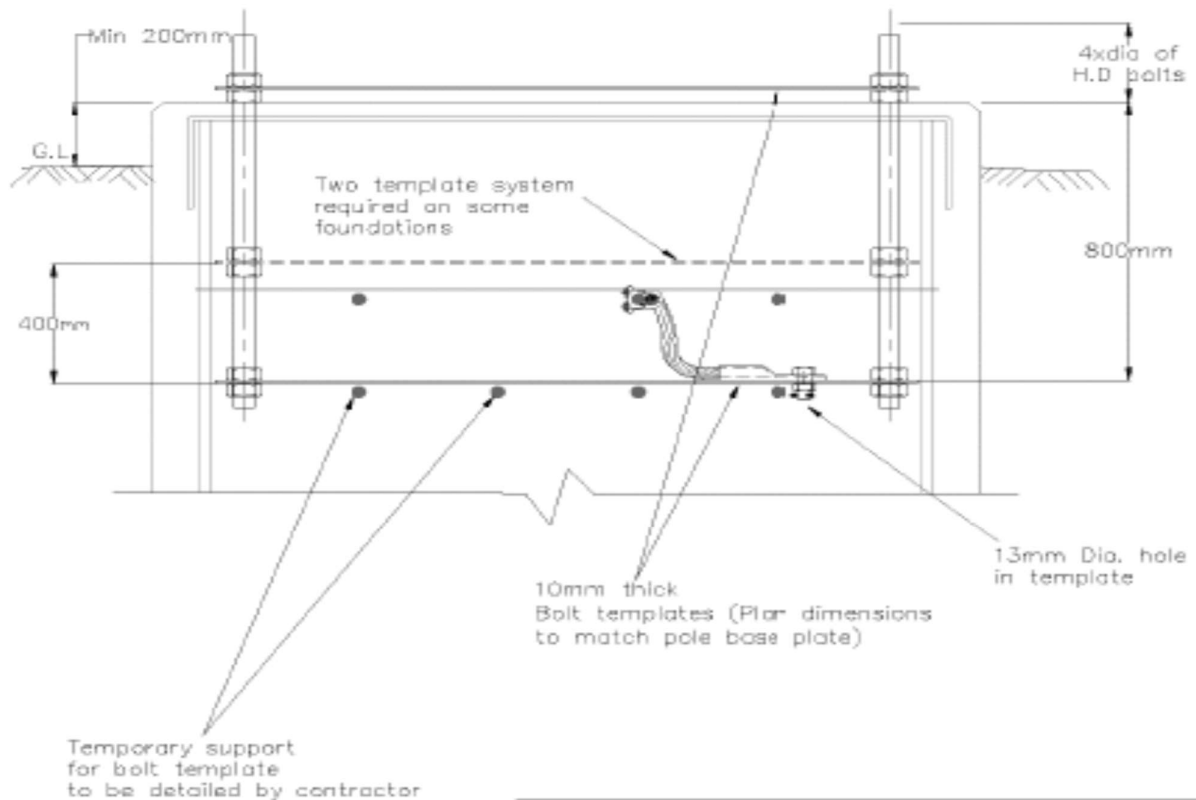


Figure 4-5: Earthing Arrangements for J-Bolts

J-Bolt systems will be connected by clamping a 500mm length of earth conductor to one of the J-bolts in the group and the other end to the re-bar as detailed on **Figure 4.5** using a 19/2.7 mm steel conductor.



**Figure 4-6: Earthing Arrangements for Straight HD Bolts**

Crosby clamp to be connected to rebar and the other end to be connected via a lug to the plate using a 19/2.7 mm steel conductor.

Where the stated resistance cannot be achieved additional earthing may need to be installed. For such applications, the incorporation of a 50 mm long, 50 x 50 x 5 angle is welded close to the base of the pole, as indicated in **Figure 4.7** – Earth lug for accommodation of additional earthing.

The incorporation of this lug shall be fitted to all poles unless specified otherwise.

The stub designs for tubular steel structures, namely the 531 structures, must accommodate for the earthing straps.



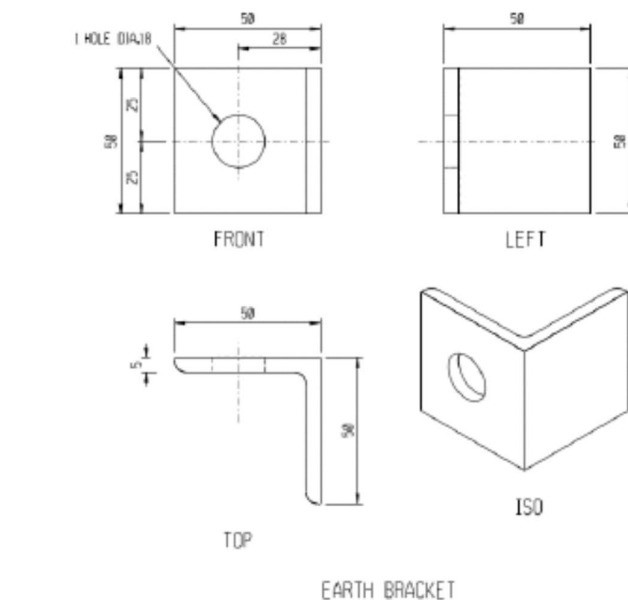


Figure 4-7: Earth-Lug for Additional Earthing on Tubular Steel Structures

#### 4.6. TOWER FOOTING RESISTANCE REQUIREMENTS

Upon complete installation of all planned connections between foundations, bonding conductors and any counterpoise that may have been added, the tower footing resistance of each structure is to be measured with an approved earth tester and the measurements are to be submitted to the relevant Eskom project manager. The footing resistance of each structure is to be measured either before connecting the earth wires to the structure or after temporarily isolating the earth wires from the structure. Where the above footing resistances cannot be met, the contractor must inform the project manager who will request an appropriate value to be calculated based on the back flashover rate. For A 400kV line the footing resistances of the second, third, fourth and fifth towers from the substation should be greater than or equal

to 10  $\Omega$  and should be less than or equal to 20  $\Omega$ . If, however, a case is encountered, where the footing resistance of such a structure of a strain type is less than 10  $\Omega$ , then jumper leads must be fitted across the structure.

The tower footing resistance is less than or equal to 30 Ohm as a target for each tower. If greater than 30 Ohm, seek advice from the LES design engineer before implementing any solution.

The first tower footing resistance measurement is to be witnessed by Eskom Designer.

The maximum footing resistance for:

- ☐ 132kV is 20 $\Omega$ ,
- ☐ 220kV is 30 $\Omega$ ,
- ☐ 275kV is 30 $\Omega$ ,
- ☐ 400kV is 40 $\Omega$ ,
- ☐ 765kV is 50 $\Omega$ .

#### 4.7. ADDITIONAL EARTHING REQUIREMENTS

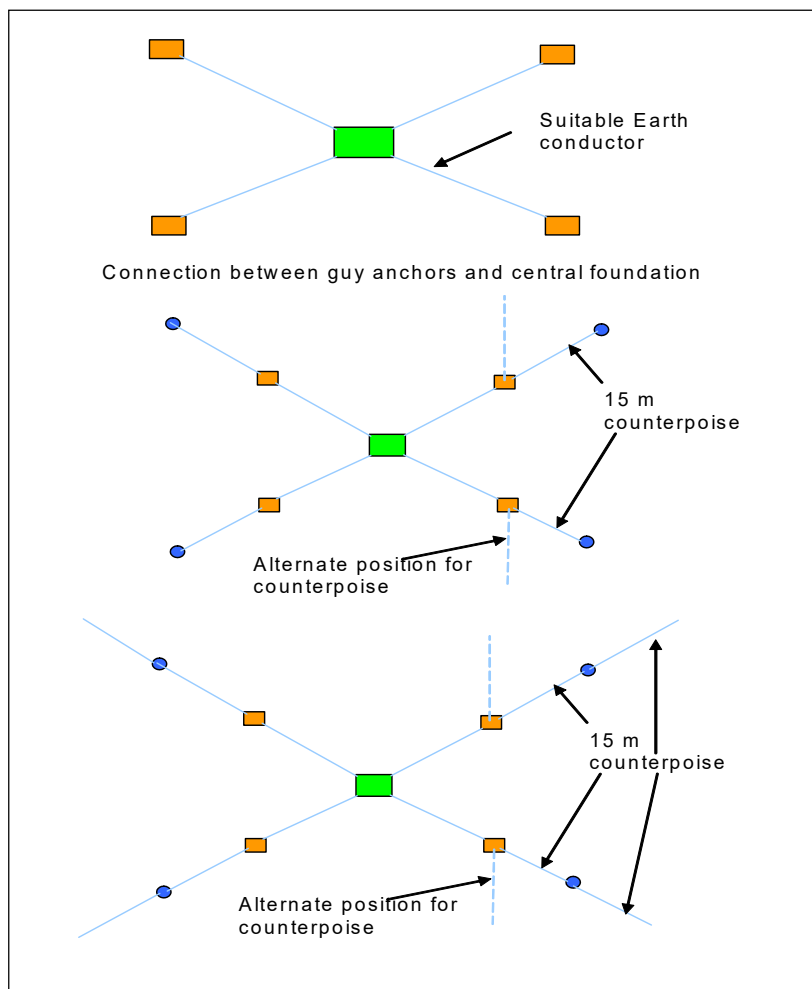
Where the required tower footing resistances cannot be achieved additional earthing in the form of counterpoise may be required.

Prior to installing counterpoise soil resistivity tests should be performed to determine a suitable system for additional earthing. Additional earthing can be installed in three basic ways. It can either consist of: 15 m radial counterpoise, buried 600 mm below ground level; deep drilled electrodes; or, a combination of 15 m radial counterpoise and deep drilled electrodes.. An

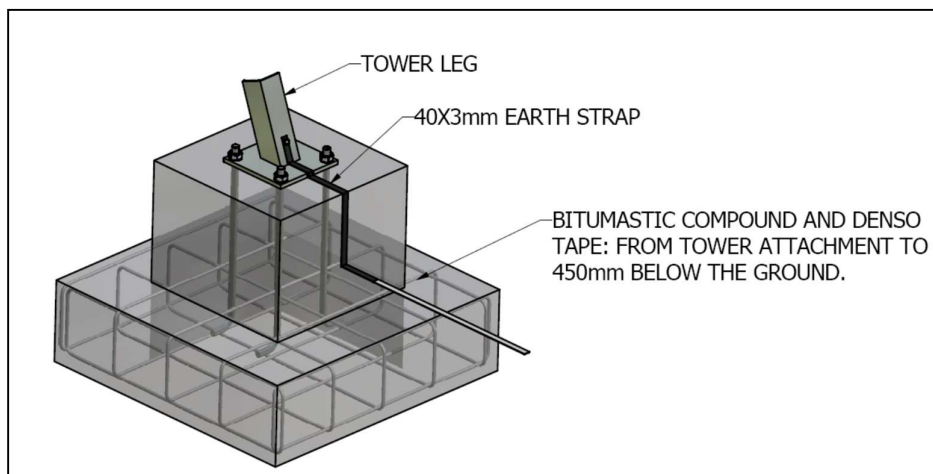
For example, **Figure 4.8** shows that counterpoise must be added on either side of the base of a guyed tower in the direction of the guys using brazed copper joints and it must be added to two opposite legs of a self-supporting tower <sup>[3]</sup>. If further reduction in the footing resistance is required, additional 15m-long counterpoise must be added either to each of the other two tower legs or at right angles to the counterpoise that would already be installed.

The choice of whether to lay counterpoise in trenches or in drilled holes depends on the resistivity of the soil layers which will be determined from soil resistivity tests. All holes must be backfilled with soil. In rocky areas and areas with high resistivity, a conductive mixture of carbonaceous aggregate shall be used as a backfill.

Counterpoise must be painted with two coats of an approved bitumastic compound from the attachment at the tower leg to approximately 450 mm below ground level. **Figure 4.9** shows the parts of the tower and of the foundations that the bitumastic compound must be applied to.



**Figure 4-8: Additional Earthing for Guyed “V” and Cross Rope Suspension Towers**



**Figure 4-9: Paint Detailing of Counterpoise**

#### **4.8. FITTING REQUIREMENTS**

The SCSASACB1 Eskom standard states that measures must be taken to ensure that no current flows through fittings and assemblies that are not designed to carry current, even during fault conditions. Thus, all earth-electrode connections must make use of internationally acceptable clamps that are specifically designed to carry current.

A combinational use of external, visible conductors and embedded bonding electrodes will be used for the earthing system of the line. It should also be noted that all construction work must comply with the 240-47172520 Eskom specification.

#### **4.9. EXCEPTIONAL CASES**

Structures which are within 800 m of, and that either cross or run parallel to, railway tracks or metal pipelines are to be protected from galvanic corrosion by insulating the ground-wires from the structures. If such structures are of a strain type, then jumper leads must be fitted across the insulated ground-wire assemblies.

## 5. INSULATOR REQUIREMENTS

Insulators are supplied free issue by Eskom to contractor. the typical glass cap and pin and composite insulators for 400kV are as follows .

**Table 5-1: Requirements for Glass Cap and Pin Insulators**

Single Disc Parameters	Units	GLASS CAP AND PIN INSULATOR REQUIREMENTS		
Mechanical Strength	kN	120	210	300
Disc Coupling length	mm	146	170	195
Disc Creepage length	mm	320	380	480
String Parameters				
Total Creepage	mm	8320	8740	8640
Discs Per String		26	23	18
Total Length	mm	3796	3910	3510
End-Fitting Size	mm	16	20	24
Specific Creepage	mm/kV	19.8	20.8	20.6
Basic Insulation Level	kV	1425		
Switching Insulation Level	kV	1050		

**Table 6-2 Composite Insulator Characteristics**

Composite Insulator	210	300
Creepage Distance (mm)	31mm/kV	31mm/kV
Dry Arcing Distance (mm)	≥3200	≥3200
Connecting Length (mm)	≤3700	≤3700
End Fitting Size (mm)	20mm	24mm
Corona Rings	Both	Both
BIL	1425	1425
BSL	1050	1050

**Table 5-2: Earth Wire Composite Insulator Characteristics**

PARAMETER	USER REQUIREMENTS
Shed Material	Silicone-based
Standards	Comply with IEC60815, IEC61109
Corecover Thickness	≥ 3 mm
Insulator Class	Class A
Connecting Length	375 (±12) mm
Creepage length	≥ 174 mm
Pf. Dry, one minute withstand	50 kV (without arcing horns)
Pf. Wet, one minute withstand	25 kV (without arcing horns)
Lightning positive impulse withstand	80 kV (without arcing horns)
Minimum mechanical strength	120 kN
Coupling method	In-line tongue and clevis caps in accordance with IEC 60471 size 16L
Arcing horn shape	“Jacob’s Ladder” with minimum strait horn lengths of 50mm and an angle of 60±5 degrees between them
Arcing horn bending radius	≥2mm times the arcing horn rod/bar diameter at the base
Arcing horn material	Hot dipped galvanized forged steel
Arcing horn cross sectional area	> 18 mm <sup>2</sup> each
Arcing horn gap size	8 (± 2) mm fixed

**Table 5-3: Proposed Line Post Earth wire Insulator Characteristics for 529 Towers**

Description	Eskom’s minimum requirements
Earthwire Type	Horse ACSR conductor
Altitude	≤1800 m
Required Life Expectancy	≥30 years
<b>Technical details</b>	
Insulator Class	Class A
Core material Cover Thickness	≥3mm
Shed material	Silicone based
Shed profile	Flat Shed preferred
Shed Spacing to Projection Ratio	≥ 1 (if more than one shed)
Shed Diameter	Supplier to specify

Operating Temperature	
- Minimum	-5 °C
- Maximum	50 °C
- Maximum Diurnal Variation	30 °C
Strength Requirements	
- CBL	Supplier to specify
- SCL	25 kN
- MDCL	12.5 kN
Maximum Connecting Length of Insulator	252 ± 10 mm
Vertical Inclination for Installation	0 Deg.
Live End Fitting	Vertical Trunnion Head
Dead End Fitting	Flange Base PCD 127.0 mm 4xØ18 Thru holes
Minimum Creepage Distance	150 mm
Lightning Impulse withstand Voltage acc. to IEC 61952	110 kV
60 sec Power Frequency Withstand Voltage acc. to IEC 61952	20 kV
FRP Rod Diameter	Supplier to specify
Diameter over sheath	Supplier to specify
Minimum Dry Arcing Distance	105 mm
Minimum Galvanizing thickness	85 µm
Arcing horns <ul style="list-style-type: none"> <li>Type</li> <li>Gap size</li> <li>Galvanizing thickness</li> </ul>	Adjustable Jacobs Ladder type Min. Gap size = 8 ± 2 mm Galvanizing thickness 85 µm

The 529 structures shall be fitted with a composite line post insulator, for the earth wire, where required as per **Table 5.3**.

For the earth wire insulator assemblies, i.e. both suspension and strain, only 120 kN composite longrod insulators will be used

The insulator and hardware drawings are shown in **APPENDIX C**.



## 6. LINE LABELS

All labels shall be designed, manufactured and installed in strict accordance with the following Eskom Specifications: 240-120804300 (TSP41-604 REV.1) and 240-75660336.

. All tower labels shall be made of a material approved by Eskom.

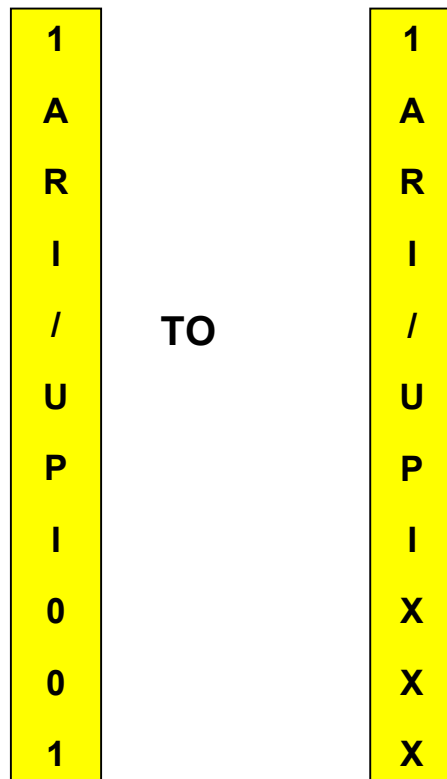
### 6.1. LINE DESIGNATION LABELS LAYOUT AND WORDING

An example of line label designation is shown below .The Aries – Upington 1 400 kV line will have the following labelling (at Aries substation and Upington substation)

**1ARI / UPI**

### 6.2. TOWER LABELS

Aries – Upington 1 400 kV Line (X = total number of towers on the line)



### 6.3. CROSSING LABELS

A line crossing label shall be attached to each transverse face of the bridge, on the first, second and third poles/ towers on all sides of a crossing as indicated in the drawing below.

Line crossing labels shall be used when:

- a) one-line crosses over another line
- b) two lines converge to run parallel with each other in a single servitude
- c) there are tee-off points

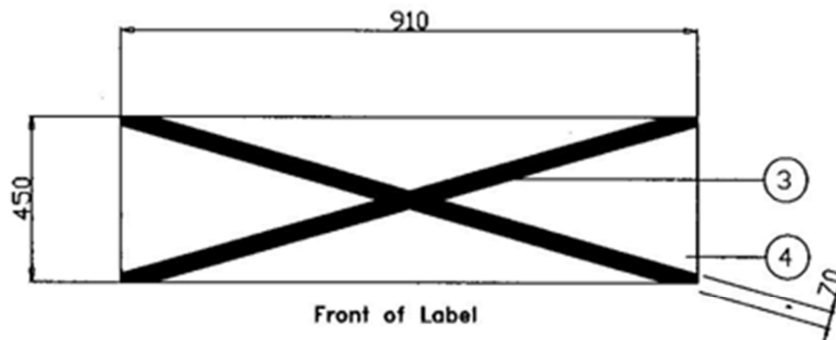


Figure 6-1: Crossing Label

### 6.4. PHASE DISK LABELS

- a) All Terminal Towers shall be fitted with phase disk labels.
- b) Structures adjacent to transposition towers shall be fitted with phase disk labels on both sides.
- c) All bypass terminal structures shall be fitted with phase disk labels.

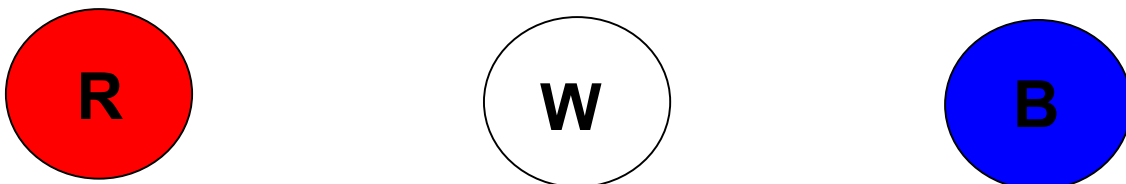


Figure 6-2: Phase Disk Labels

## 6.5. WARNING SIGN

This is a sign to be placed on every structure, in high public exposure areas, on the main leg before the anti-climb device, to warn the public that the structure is part of a high voltage system and that could endanger their lives if interfered with. Based on the standard safety signs available as part of the SANS 1186-1:2011, the figure below can be utilised. On all new lines constructed, these signs must be part of the new tower as per SANS 10280-1: 2017, section 14. See SANS 10280-1: 2017 for more details on the exposure areas.

This will be done according to the NRS041-1-2013 document which stipulates the design and requirements for such warning signs. Also consider the DST-34-1168 document which will stipulate the requirements for such warning signs to be put up in these areas. The warning signs should have approximate dimensions of 300 mm x 300 mm with strap holes to fit onto 200 mm leg.

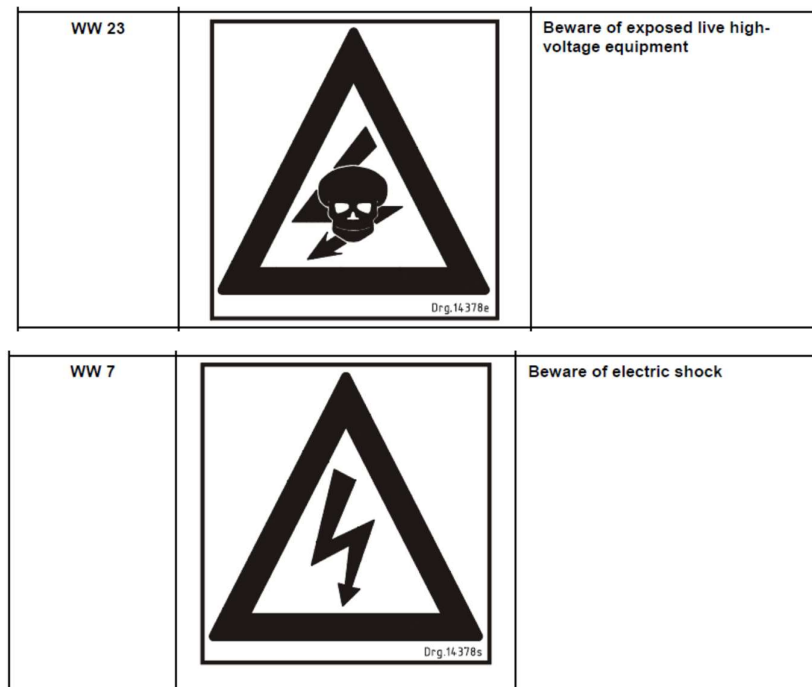


Figure 6-3: Warning Signs

## 7. APPENDIX A: STANDARDS AND SPECIFICATIONS

### 7.1. STANDARDS

The standards within this section provide for the design and technical requirements of the line:

<b>IEC 60652</b>	Load tests of transmission towers.
<b>CSIR: 1990</b>	Transmission Line Loading Part 1: Recommendations and commentary - 1990
<b>ASCE – 10</b>	Guide for design of steel transmission towers.
<b>OHS Act and Regulations</b>	OHS Act and Regulations (latest revision)
<b>SANS 50196-21</b>	Methods of testing cement Part 21: Determination of the chloride, carbon dioxide and alkali content of cement
<b>IEC 60888 Ed. 1.0 b</b>	Zinc-coated steel wires for stranded conductors
<b>SANS 10111-1</b>	Engineering drawing Part 1: General principles 1993 3.01
<b>SANS 1556-1,2,3</b>	ISO Metric screw threads
<b>SANS 1491-1,2,3</b>	Portland cement extenders
<b>SANS 1355-3</b>	ISO metric machine screws and nuts, hexagon socket screws and set-screws (coarse thread series) Part 3: Set-screws
<b>SANS 10044-1, 2, 3, 4, 5</b>	Welding
<b>SANS 1391-1</b>	Thermally sprayed metal coatings
<b>ISO 1461 / SANS 121</b>	Specification for hot dip galvanized coatings on iron and steel articles.
<b>SANS 935</b>	Hot-dip (galvanized) zinc coatings on steel wire
<b>SANS ISO 4998</b>	Continuous hot-dip zinc-coated carbon steel sheet of structural quality
<b>SANS 10144</b>	Detailing of steel reinforcement for concrete
<b>BS 5835: 1980</b>	Compatibility test for graded aggregates.
<b>BS 6949: 1991</b>	Specification for bitumen based coatings for cold application excluding use in contact with potable water.
<b>SABS EN 795 SABS EN 353-1</b>	Code of practice for ground anchorages.
<b>SANS ISO 9001</b>	Quality Management Systems Requirements.
<b>SANS EN 10025</b>	Hot rolled products of non-alloy structural steels. Technical delivery conditions.

<b>BS EN 10210:</b>	Hot finished structural hollow sections of non-alloy and fine grain structural steels.
<b>SABS ISO 5177 SABS ISO 6520 SABS ISO 4136 SABS 10443-3 SABS 10443-6</b>	Approval testing of welders for fusion welding. Part 1: Essential variables, range of approval examination and testing, acceptance requirements, re-tests, period of validity. Annexes on steel groups, welders' test certificates, procedure specification and job knowledge.
<b>SABS 1033 SABS 864 SABS 1293 SABS 1370</b>	Specification and approval of welding procedures for metallic materials. Part 3: Welding procedure tests for the arc welding of steels.
<b>BS4482</b>	Specification for cold reduced steel wire for the reinforcement of concrete.
<b>SANS 50197-1, 2</b>	Cement composition specification and conformity criteria – Part 1: Common cements
<b>SANS 5860, 5861, 5862, 5863, 5865</b>	Concrete tests
<b>SANS 10162</b>	The structural use of steel
<b>SANS 1431</b>	Weldable structural steels
<b>SABS 10100</b>	Part I: The structural use of concrete. Part II: Materials and execution of work
<b>IEC 60120</b>	Dimensions of ball and socket couplings of string insulator units.
<b>IEC 61089:</b>	Round wire concentric laid overhead electrical stranded conductors.
<b>IEC 61284</b>	Overhead lines – Requirements and tests for fittings.
<b>IEC 60372</b>	Locking devices for ball and socket couplings of string insulator units.
<b>IEC 60383</b>	Insulators for overhead lines with nominal voltage above 1000V.
<b>IEC 60471</b>	Dimensions of clevis and tongue couplings of string insulator units.
<b>IEC 60826</b>	Loading and strength of overhead transmission lines.
<b>BS 2874</b>	Specification for wrought steel for mechanical and applied engineering purposes.
<b>ISO 14399</b>	ISO Metric screw threads.
<b>BS 4190</b>	Specification for ISO metric black hexagon bolts, screws and nuts.

<b>BS 7668</b>	Specification for weld able structural steels. Hot finished structural hollow sections in weather resistant steels.
<b>BS EN 10137</b>	Plates and wide flats made of high yield structural steels in quenched and tempered or precipitation hardened conditions.
<b>BS EN 10029</b>	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick or above.
<b>BS 970</b>	Specification for wrought steel for mechanical and applied engineering purposes.
<b>BS EN ISO 9001</b>	Quality systems model of quality assurance in design, development, production, installation and servicing.
<b>BS EN 10025</b>	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
<b>BS EN 10163</b>	Specification for delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
<b>BS EN 287-1</b>	Approval testing of welders for fusion welding. Part 1: Essential variables, range of approval examination and testing, acceptance requirements, re-tests, period of validity. Annexes on steel groups, welders' test certificates, procedure specification and job knowledge.
<b>BS EN 288-3</b>	Specification and approval of welding procedures for metallic materials Part 3: Welding procedure tests for the arc welding of steels.

Live-line equipment is to be as per IEC standards 743, 895, 900, etc.

## 7.2. SPECIFICATIONS

This line specification shall take precedence if there is any conflict between it and the following specifications:

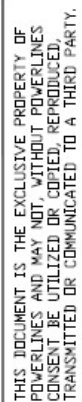
<b>PHASE CONDUCTOR AND GROUNDWIRE</b>	
IEC 60888	Zinc-coated steel wires for stranded conductors.
TST41-168	Quality requirements for the procurement of quality related assets, goods and services.
240 - 75521456	Phase conductor for Eskom Overhead Lines
<b>HARDWARE</b>	

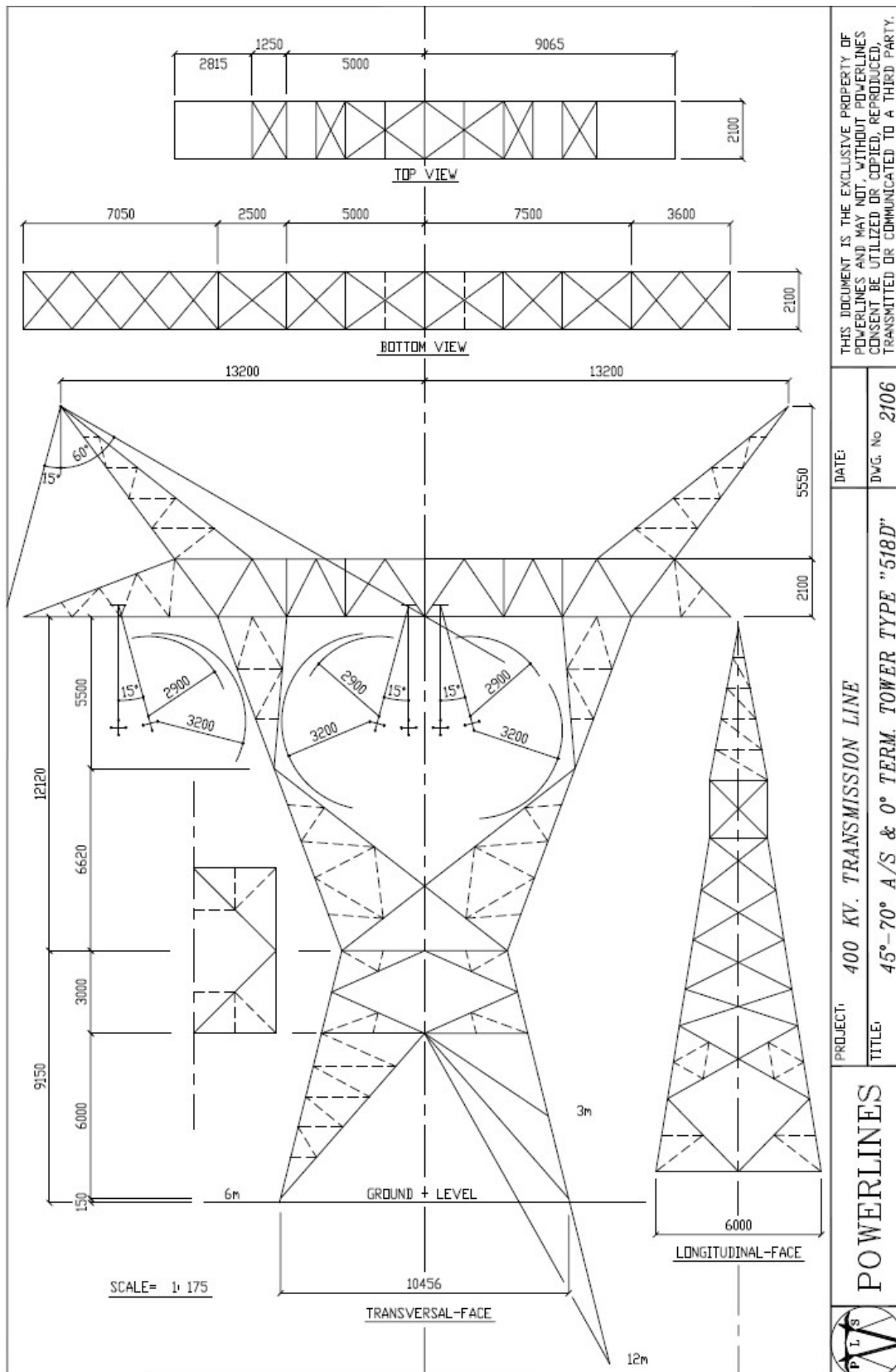
SANS 10280: 2017	Code of practice for overhead power lines for conditions prevailing in South Africa.
NWS 1019 Rev 1	Compression accessories for phase and earth conductors for transmission lines.
240-120804300, 240-75660336	Design, manufacture and installation specification for transmission line labels
TST41-168	Quality requirements for the procurement of quality related assets, goods and services.
240-77125760	Ceramic and Glass Cap and Pin Insulators
240-77125772	Specification for polymeric long rod insulators for Transmission voltages of 220kV and above
TRMSCAAI3:	Spacer or spacer damper assemblies for conductor bundles for transmission lines.
Technical Instruction 240-47172520 – latest version	Transmission line towers and line construction. (TRMSCAAC)
240-60725647	Phase conductor for transmission lines.
240-60777474	Specification for suspension and strain assemblies and for hardware for transmission lines.
240-75883874	Requirements and tests for Stockbridge type Aeolian vibration dampers.
240-16259196	Transmission Bird Perch Guidelines
<b>EARTHING REQUIREMENTS</b>	
240-130615862	Earthing of transmission line towers
IEEE 524	Guide to the Installation of Overhead Transmission Line Conductors
<b>TOWERS</b>	
Technical Instruction 240-47172520- Rev 6	Transmission line towers and line construction.

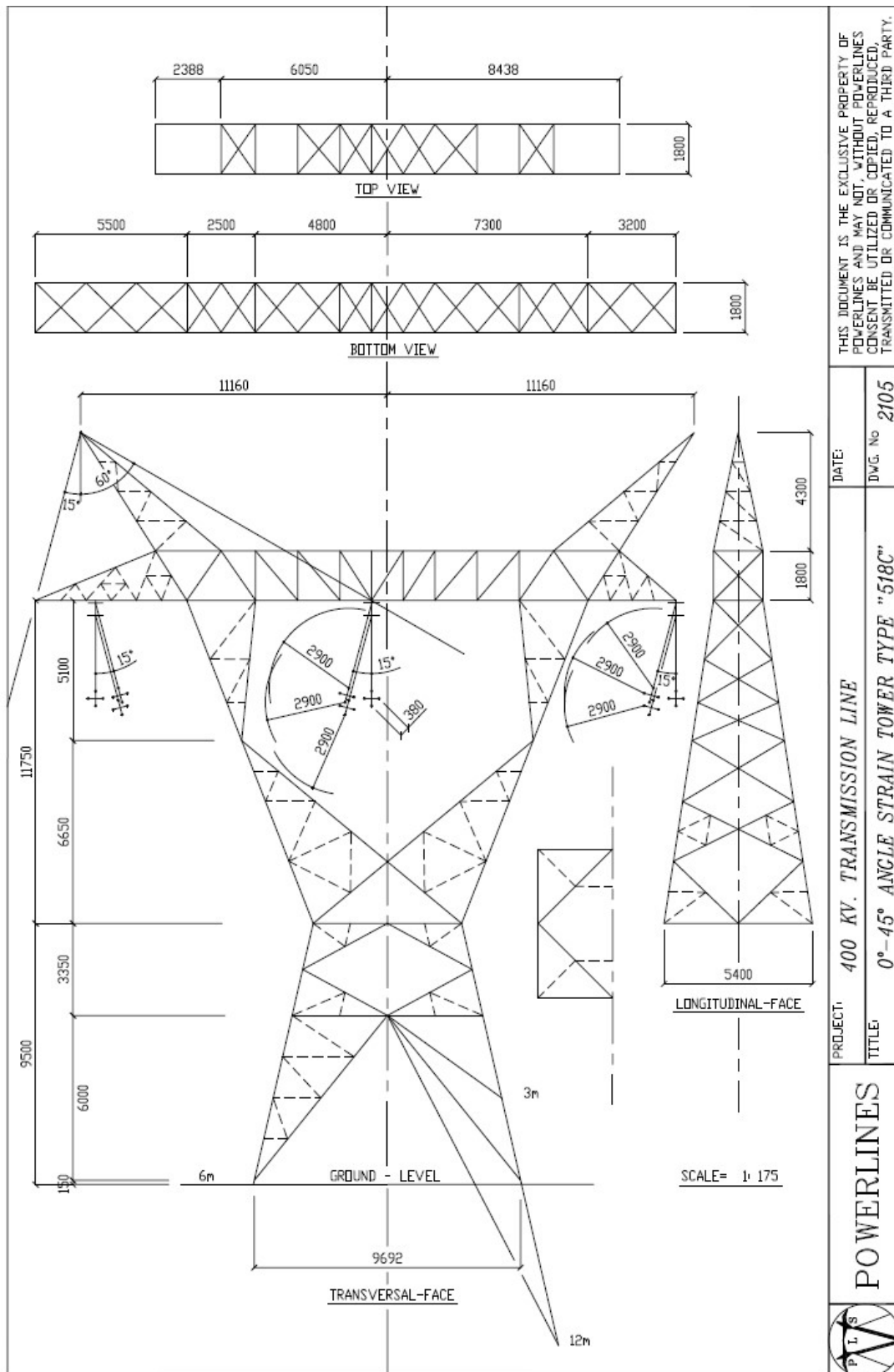
**NOTE:** Wherever reference is made to supplier(s), vendor(s), etc., it shall mean *the Contractor*.

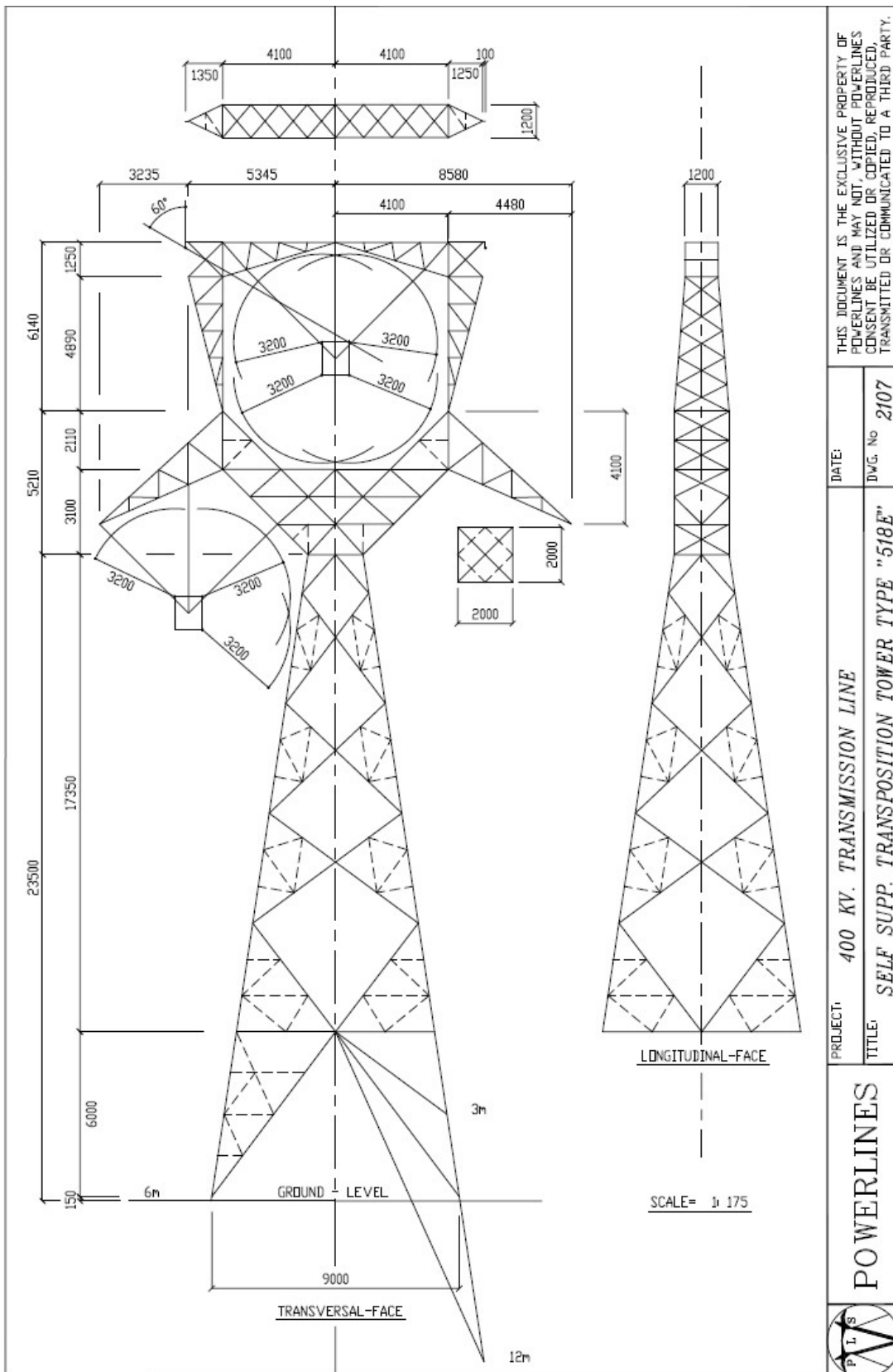
## 8. APPENDIX B: TOWER OUTLINE DRAWINGS

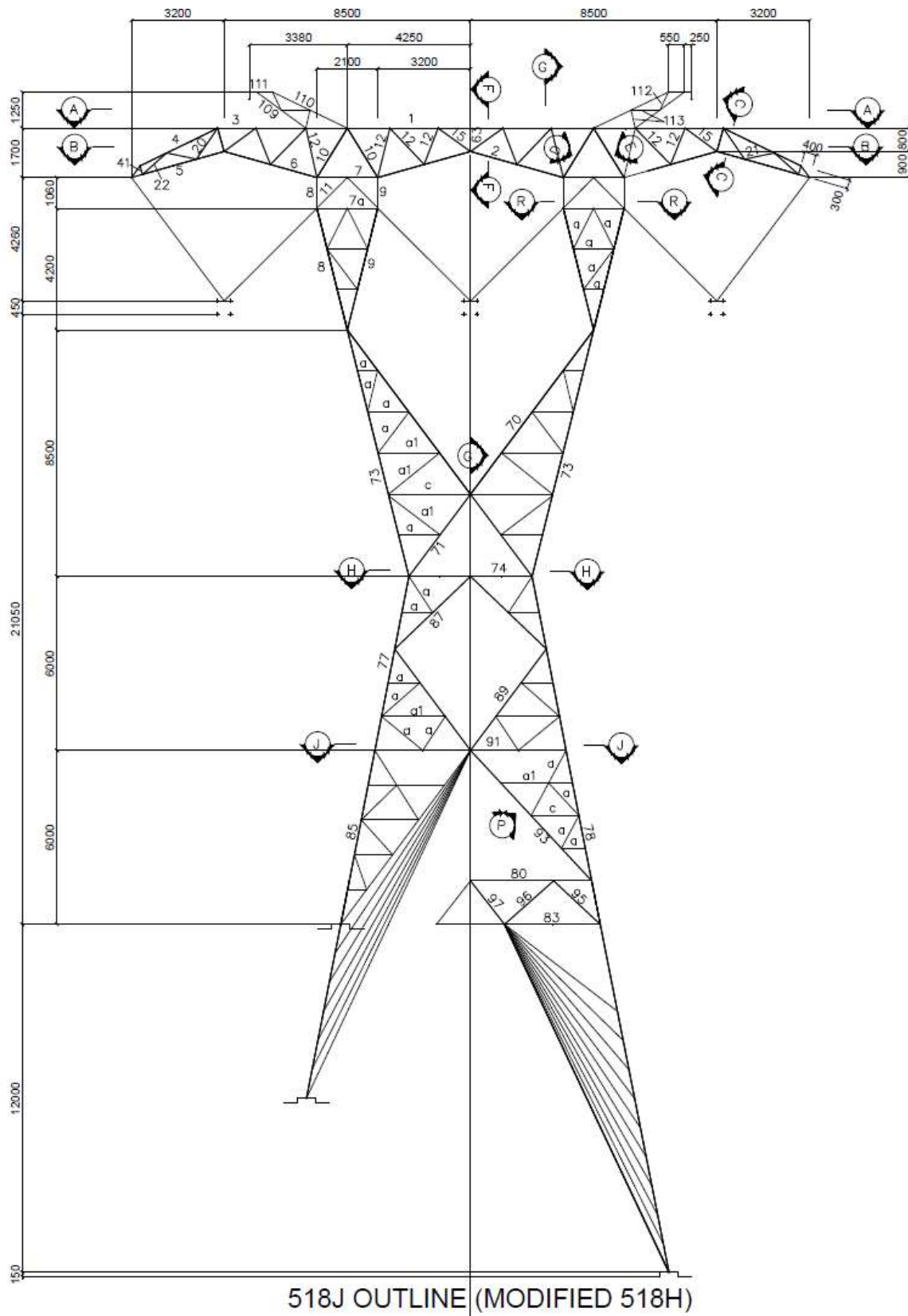




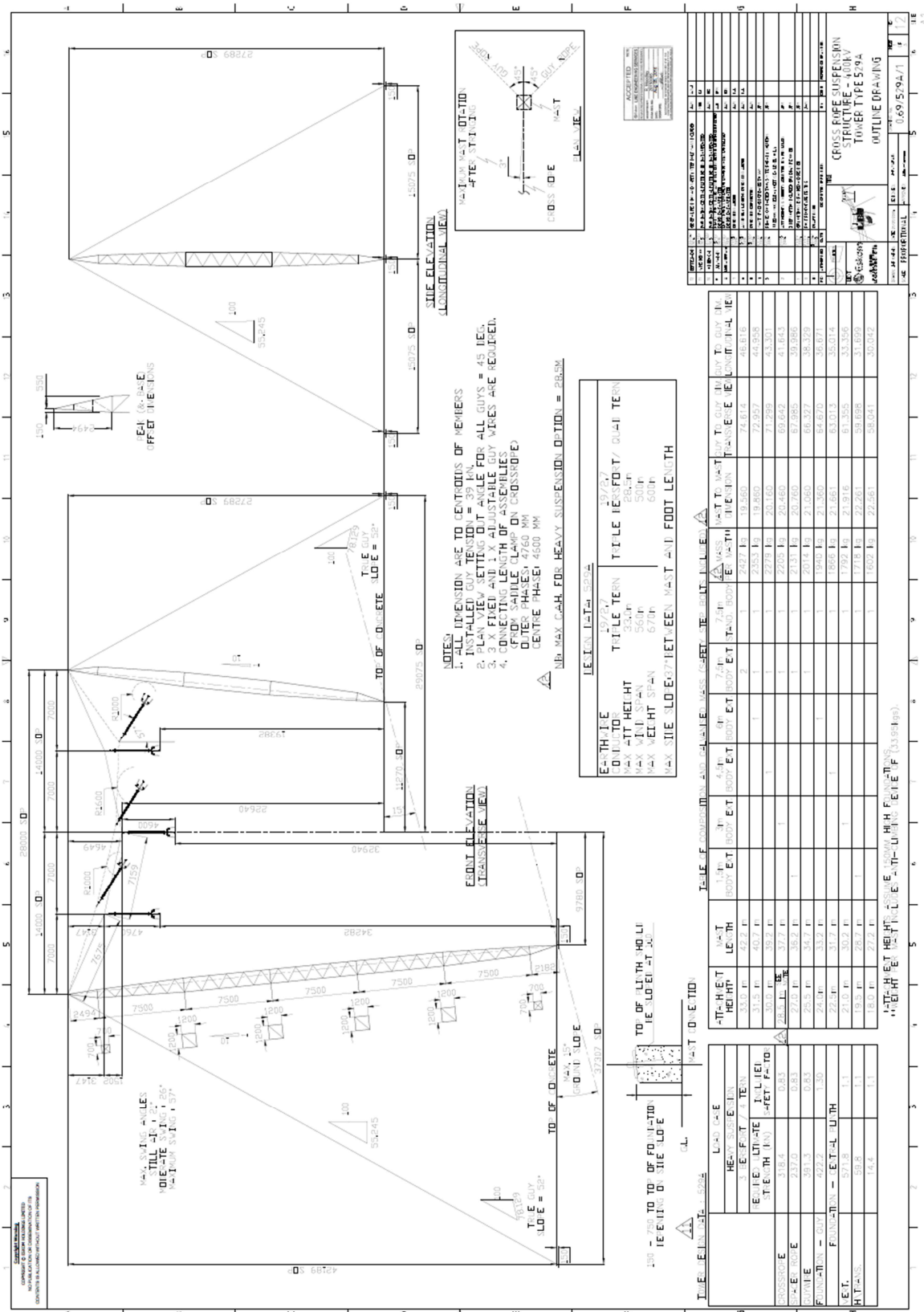


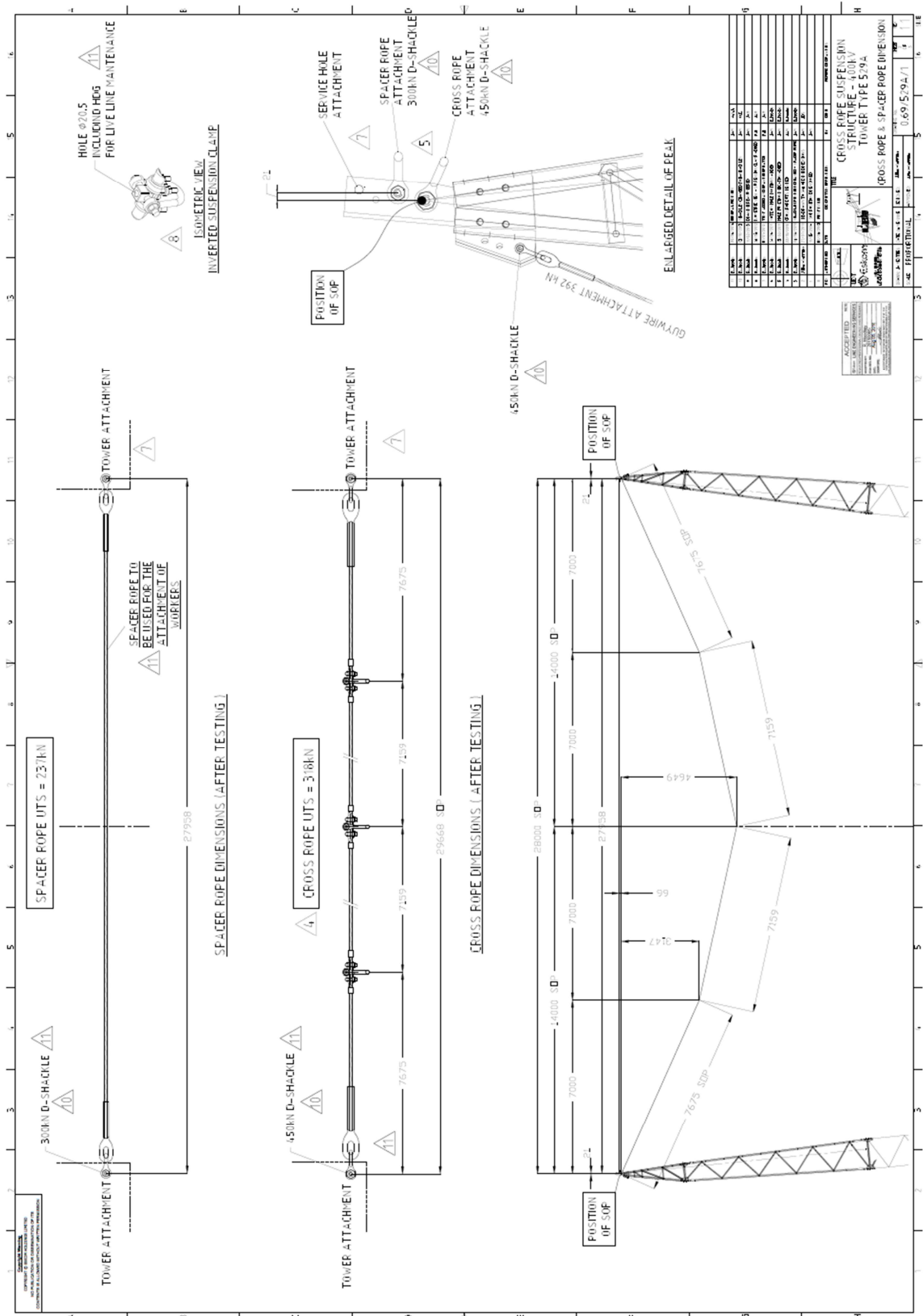






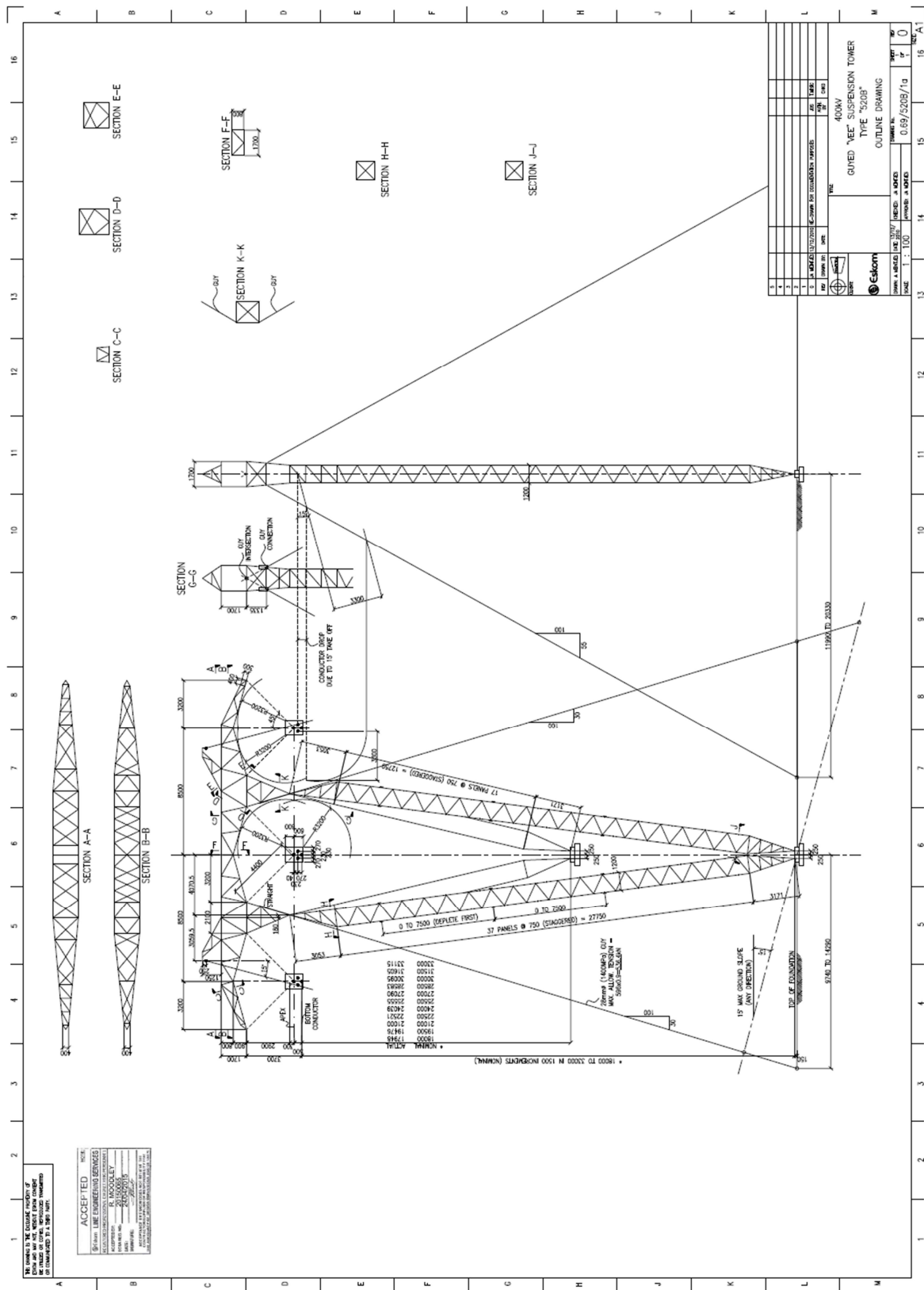


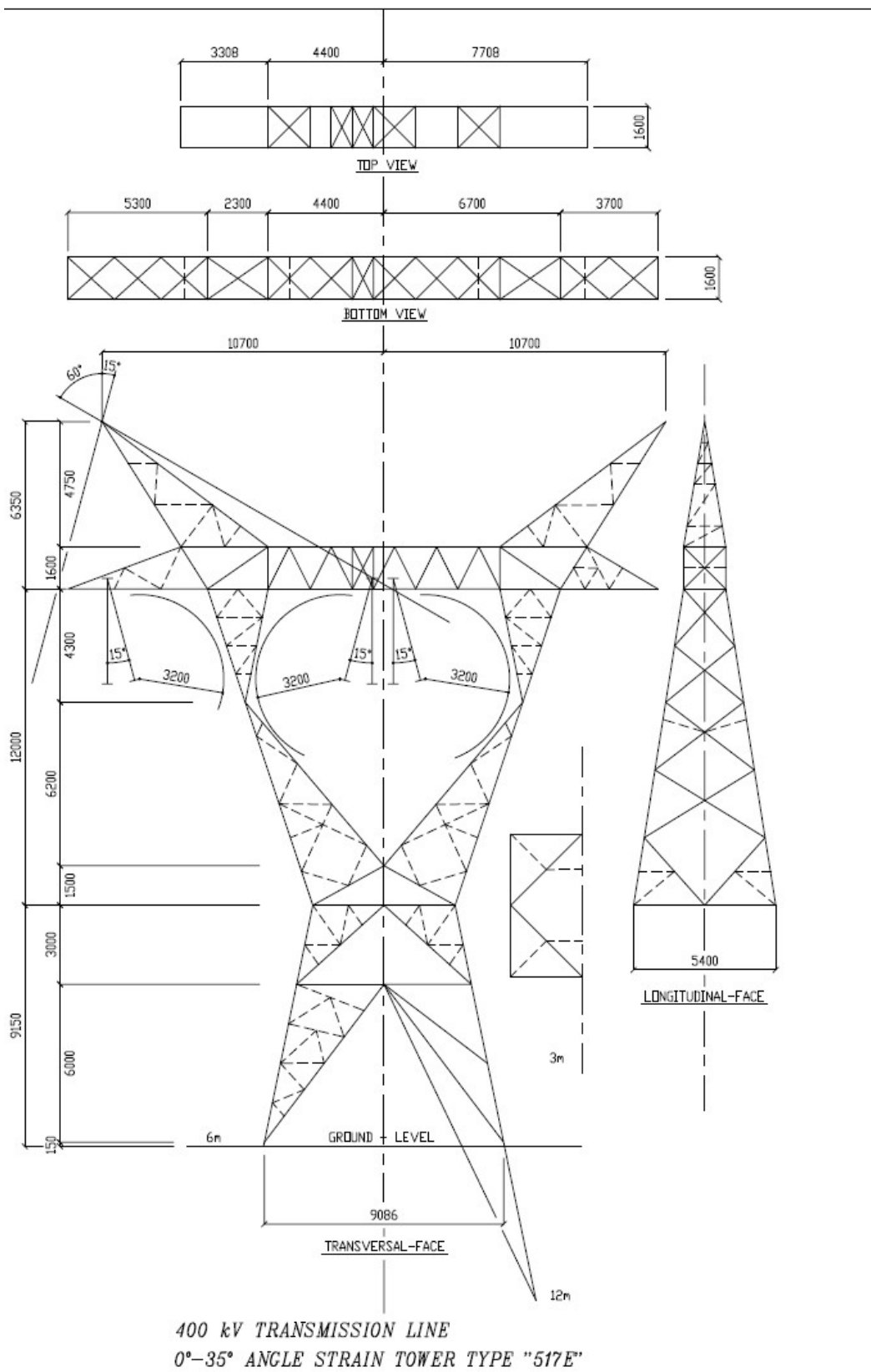


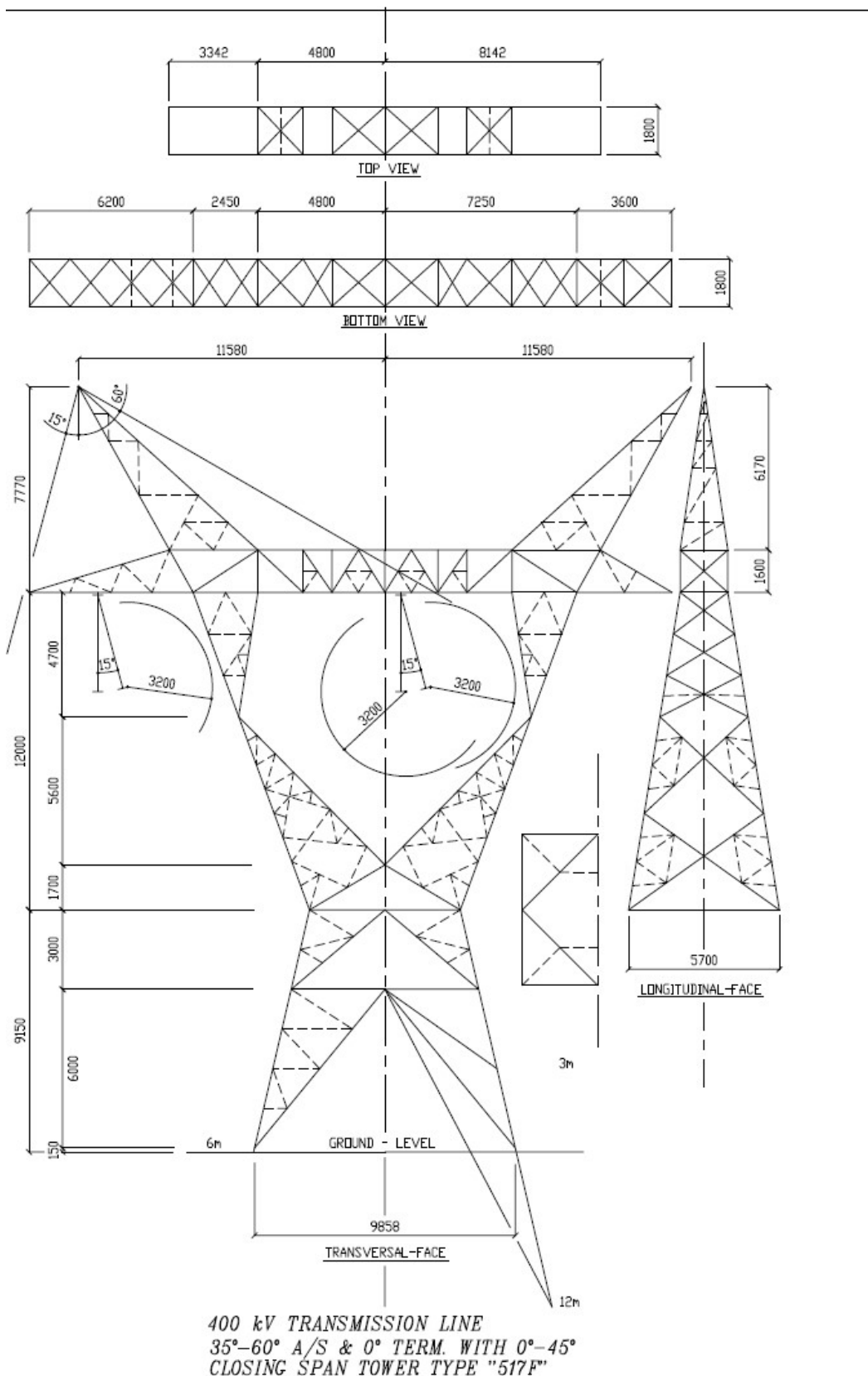






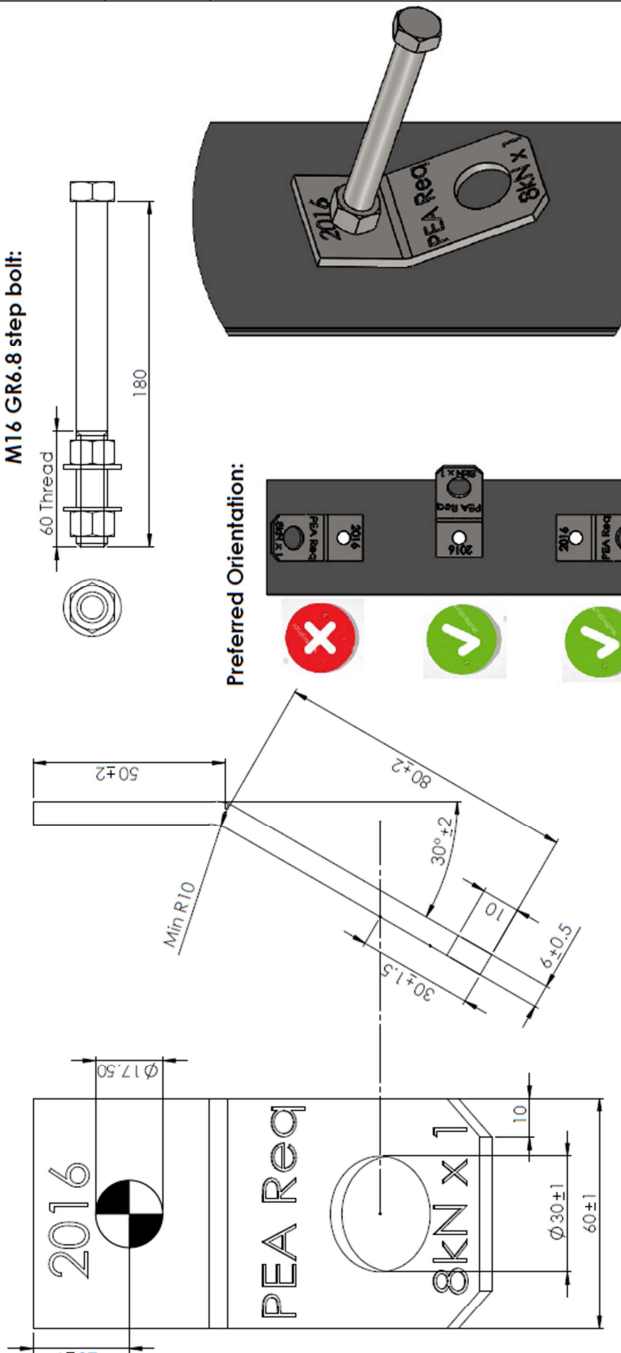






## Fall Arrest Anchor

REV NR.	CHANGES MADE	DATE	REVISED BY	




**M16 GR6.8 step bolt:**

60 Thread

180

**Preferred Orientation:**



**Mass of bolt: 0.4 kg**  
**Mass of plate: 0.3 kg**  
**Total mass: 0.7 kg**

**Note:** The item has been tested to SANS 50795 and ANSI Z359-6 (100kg dropped through 2.5m). The item has been designed for a single person using a PEA (Personal Energy Arrestor) to a load of 8kN and should be stamped accordingly as indicated on the drawing. It should be stamped with the year of manufacture.

It should be bolted to the structure with a WPS (Work Positioning System - "Step bolt") with two washers manufactured according to SANS 50358 equivalent to a SANS1700-5-1 GR6.8 bolt 180mm long, 60mm thread. The "Step bolt" is not intended for fall arrest.

The item should be manufactured from 60mm wide S355JR flat bar.

It is only meant as an Anchor device as defined in the SANS 50795 and ANSI Z359-6 specifications for attachment of a PEA as part of a fall arrest system and should not be used for any other purpose.

NAME	SIGNATURE	DATE	DESCRIPTION	REVISION

DRAWN	CHECKED	Eskom (Pty) Ltd.	SANS 50795 ANCHOR DEVICE	REVISION

**ESKOM - GROUP TECHNOLOGY**

**LES - LINE ENGINEERING SERVICES**

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**ESKOM**

**N.T.S.**

**Sheet 1 of 1**

## 9. APPENDIX C: HARDWARE ASSEMBLY DRAWINGS AND INFORMATION

### 9.1. HARDWARE ADDITIONAL INFORMATION

The standards within this section provide for the design and technical requirements of the line:

Table 9-1: Hardware Standards

<b>IEC 60120</b>	Dimensions of ball and socket couplings of string insulator units.
<b>IEC 61089</b>	Round wire concentric lay overhead electrical stranded conductors.
<b>IEC 61284</b>	Overhead lines – Requirements and tests for fittings.
<b>IEC 60372</b>	Locking devices for ball and socket couplings of string insulator units.
<b>IEC 60383</b>	Insulators for overhead lines with nominal voltage above 1000 V.
<b>IEC 60471</b>	Dimensions of clevis and tongue couplings of string insulator units.
<b>IEC 60826</b>	Loading and strength of overhead transmission lines.
<b>BS 2874</b>	Specification for wrought steel for mechanical and applied engineering purposes.
<b>ISO 14399</b>	ISO Metric screw threads.
<b>BS 4190</b>	Specification for ISO metric black hexagon bolts, screws and nuts.
<b>BS 7668</b>	Specification for weld able structural steels. Hot finished structural hollow sections in weather resistant steels.
<b>BS EN 10137</b>	Plates and wide flats made of high yield structural steels in quenched and tempered or precipitation hardened conditions.
<b>BS EN 10029</b>	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick or above.
<b>ISO 1461</b>	Specification for hot dip galvanized coatings on iron and steel articles.
<b>BS 970</b>	Specification for wrought steel for mechanical and applied engineering purposes.
<b>BS EN ISO 9001 9002</b>	Quality systems model of quality assurance in design, development, production, installation and servicing.
<b>BS EN 10025</b>	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
<b>BS EN 10163</b>	Specification for delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
<b>BS EN 10210</b>	Hot finished structural hollow sections of non-alloy and fine grain structural steels.
<b>BS EN 287-1</b>	Approval testing of welders for fusion welding. Part 1: Essential variables, range of approval examination and testing, acceptance requirements, re-tests, period of

	validity. Annexes on steel groups, welders' test certificates, procedure specification and job knowledge.
<b>BS EN 288-3</b>	Specification and approval of welding procedures for metallic materials Part 3: Welding procedure tests for the arc welding of steels.

## 9.2. HARDWARE SPECIFICATIONS

This line specification shall take precedence if there is any conflict between it and the following specifications:

**Table 9-2: Hardware Specifications**

<b>TST41-168</b>	Quality requirements for the procurement of quality related assets, goods and services.
<b>SANS 10280</b>	Code of practice for overhead power lines for conditions prevailing in South Africa.
<b>240-77125760</b>	Ceramic and Glass Cap and Pin Insulators
<b>240-77125772</b>	Specification for polymeric long rod insulators for Transmission voltages of 220kV and above
<b>TRMSCAAI3</b>	Spacer or spacer damper assemblies for conductor bundles for transmission lines.
<b>240-47172520</b>	Transmission line towers and line construction.
<b>240-60725647</b>	Phase conductor for transmission lines.
<b>240-60777474</b>	Specification for suspension and strain assemblies and for hardware for transmission lines.
<b>240-75883874</b>	Requirements and tests for Stockbridge type Aeolian vibration dampers.
<b>240-120804300</b>	Design, Manufacture and Installation specification for transmission line labels.
<b>240-147885960 and 240-156074235</b>	Transmission Bird Perch Diverter Standard and Installation Guidelines

**NOTE:** Wherever reference is made to supplier(s), vendor(s), etc., it shall mean *the Contractor*.

## 9.3. COMMON HARDWARE

The assembly for all towers must be tested with corona free fittings and with and without grading rings (if acceptable without grading rings – then remove grading in final assembly – this will allow extra gap for lightning faults). This is done at tender evaluation stage (hence for

project stage, the supplier does not need retest – the designer will confirm test certificates for the particular configuration is available). All hardware installed on the line will be such that the hardware can carry the fault current especially for the tools used during construction. Test certificates for all the components should be provided which indicate the ability of the hardware to carry such fault currents.

Grading ring, if needed, should be fitted in so that it does not compromise window clearances - (this again will give a larger gap for lightning faults). LES (Hardware Designer) to confirm and accept for each project.

Only preformed clamps are to be used for spacer dampers and no bolted fittings are to be used on the line.

### 9.3.1. Hardware Assemblies

Hardware assemblies should be assembled as per assembly drawings from the approved supplier. An example of each assembly type should be assembled in the site camp for inspection before use.

### 9.3.2. Spacer dampers for phase conductors

The table below shows the standardised spacing used for various diameters of phase conductor. It also shows the selected bundle spacing for this transmission line.

Table 9-3: Recommended bundle spacing for various conductor diameters

Conductor diameter (mm)	Required Spacing (mm)	Selected bundle spacing
18 – 24	380	
25 – 31	450	
31 - 36	570	

The selected conductor spacing should be maintained throughout the spans. Suitable spacer dampers should be installed as per the supplier's recommendations and corresponding spacing for the specified conductor.

If a twin bundle conductor is used stockbridge type dampers must also be utilised in addition to the spacer dampers.

The schedule for the spacing should include spans of 100 m to 1 500 m for the product offered. The phase conductor will be strung to a C-value of 1800 m,

Where:

$$C = H/W$$

H = Final horizontal tension (N)

W = Vertical weight of conductor (N/m)



### **9.3.3. Rigid Spacers for Jumpers**

The jumper spacing should be kept uniform throughout the jumper according to the table above. Suitable rigid spacers should be offered to maintain the sub-jumper spacing for the specified conductor.

A minimum of 4 rigid spacers should be used in the jumper bundle.

### **9.3.4. Vibration Dampers for Earth Wires and OPGW**

Only Stockbridge type vibration dampers will be acceptable. Vibration dampers should be installed as per the supplier's recommendations for spans of 100 m to 1 500 m for the product offered. The earth wires and OPGW will be strung to a C-value of 2 100 m.

### **9.3.5. Anti-Bird Perch Devices**

Strain towers must be fitted with the approved Eskom anti-bird perch devices as per Eskom's specification- 240-16259196 (Transmission Bird Perch Guidelines).

### **9.3.6. Bird Diverters**

The construction and design of the Bird Flight Diverter must be such that:

- There are no moving parts and the attachment to the Ground wire/OPGW shall be rigid.
- It is highly visible. Colours required are solid black and solid white
- The attachment to the ground wire/OPGW is a preformed type, and rigid with no movement between the clamp and the ground wire
- The attachment device facilitates quick, easy installation and removal of the Bird Flight Diverter.
- The attachment device will cause no damage or stress concentration to the ground wire or OPGW

All other suggested attachment methods offered, will be subject to Eskom's approval.

#### **Installation of Bird Flight Diverters on Earth Wires / O.P.G.W,**

The Bird Flight Diverters should be installed on both the earth wires / O.P.G.W, in the case of a line having two earth wires, in a staggered alternating configuration as indicated in the figure below.



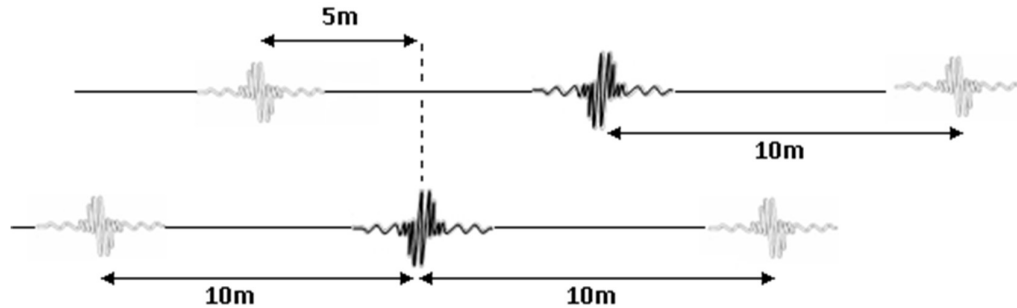


Figure 9-1: Typical Installation of a Bird Flight Diverter

### 9.3.7. Conductor Warning Lights

The unit should comprise of a fluorescent tube (4 ft. long), wire pigtails at the ends of the fluorescent tube, an extruded plastic shield, as well as suitable clamps for attachment to the conductor. The fluorescent tube is designed to be encased in the plastic shield while still allowing the pigtail wires to protrude at either end; the plastic shield provides protection for the tube. These pigtails are then wrapped around the conductor, to make the connection. The arrangement is to be alternated every 25 m in such a manner that there is 50 m between subsequent units on any phase conductor. LES must be contacted before this is implemented.

### 9.3.8. Aerial Warning Spheres

All Aerial Warning Spheres shall be manufactured from UV stabilized material such as, low density polyethylene (LLPDE), or aluminium of uniform thickness not less than 1.6 mm. Any other material shall be subject to approval by Eskom.

The Aerial Warning Sphere must be spherical in shape, with a minimum diameter of 600 mm. No deviation to this will be accepted. The colour of these spheres must be solid white, solid red or solid orange. The colour of the sphere must be visible from a distance and should not fade with time. Aluminium type spheres shall be powder coated on all external surfaces.

The Aerial Warning Sphere may consist of two halves (hemispheres), provided that a lip or similar feature will be incorporated in the design of the top hemisphere, to reduce water ingress and to facilitate the assembling of the two hemispheres. Stainless steel screws or bolts and nuts shall be used.

Adequate water drainage holes of at least 10 mm diameter shall be located on the bottom end of the Aerial Warning Sphere. The device for attaching the Aerial Warning Sphere to the earth wire shall be located at the top of the sphere or in such a way that the earth wire passes through the centre of the Aerial Warning Sphere.

The design of the attachment device shall facilitate quick and easy installation and removal of the Aerial Warning Sphere. The attachment shall be such that, in case of aluminium spheres electrical contact shall exist between sphere and ground wire. The design of the device shall prevent the Aerial Warning Sphere from sliding along the earth wire after installation. Design of the attachment clamp of the Aerial Warning Sphere, shall be as such that it will cause no

damage or stress concentration to the earth wire. If necessary to install on O.P.G.W conductor, the use of suitable armor rods will be required.

#### Installation of Aerial Warning Spheres on Ground Wires

For the installation of Aerial Warning Spheres, it is recommended to use the following procedure:

- Install the Aerial Warning Spheres on a single ground wire, but alternate the colours (white and red or orange)
- The Aerial Warning Spheres have to be installed on the highest wire of the affected line spans, typically on the ground wires
- They are to be located 30 m from the tower, and 30 m from each other along the span. White and Red/Orange Aerial Warning Spheres should alternate along the span, as shown in the figure below. This method will guarantee that the pilot sees the alternating affect from any approach angle.
- If bird flight diverters are required on the same span, they will be installed as usual with the ones clashing with the position of the Aerial warning spheres omitted.

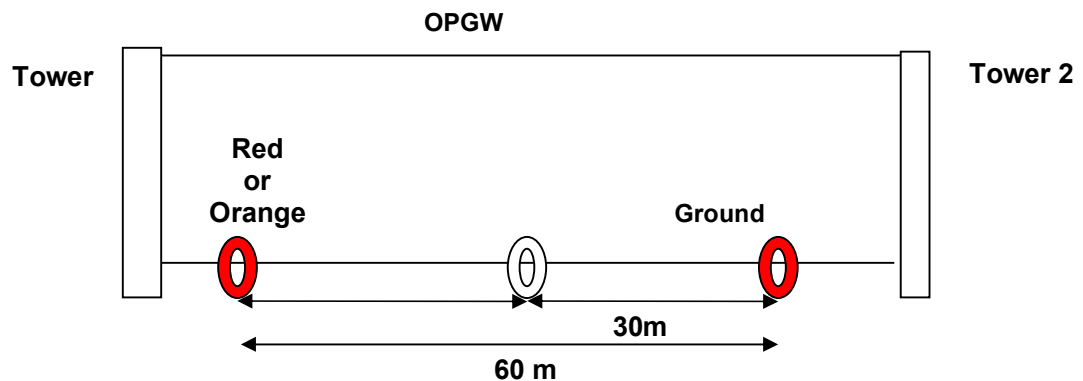


Figure 9-2: Typical Installation of an Aerial Warning Sphere

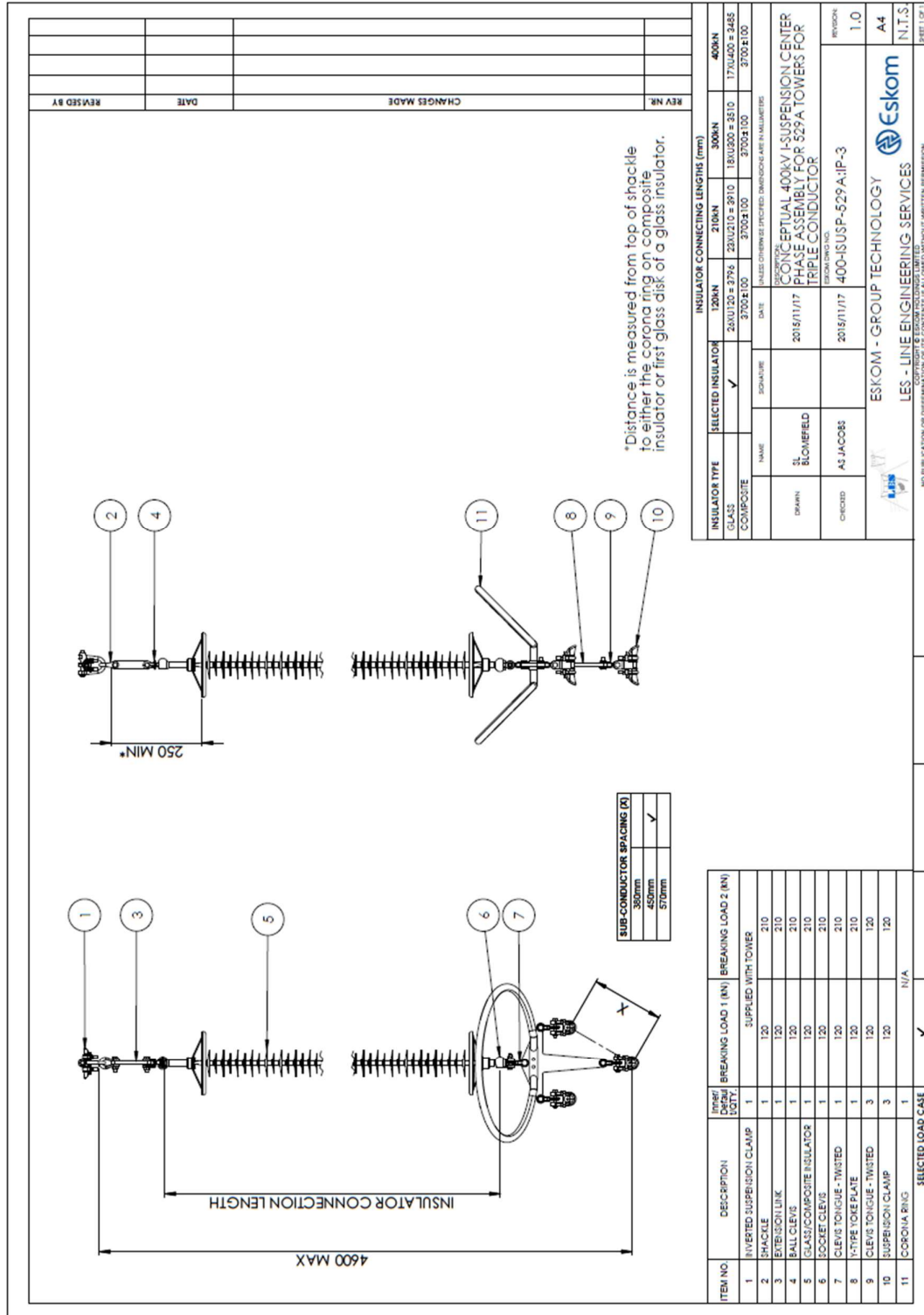
#### 9.3.9. Transport and Packaging

All hardware components should be packed in suitable crates which are rigid enough to withstand loading and shipping conditions. If timber is used as packing material, it should be treated with suitable preservatives that will not lead to timber rot during shipping and storage of material for a period of up to one year. The crates should be clearly marked with the contents indicating which hardware components are inside. The design of the crates should be such that standard off-loading equipment like fork-lifts and cranes can readily off-load the material without damaging the crates.

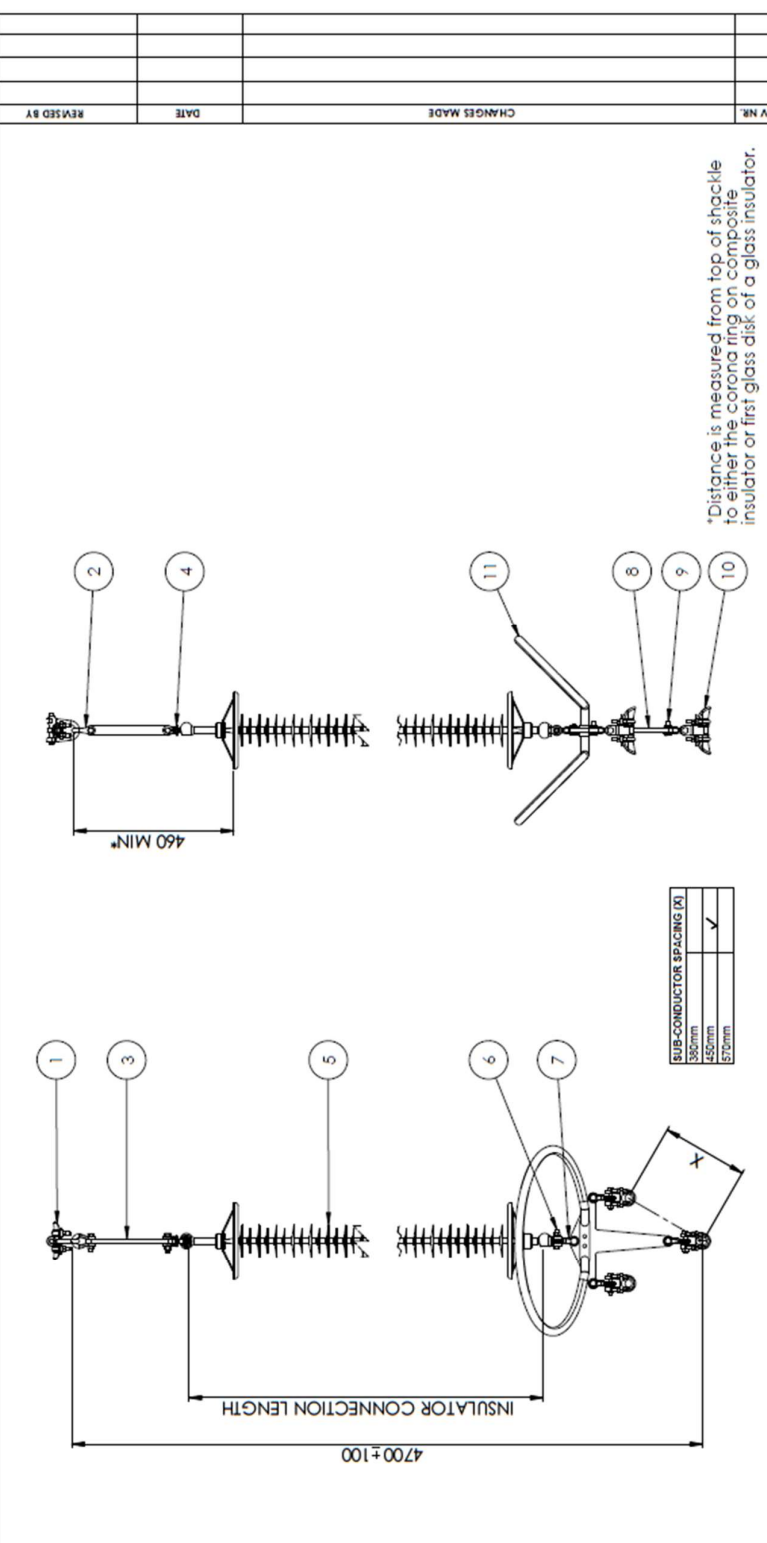


## 9.4. HARDWARE ASSEMBLY DRAWINGS

### 529A I-Suspension Assembly – Centre Phase (Tern conductor)



## 529A I-Suspension Assembly – Outer Phase (Tern conductor)

REV NR	CHANGES MADE	DATE	REVISED BY	
 <p style="text-align: center;">*Distance is measured from top of shackle to either the corona ring on composite insulator or first glass disk of a glass insulator.</p>				

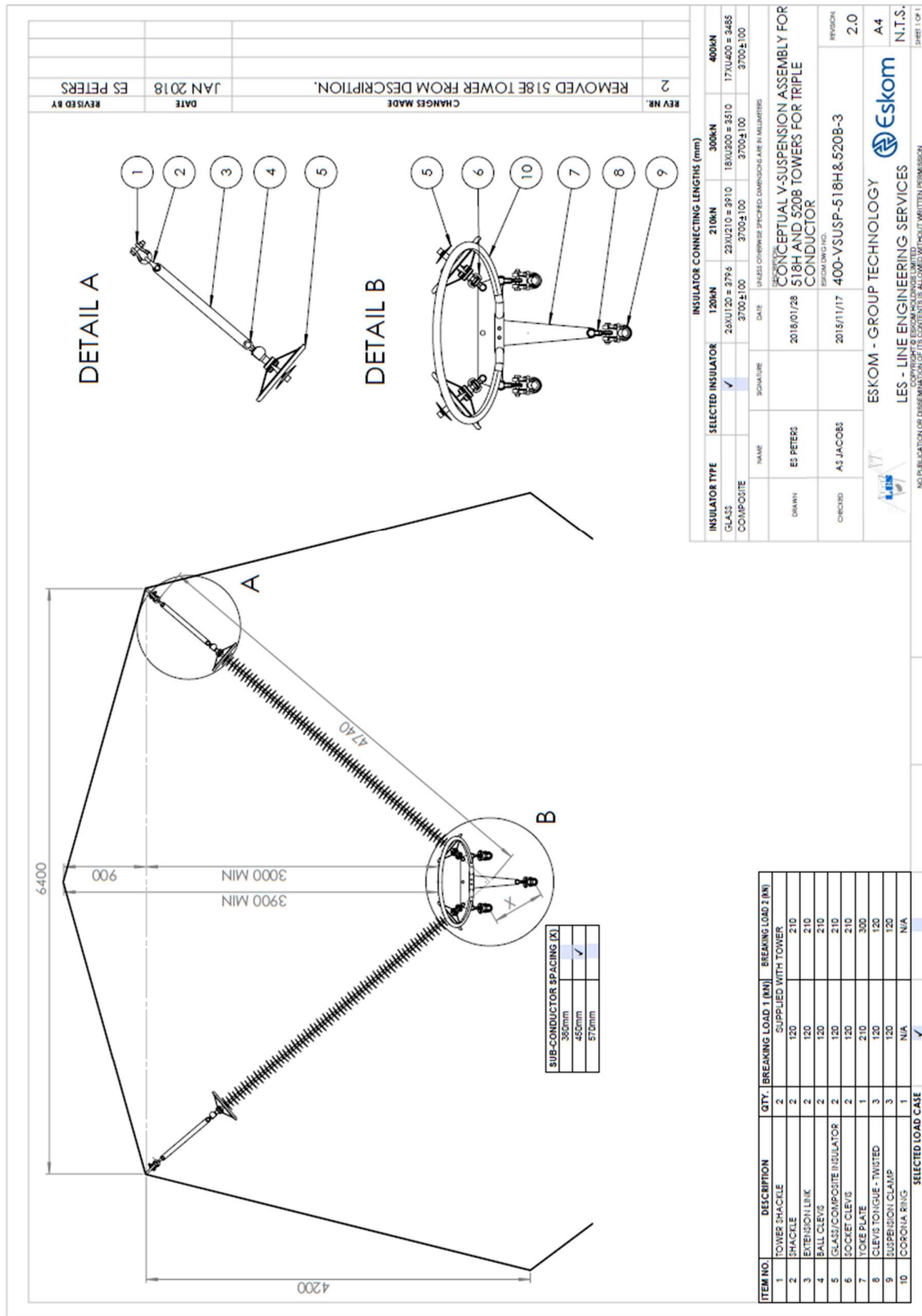
INSULATOR TYPE		SELECTED INSULATOR		INSULATOR CONNECTING LENGTHS (mm)			
GLASS	COMPOSITE	✓		1200N	2100N	3000N	4000N
				2600/120 = 375	2200/210 = 3910	1800/300 = 3485	1700/400 = 3485
				3700 ± 100	3700 ± 100	3700 ± 100	3700 ± 100
				DATE: 2018/11/17			
				SIGNATURE: AS JACOBS			
				NAME: EL BLUMENFELD			
				DRAWN: 2018/11/17			
				CHECKED: 2018/11/17			
				400-HSUSP-529A.C:OP-3			
				CONCEPTUAL 400kV I-SUSPENSION OUTER PHASE ASSEMBLY FOR 529A AND C TOWERS TRIPLE CONDUCTOR			
				REVISION: 1.0			
				A4			
				N.T.S.			
				Eskom			
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ITEM NO.	DESCRIPTION	QTY	BREAKING LOAD 1 (kN)	BREAKING LOAD 2 (kN)	BREAKING LOAD 3 (kN)
1	INVERTED SUSPENSION CLAMP	1	120	210	210
2	SHACKLE	1	120	210	210
3	EXTENSION LINK	1	120	210	210
4	BALL CLEVIS	1	120	210	210
5	GLASS/COMPOSITE INSULATOR	1	120	210	210
6	SOCKET CLEVIS	1	120	210	210
7	CLEVIS TONGUE - TWISTED	1	120	210	210
8	N-TYPE YOKE PLATE	1	120	210	210
9	CLEVIS TONGUE - TWISTED	3	120	210	210
10	SUSPENSION CLAMP	3	120	210	210
11	CORONA RING	1	N/A	N/A	N/A

SELECTED LOAD CASE	✓
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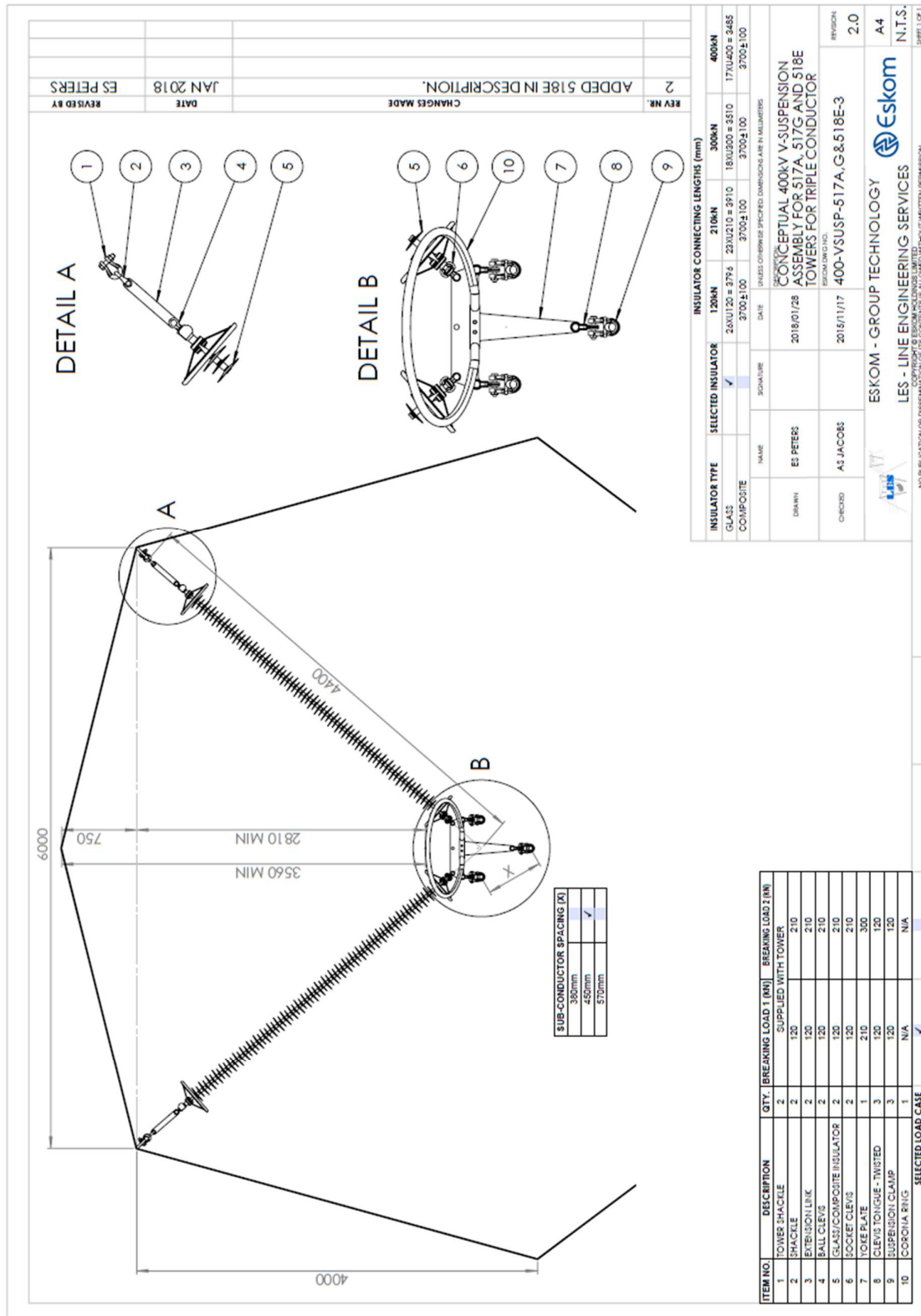
## 518H & 520B V-Suspension Assembly (Tern conductor)



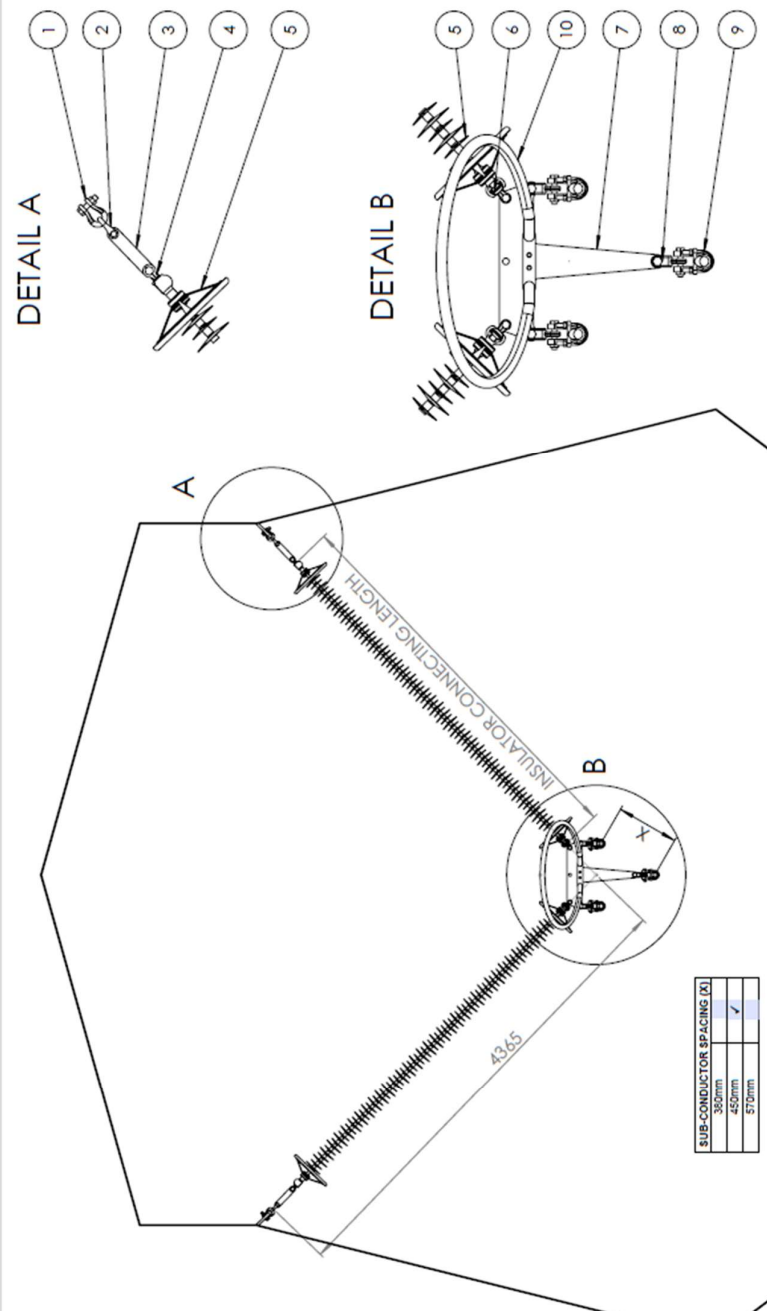




## 518E V-Suspension Assembly (Tern conductor)



## 518J – V-Suspension Assembly Centre Phase (Tern conductor)



INSULATOR CONNECTING LENGTHS (mm)	
INSULATOR TYPE	SELECTED INSULATOR
GLASS	✓
COMPOSITE	

ITEM NO.	DESCRIPTION	QTY.	BREAKING LOAD 1 (kN)	BREAKING LOAD 2 (kN)
1	TOWER SHACKLE	2	120	210
2	SHACKLE	2	120	210
3	EXTENSION LINK	2	120	210
4	BALL CLEVIS	2	120	210
5	GLASS/COMPOSITE INSULATOR	2	120	210
6	SOCKET CLEVIS	2	120	210
7	YOKER PLATE	1	120	210
8	TWISTED CLEVIS TONGUE	3	120	120
9	SUSPENSION CLAMP	3	120	120
10	CORONA RING	1	N/A	N/A

SUB-CONDUCTOR SPACING (A)	
380mm	✓
450mm	
570mm	

DETAIL A

DETAIL B

REV. NR.	CHANGES MADE	DATE	REVISOR BY

INSULATOR TYPE		SELECTED INSULATOR		INSULATOR TYPE		SELECTED INSULATOR	
GLASS	✓	GLASS	✓	GLASS	✓	GLASS	✓
COMPOSITE		COMPOSITE		COMPOSITE		COMPOSITE	

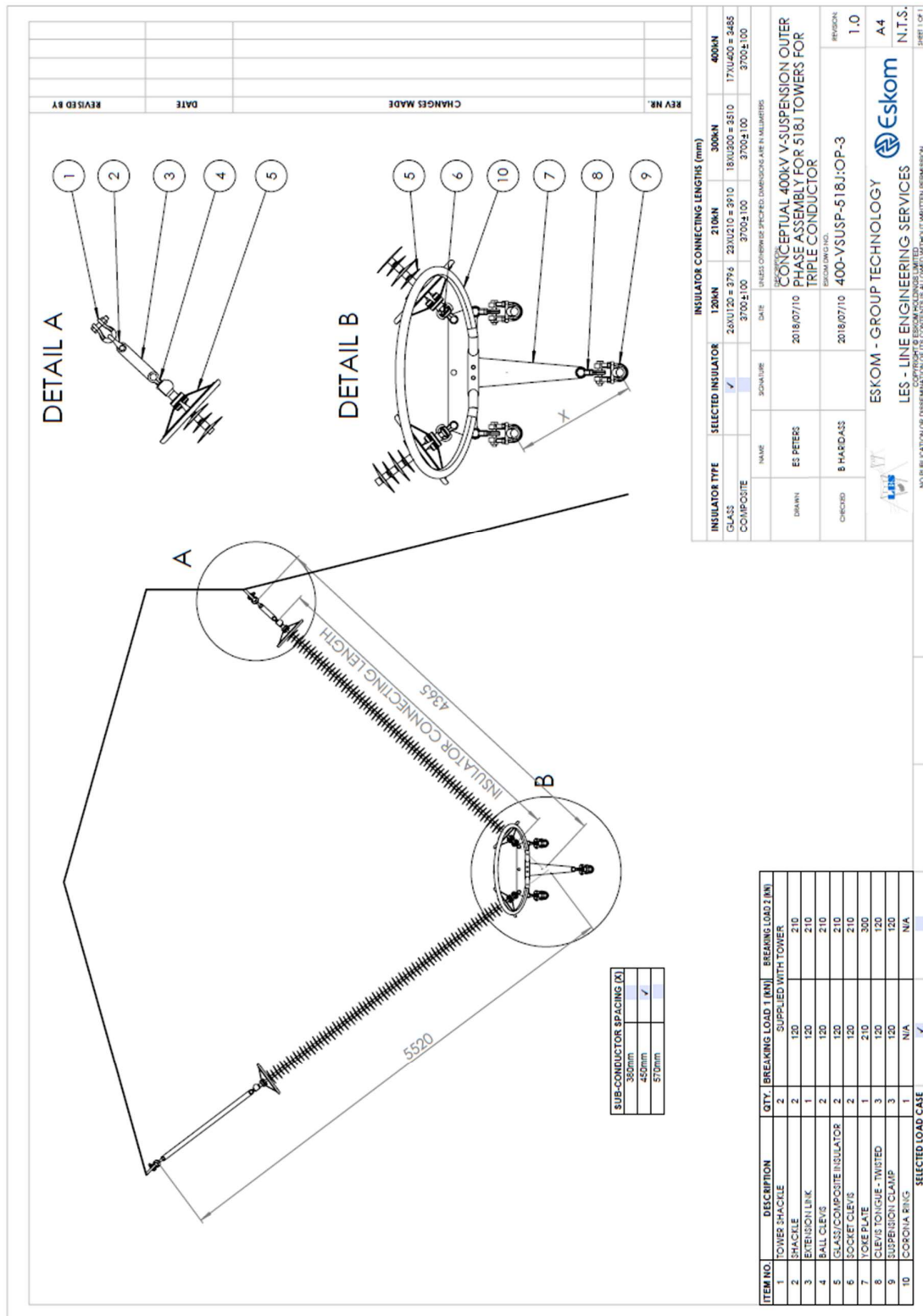
  

NAME	SIGNATURE	DATE	DESIGN (mm)
ES PETERS		2018/07/10	400-VSUSP-518J-CP-3
B HADJAS		2018/07/10	400-VSUSP-518J-CP-3

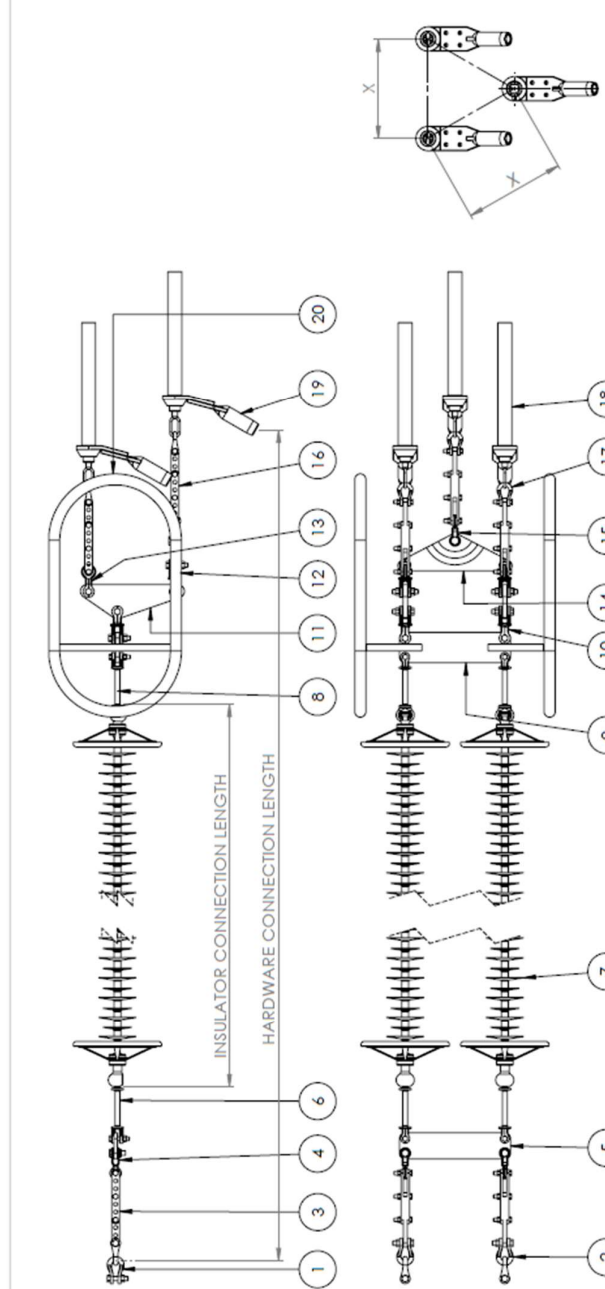
REVISION	NO.	DESCRIPTION
1.0	A4	N.T.S.

## 518J – V-Suspension Assembly Outer Phase (Tern conductor)



## Double Attachment Strain Assembly (518C, D) (Tern conductor)

REV NR.	CHANGES MADE	DATE	REVISED BY
2	UPDATED BREAKING LOADS		

INSULATOR TYPE	SELECTED INSULATOR	INSULATOR CONNECTING LENGTHS (mm)
GL432	✓	1200N 26XU120 = 3796 22XU210 = 3510 3000N 18XU300 = 3510 4000N 17XU400 = 3485
COMPOSITE		3700±100 3700±100 3700±100 3700±100

PAUSES OR OTHERS SPECIFIED DIMENSIONS ARE IN MILLIMETERS

CONCEPTUAL 400KV STRAIN ASSEMBLY WITH DOUBLE ATTACHMENT FOR TRIPLE CONDUCTOR

PERSONAL NO. 2017/07/05

CHECKED AS JACOBS 2017/07/05

REGION 2.0

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SHEET 1 OF 1

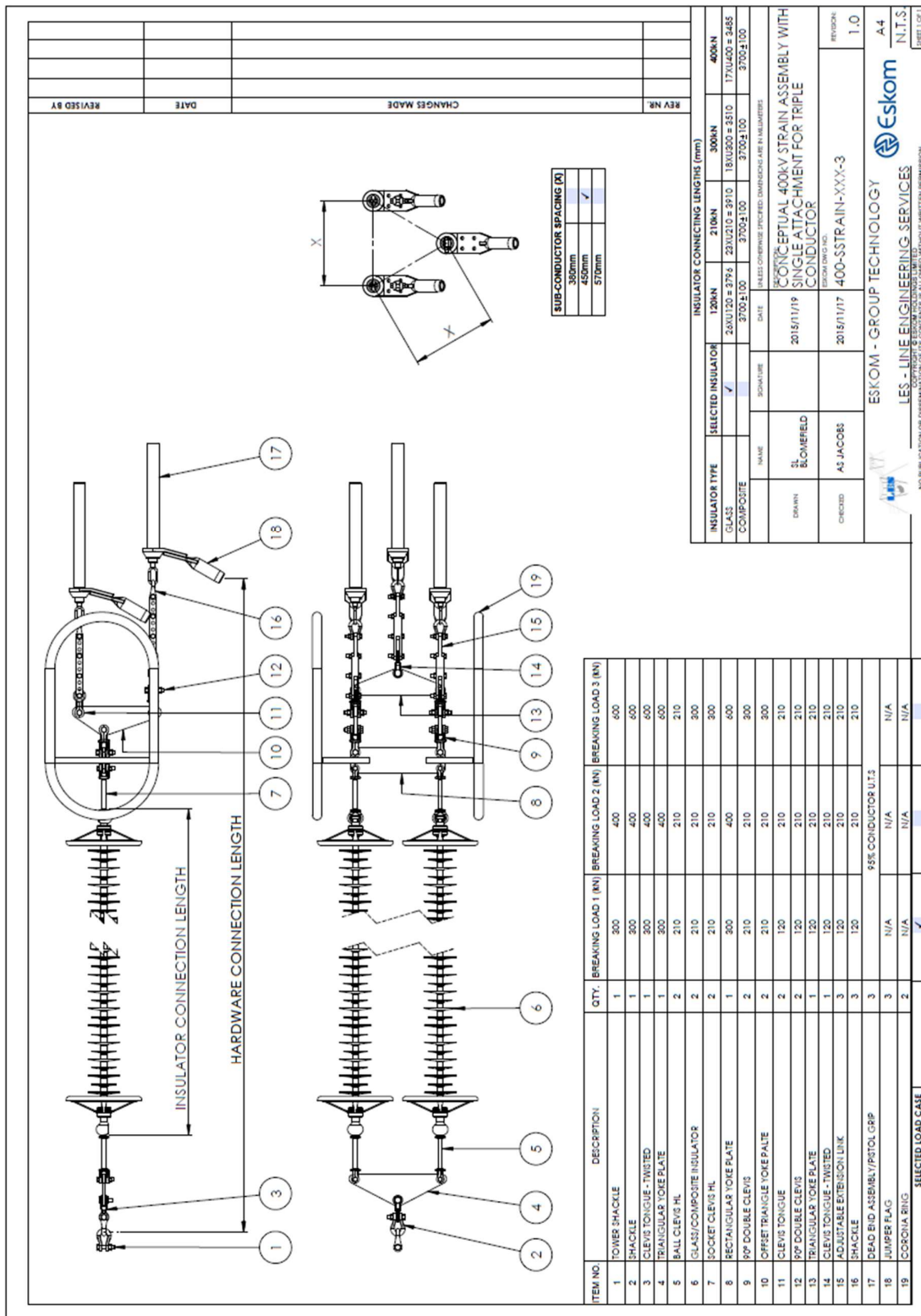
  

ITEM NO.	DESCRIPTION	QTY.	BREAKING LOAD 1 (kN)	BREAKING LOAD 2 (kN)	BREAKING LOAD 3 (kN)
1	TOWER SHACKLE	2	300	300	300
2	SHACKLE	2	300	300	300
3	ADJUSTABLE EXTENSION LINK	2	300	300	300
4	CLEVIS TONGUE - TWISTED	2	300	300	300
5	RECTANGULAR YOKE PLATE	1	300	400	600
6	BALL CLEVIS PL	2	210	210	300
7	GLASS/COMPOSITE INSULATOR	2	210	210	300
8	ROCKET CLEVIS PL	2	210	210	300
9	RECTANGULAR YOKE PLATE	1	300	400	600
10	90° DOUBLE CLEVIS	2	210	210	300
11	OFFSET TRIANGLE YOKE PLATE	2	210	210	300
12	90° DOUBLE CLEVIS	2	120	120	210
13	CLEVIS TONGUE	2	120	210	210
14	TRIANGULAR YOKE PLATE	1	120	120	210
15	CLEVIS TONGUE - TWISTED	1	120	210	210
16	ADJUSTABLE EXTENSION LINK	3	120	210	210
17	SHACKLE	3	120	210	210
18	DEAD END ASSEMBLY / PISTOL GRIP	3	N/A	N/A	N/A
19	JUMPER FLAG	3	N/A	N/A	N/A
20	CORONA RING	2	N/A	N/A	N/A

SELECTED LOAD CASE



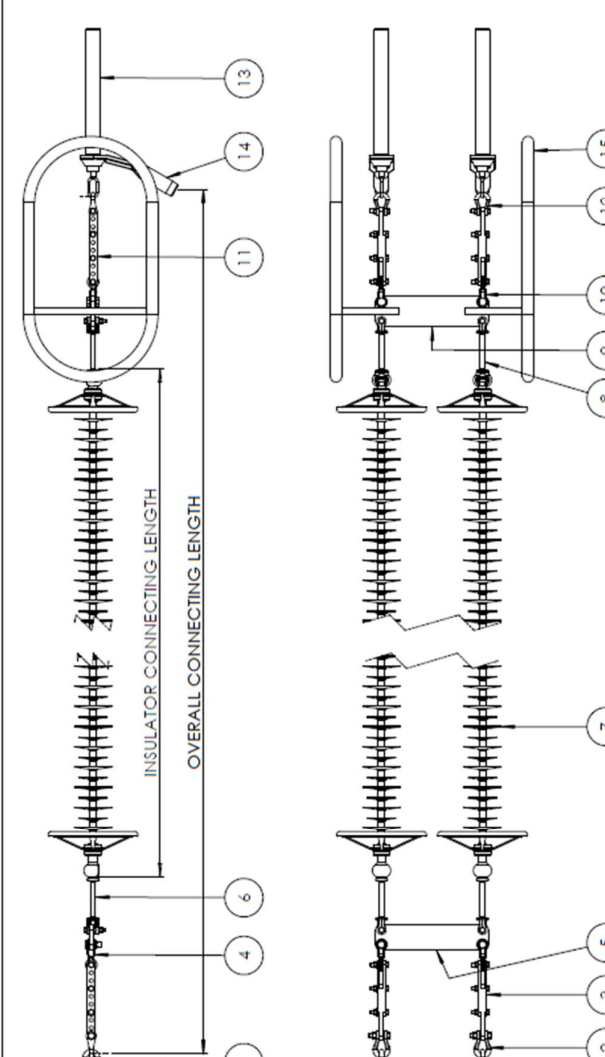
### 517E, F and gantry Strain Assembly (Tern conductor)





## 518DR Strain Assembly (Bull conductor)

REV. NR.	CHANGES MADE			DATE	REVISED BY		



INSULATOR CONNECTING LENGTHS (mm)			
INSULATOR TYPE	SELECTED INSULATOR	120kV	210kV
GLASS	<input checked="" type="checkbox"/>	26xU120 = 2794	23xU210 = 3910
COMPOSITE	<input type="checkbox"/>	3700 ± 100	3700 ± 100

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS

CONCEPTUAL 400kV STRAIN ASSEMBLY WITH DOUBLE ATTACHMENT FOR TWIN CONDUCTOR

DATE: 2015/12/01

CHECKED: AS JACOBS

DESIGNED: 2015/12/01

400-DSTRAIN-XXX-2

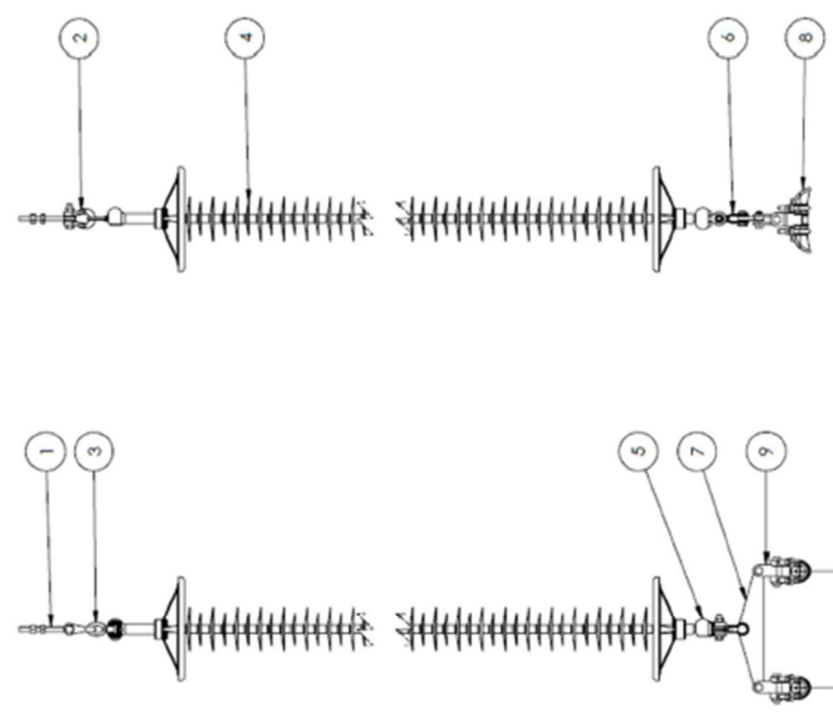
REVISION: 1.0

A4

N.T.S.

ITEM NO.	DESCRIPTION	QTY.	BREAKING LOAD 1 (kN)	BREAKING LOAD 2 (kN)	BREAKING LOAD 3 (kN)
1	TOWER SHACKLE	2	300	300	300
2	SHACKLE	2	300	300	300
3	ADJUSTABLE EXTENSION LINK	2	300	300	300
4	CLEVIS TONGUE - TWISTED	2	300	300	300
5	RECTANGULAR YOKER PLATE	1	210	210	210
6	BALL CLEVIS HL	2	120	210	210
7	GLASS/COMPOSITE INSULATOR	2	120	210	210
8	SOCKET CLEVIS HL	2	120	210	210
9	RECTANGULAR YOKER PLATE	1	210	300	400
10	CLEVIS TONGUE - TWISTED	2	120	210	210
11	ADJUSTABLE EXTENSION LINK	2	120	210	210
12	SHACKLE	2	120	210	210
13	DEAD END ASSEMBLY / RIGID GRIP	2	85% CONDUCTOR U.T.S	210	210
14	JUMPER FLAG	2	N/A	N/A	N/A
15	CORONA RING	2	N/A	N/A	N/A

REVISED BY	DATE	CHANGES MADE	REV. NOL.	



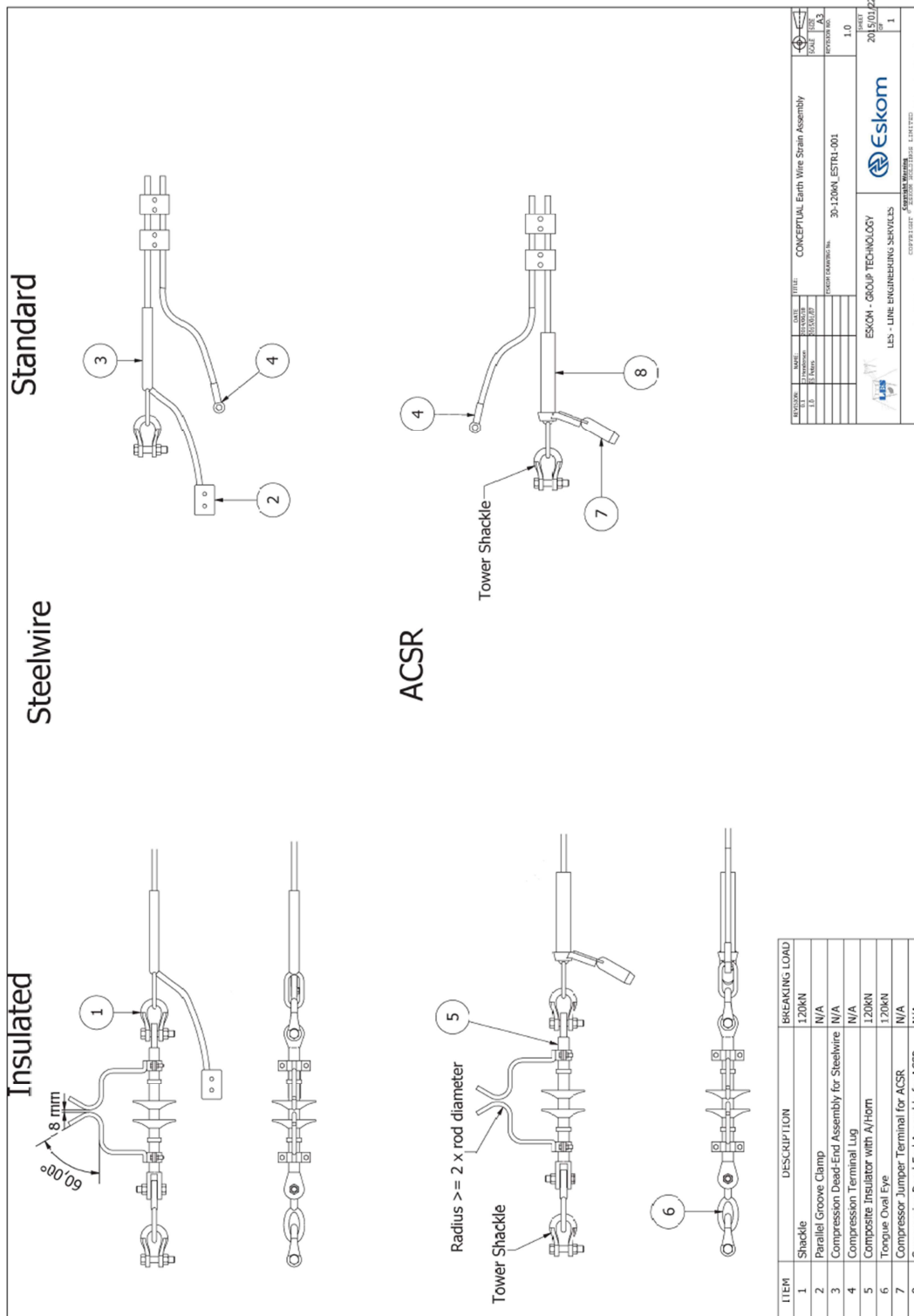
ITEM NO.	DESCRIPTION	QTY.	BREAKING LOAD 2 (kN)
1	TOTIGUE SOLT	1	210
2	SHACKLE	1	210
3	BALL OVAL EYE	1	210
4	COMPOSITE INSULATOR	1	210
5	SHACKLE	1	210
6	SHACKLE	1	210
7	SHACKLE	1	210
8	SHACKLE	1	210
9	SHACKLE	2	120

NAME	DATE	SIGNATURE	REVISION	<div style="display: flex; justify-content: space-between;"> <div> <p>UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS</p> <p>DESCRIPTION: CONCEPTUAL 400V JOCKEY INSULATOR ASSEMBLY FOR TWIN CONDUCTOR</p> <p>PROJECT Dwg. NO: 400-JOCKEY-XXX-2</p> </div> <div> <p>ESKOM - GROUP TECHNOLOGY</p> <p>LES - LINE ENGINEERING SERVICES</p> </div> </div>
SKETCH	2017/02/02		1.0	<div style="display: flex; justify-content: space-between;"> <div> <p>ESKOM</p> <p>LES - LINE ENGINEERING SERVICES</p> </div> <div> <p>NO PUBLICATION OR DISTRIBUTION OF THIS DOCUMENT IS ALLOWED WITHOUT WRITTEN PERMISSION</p> </div> </div>
CHECKED	2017/02/06			<div style="display: flex; justify-content: space-between;"> <div> <p>ESKOM</p> <p>LES - LINE ENGINEERING SERVICES</p> </div> <div> <p>NO PUBLICATION OR DISTRIBUTION OF THIS DOCUMENT IS ALLOWED WITHOUT WRITTEN PERMISSION</p> </div> </div>



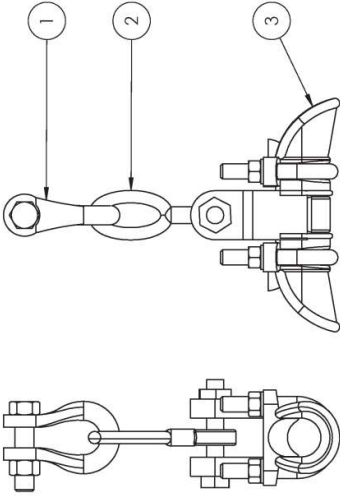
## EARTH WIRE ASSEMBLIES

Earth Wire Strain Assemblies:

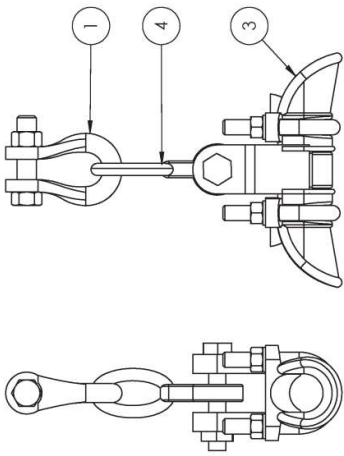


**Earth Wire Suspension Assemblies – Non-Insulated**

OPTION 1 ☒




OPTION 2 ☐



ITEM NO.	DESCRIPTION	OPTION 1 QTY.	OPTION 2 QTY.	BREAKING LOAD (kN)
1	TOWER SHACKLE	1	1	SUPPLIED WITH TOWER
2	TONGUE OVAL EYE	1	-	120
3	SUSPENSION CLAMP	1	1	120
4	TONGUE OVAL EYE - TWISTED	-	1	120

NAME	SIGNATURE	DATE	UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS
ES PETERS		2016/07/06	DESCRIPTION: <b>CONCEPTUAL NON-INSULATED EARTH WIRE            SUSPENSION ASSEMBLY</b>  ESKOM DWG NO.: <b>EW-SUSP-NON</b>
AS JACOBS		2016/07/06	

REV	NR.	CHANGES MADE	DATE	REVISED BY



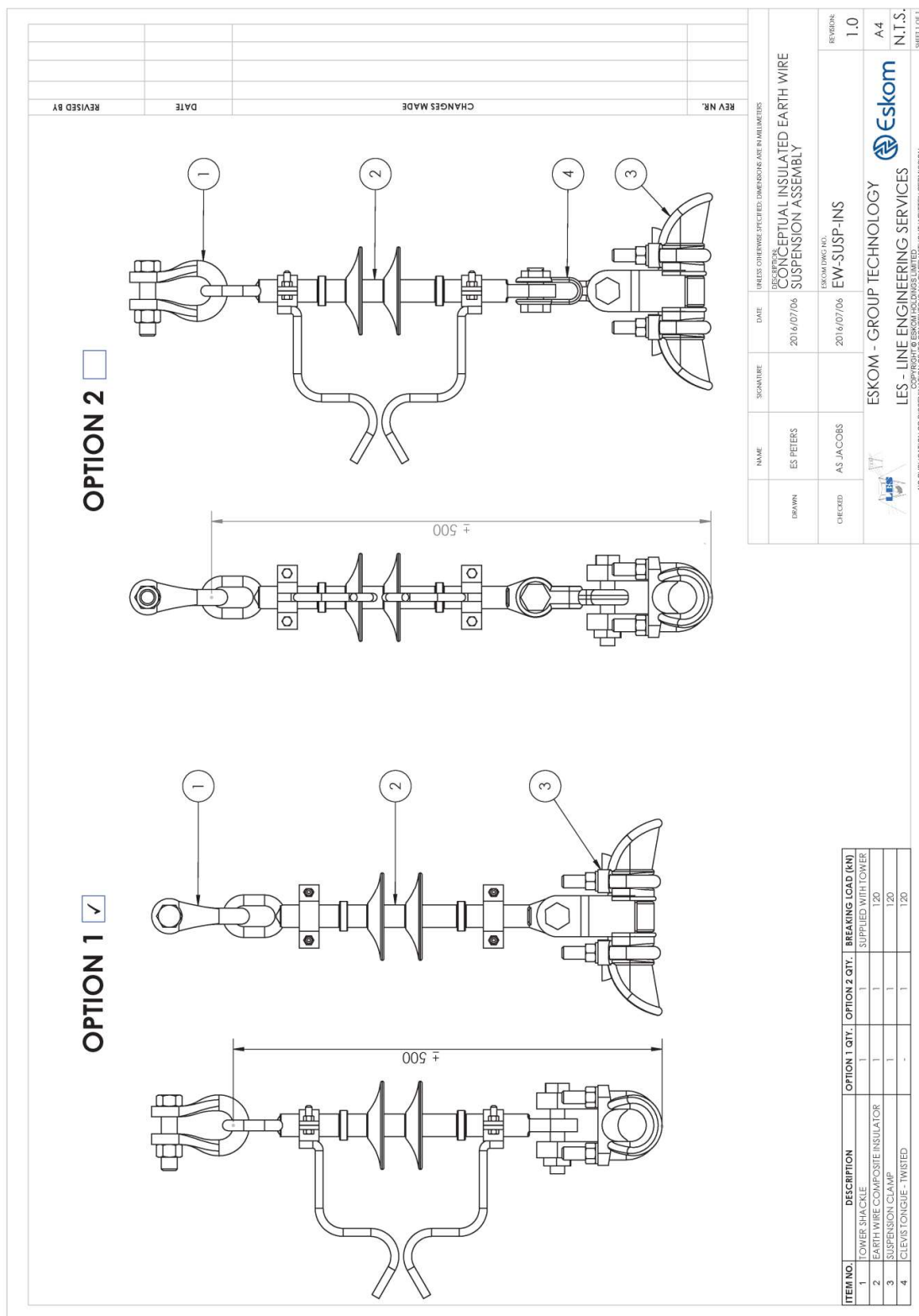
ESKOM - GROUP TECHNOLOGY  
LES - LINE ENGINEERING SERVICES

REVISIONS:  
1.0  
A4  
N.T.S.

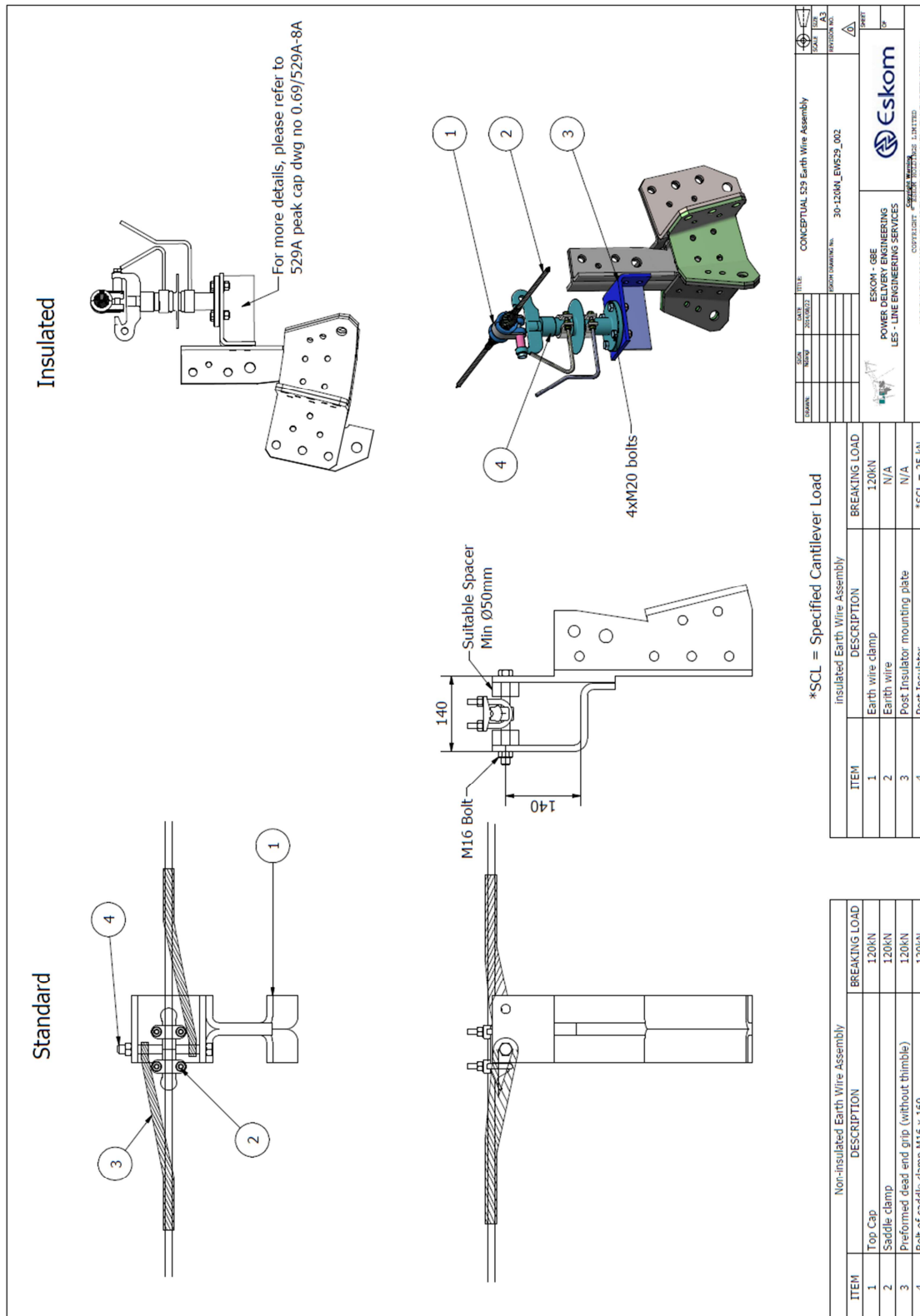
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SHEET 1 OF 1

**Earth Wire Suspension Assemblies – Insulated**



Earth Wire Cross Rope Assembly



## 10. APPENDIX D: STRUCTURES ADDITIONAL INFORMATION

Eskom owns copyright on the designs of all these towers and full fabrication drawings of the structures will be supplied to the successful tenderer.

All towers are to be fabricated using S355JR steel, in accordance with recent industry changes. Thus all references to the use of 300WA or lower grade of steel shall be taken to read S355JR. (The towers were designed for either grade 300WA or 350WA for the main members). Where 300WA steel was originally specified - this requirement is however – subject to the availability of S355JR steel. The contractor shall confirm availability and notify the project manager regarding the steel grade to be used. If the tower consists of mixed grades of steel then the higher grade steels must be marked with “H” as a suffix after the member label. If a tenderer wishes to propose the use of other grades of steel, the towers may need to be redesigned and re-tested.

A prototype of each type of tower with all body and leg extensions shall be assembled at the manufacturing premises for inspection by the Design Engineer prior to start full fabrication. The contractor shall do pilot installation on site of all types of towers according to reviewed safe work procedures and in presence of the Design Engineer.

For the alternative designs, the tenderers are free to design their own towers, to suit the steel grade and section sizes available to them, based on the outline drawings, attachment heights and clearance dimensions provided and in accordance with the required loading schedules. All steel shall be in accordance with BS EN 10025 or BS EN 10210 and the quality of finished steel to BS EN 10163. Bolts for lattice structures shall be metric to SABS 136-1991 grade 6.8 with thread length 1,5 $\phi$  as per SABS 135-1991.

On the lattice structures anti climb devices shall be of the spike or palisade type.

Mechanical properties of grade S355JR steel for flat bars and sections are to be used where:

- J refers to the Charpy impact test withstand value of 27J and
- R refers to the test temperature (20 deg Celsius temperature)

### 10.1. TEMPERATURE

The maximum wind loads will be applied at an ambient temperature of 15 °C. Conductor loads will be checked at maximum and minimum temperatures. A maximum templating temperature of 60 °C will be used. A minimum temperature of -5 °C should be considered.

### 10.2. CONDUCTOR, GROUNDWIRE TENSIONS

Sag-tension tables will be compiled for a range of spans, considering the erection conditions and the tower capacities. Final tension will be governed by vibration limits. **Equation 1** below relates catenary, C, to horizontal tension, H, and weight, W.



$$C = \frac{H}{W} [m] \quad (1)$$

Where:

H = final horizontal tension (N); and

W = vertical unit weight of conductor (N/m).

For the conductor, the final tension at 15 °C will be governed by a C-value of 1800 m; for the earth wire, the final tensions at 15 °C will be governed by C-values of 2100 m unless reduced by the table presented in the profiling section above.

**Table 10-1: Sag Tension Limits**

CASE	PHASE CONDUCTOR	EARTH WIRE
Final C –value at 15 °C	1800	2100
Maximum conductor temperature	60 °C	40 °C
Minimum conductor temperature	-5 °C	-5 °C
Final condition at 15 °C and wind pressure at 1050 Pa	70% UTS	70% UTS

### 10.3. GUY WIRES

All guy wires shall conform to Eskom specification NWS 1074 – Guy strand grips for transmission lines.

As part of the towers the steel guy strands (single strands), end fittings, shackles, etc. shall be included for the installation of the suspension towers. Guys for the Cross-rope suspension towers shall be pre-cut and compression end fittings shall be installed prior to testing and shipping the guys to site.

For the cross rope towers three of the guys of each tower shall have no adjustment whatsoever. Only one of the four guys shall have tension adjustment, at the bottom connection only. The adjustable end on the fourth guy shall be simple. It is suggested that a U-bolt be connected to the end of the anchor rod, and that a steel plate be installed on the U-bolt for guy-length regulation.

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.

Further to 240-47172520, adjustment of 350 mm for the guy length shall be provided on all guys at the bottom end only for Guyed “V” towers and not for cross-rope towers.

The tolerance for the complete length of the guys (calculated distance between centres of top and bottom attachment points) shall be  $\pm 20$  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.

The bidders shall propose convenient attachment configurations between guys and tower, and guys and anchor rods.

**All ropes with compression end fittings shall be tested individually to a tensile load equal to 83 % of the ultimate 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 length of all ropes, which are to be tested.

#### 10.4. MATERIAL

The material and manufacture processes selected for each component of the guy strand grip assemblies shall be subject to Eskom's approval<sup>0</sup>. The approval procedure will consider the material strength characteristics, ductility and fracture toughness.

#### 10.5. TESTING

##### 10.5.1. Qualifying Design Tests

Before the closing date for tendering, all tenderers shall satisfactorily perform the following tests, where applicable, to qualify their guy strand grips and compression guy assemblies as acceptable for Eskom's transmission system.

The contractor shall submit proposals to Eskom for acceptable test procedures, test equipment and recording devices. The contractor shall communicate in writing to Eskom, in good time, the site and the date of the tests.

No testing of cables shall take place without a representative from Eskom being present. The contractor shall identify each individual cable and shall keep records of all the test results. Copies of these records shall be submitted to Eskom.

Test to include testing foundation link and tower attachment plate that can fit 450 kN shackles.

Tests shall be conducted on a minimum of two identical guy assemblies. If the guy assemblies successfully complete the tests, no further testing needs to be performed. If any component fails a test, the guy assembly cannot be retested until Eskom has approved the design modifications.

Three copies of each test certificate showing the results of the tests shall be submitted.

- Visual and dimensional tests
- Material properties test

#### 10.5.2. Production Routine Tests

Production routine tests shall be performed as specified in NWS 1074.

#### 10.6. LIVE LINE MAINTENANCE OF CROSS ROPE STRUCTURES

All inverted clamps on cross rope towers are to have a hole to fit a live line pin.

#### 10.7. ANTI-THEFT MEASURES

All steel members up to and including the anti-climb device shall be equipped with anti-theft fasteners on 40 % of all holes on plates and one hole per member. All fasteners to be fitted on gusset plates are to be anti-theft fasteners.

The anti-theft fasteners will be of minimum **8.8 grade** strength bolts and shall involve metal deformation during installation. Break-away nut systems will not be acceptable (unless similar performance to the latter type systems can be demonstrated satisfactorily.)

All steel members up to anti-climb device level shall be stamped with the word "ESKOM" at 300mm - 500mm intervals or ensure that all members are grooved (2 x 1mm wide parallel grooves, 4mm apart, 1mm deep).

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 aren't loosened.

The anti-vandal specification, TSP\_474-285 1 Anti-Theft Measure Tx and Dx Towers must be adhered to.

#### 10.8. SAFETY MEASURES

##### 10.8.1. Fall Arrest System

A fall arrest system will be supplied and installed by the contractor. This will be a temporary fall arrest system and is to be removed when all construction activities are complete.

##### 10.8.2. Fall Arrest Anchor

Fall arrest anchor should be installed on all lattice towers, as per standard Eskom drawing shown in **Appendix B** or as per the drawing shown in specification 240-47174520.

##### 10.8.3. Training

The Contractor's appointed supplier will provide relevant training in the use and practical application of the fall arrester system. Tenderer to ensure that applicable workforce undergo the required training.

## 11. APPENDIX E: FOUNDATIONS ADDITIONAL INFORMATION

### 11.1. FOUNDATION DESIGNS

Eskom will supply preliminary drawings (standard conventional foundations only) for tender purposes only to enable easier pricing across all tenders. These “Standard designs” issued with the tender will consist only of preliminary drawings and foundation material requirements, excluding stubs and layouts.

If these “Standard designs” are to be utilised by contractors, such designs will only be adopted if the following conditions are met:

- 1) All foundation designs must be thoroughly checked and signed off by the contractor’s Professional Engineer (with ECSA registration number), **before being submitted for Eskom acceptance and implementation as final designs for construction.**
- 2) The design, appropriate use of foundation types and quality of construction is the contractor’s responsibility.
- 3) In the development of this pricing, the contractor must include but is not limited to the following:
  - Excavation Volume – conventional excavation (for each of six soil / rock types)
  - Excavation Volume – drilled excavation (for relevant soil / rock types)
  - Backfill Volume
  - Reinforcing weight
  - Embedded Mild Steel weight (e.g. stubs)
  - Concrete and Grout Volumes

#### 11.1.1. Foundation Systems and Designs

All foundations shall be designed in accordance with *Eskom* Technical Instruction 240-47172520.

**Tables 12.1, 12.2 and 12.3** show the foundation systems that can be designed and optimised for load performance and cost effectiveness for the lines.

**Table 11-1: Standard Design Foundation**

TOWER TYPE	FOUNDATION TYPE	APPLICABLE SOIL TYPE
Self-supporting Towers	Pad and column foundations	Soil types 1 – 4

	Rock anchors	Soft rock & Hard rock
<b>Guyed Towers</b>	Mast foundations: pad and plinth	All soil types
	Deadman anchors	All soil types
	Rock anchors	Soft rock & Hard rock

**Table 11-2: Alternative Acceptance – Pile Foundations (Inclined augered piles are not allowed)**

TOWER TYPE	FOUNDATION TYPE	APPLICABLE SOIL TYPE
<b>Self-supporting Towers</b>	Multiple piles and cap	Soil types 1 , 2 & soft rock
	Rock anchor systems consisting of anchors and a connecting cap	Hard and soft rock
	Specialised pile systems	Collapsing / waterlogged soil
<b>Guyed Towers</b>	Inclined anchor piles or vertical multiple pile systems	Soil types 1 and 2 & soft rock

**Table 11-3: Alternative Acceptance –Micro-pile (including grouted driven ductile iron piles) Foundations**

TOWER TYPE	FOUNDATION TYPE	APPLICABLE SOIL TYPE
<b>Self-supporting Towers</b>	Soil anchor systems consisting of anchors and a connecting cap	Soil types 1 to 4
	Rock anchor systems consisting of anchors and a connecting cap	Hard and soft rock
<b>Guyed Towers</b>	Inclined anchor/s system or vertical multiple pile systems	Soil types 1 to 4 Hard and soft rock

#### **11.1.2. Micro pile (Grout Injected Anchor) Foundation System**

The micropile grout injected (Titan or similar type or similar) system is suitable for all soil conditions ranging from saturated soils to hard rock and is therefore very suitable for use on power line construction as it can deal with any foundation condition experienced. The added advantage is that from a logistic point of view very little material has to be brought in as the drill shafts act as tension/compression reinforcement in the constructed piles and the pile caps are smaller than conventional foundations. Furthermore, the system only requires a light drilling rig and a cement grout pump system as far as equipment is concerned.

These micropiles are formed by drilling a threaded hollow drill shaft into soil or rock and mixing the loosened virgin material with a high strength cement grout which is pumped simultaneously at high pressure through the hollow centre of the drill bar. As it is not always known how deep one needs to drill the micropile in order to get the desired load capacity from the micropile, the drill shaft can be extended by adding multiple drill shaft sections of 3m. The new section is coupled to the previous section by means of a threaded hollow coupling. The bars can also be cut into shorter pieces if a shorter section is required. Cement grout is pumped in under pressure to form a grout bubble to ensure good contact between the pile and the virgin soil in order to ensure good transfer of the load forces from the pile to the virgin soil. As the micropile stabilizes the in situ virgin material there is no chance of the drill hole collapsing and the drill shaft is covered by a layer of high strength cement grout to give it corrosion protection. Once the desired depth is reached the grout is pumped continuously until fresh grout emerges at the top surface.

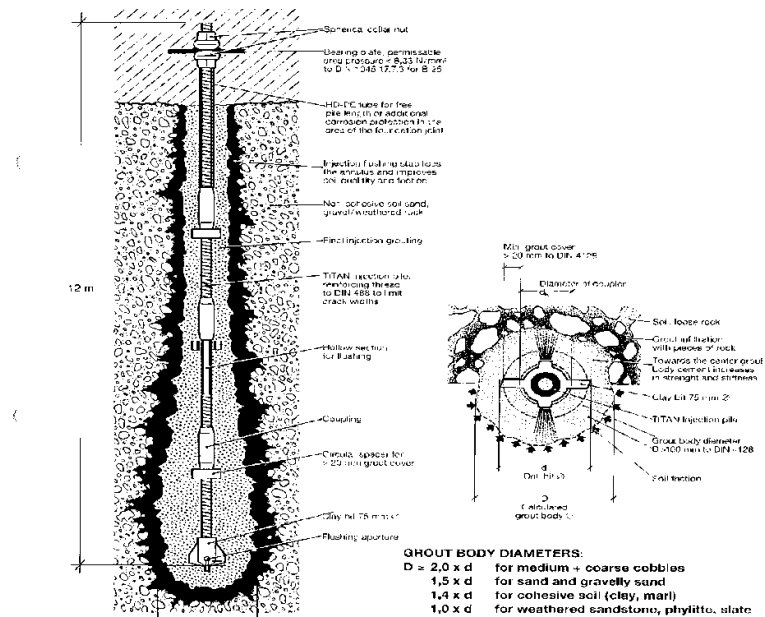


Figure 11-1: The Micro pile System Cross-Section and Plan Section

From an environmental point of view the system is extremely suitable as the natural surrounding at the foundation positions is hardly disturbed apart from the small excavations required for the pile and anchor caps. Different drill bit types and sizes and drill shaft sizes are available to suite different load requirements. Because the system constructs the micropiles in a single process and the pile caps require far less material than conventional foundations the foundation construction process has been found to be faster than the conventional approach (in the order of 3-5 times faster). Depending on the depth of bedrock on site, substantial savings in foundation costs can be accrued (up to 50%).

### 11.1.3. Guy anchor design

The use of linked metal components in direct contact with soil is not acceptable. All steel below ground line must be encased in concrete.

## 11.2. CONSTRUCTION SPECIFICATIONS

All foundations shall be constructed in accordance with *Eskom* Technical Instruction **240-47172520** (*latest version as per tender documents*).

### 11.2.1. Soil Classifications

A geotechnical investigation (for soil/rock type nomination) must be done by the contractor before foundation construction (as per the *Eskom* Technical Instruction 240-47172520, at which point the prevailing soil or rock type classification is determined, and a suitable foundation system for this material is selected.

These investigations allow foundations to be designed more precisely for the type of soil or rock encountered, rather than adopting a conservative design approach for foundations.

Foundation-Soil nominations will be performed by suitably qualified registered professionals (Engineering Geologist with SACNASP or Geotechnical Engineer with ECSA respectively), as appointed by the Contractor. This is in keeping with international practice and will greatly reduce the risk of foundation failure due to inappropriate foundation selection, which is one of the most common causes of foundation failure in South Africa.

A standard geotechnical investigation to determine the soil classification will involve observation of surface and sub-surface drainage patterns, a trial pit excavation, manual inspection of the side walls using a geologist's hammer, in-situ tests as required and logging of soil consistency down the excavation sidewalls. Signed soil profiles and Soil Nomination Summary Lists are submitted for acceptance.

This is a hold point on the Contractor's construction program (test plan) where acceptance by the Employer must first be obtained prior to constructing the foundation.

.

In selected cases or specialized designs, more thorough geotechnical investigations must be carried out in accordance with accepted, geotechnical engineering practices.

## 11.3. PROOF LOAD TESTING

In keeping with increased quality assurance measures, the proof loading of guy anchor foundations will be done on a minimum of 5% of deadman anchors and 5% of all installed piled/Micro pile guy anchors. These will be proof tested to a value of 90% of the un-factored design load or 70% of the ultimate design load for pile anchors and deadman anchors.



To achieve proof load tests, use can be made of newer, more practical foundation testing equipment. Such equipment was made available since the use of the conventional test rigs that are shown in **Figure 12.2**. As shown in **Figure 12.3**, new equipment includes semi-portable, lighter test rigs that are mounted on vehicles that are equipped with a hydraulic power take-off.

The advantage of this type of system is that it can perform tests at high rate, with minimum set up time. The disadvantage of the system is that the testing system is relatively expensive to produce and requires a heavy transporter to be relocated to different construction sites.



**Figure 11-2: Conventional Proof Load Test Rig**



**Figure 11-3: Mobile Proof Load Test Rig**



## 12. APPENDIX F: AS BUILT INFORMATION REQUIREMENTS

### Outline of Requirements

As Built information to be provided as per Eskom requirements, as outlined in specification As-Built Document 240-72252925. This must include ALS covering the substations as well (Aerial Laser Survey). Please request for the accompanying Excel spreadsheet template for capturing as-built data from the LES design engineer.

**Table 12-1: As-Built Requirements as Outlined in Specification**

ITEM	DATA	INFORMATION SUPPLIED BY:
<b>A.</b>	<b>General Line Data</b>	Project Manager
<b>B.</b>	<b>Contractor Details</b>	
B.1.	Main Contractor	Contractor
B.2.	List of Sub-Contractors	Contractor
<b>C.</b>	<b>Summary of Project (Towers, Foundations and Earthing Specification)</b>	Contractor
<b>D.</b>	<b>Earth Resistance Measurements</b>	Contractor
<b>E.</b>	<b>OPGW Installation</b>	OPGW Contractor
E.1.	OPGW Schematic Layout	
E.2.	Colour Coding and Numbering	
E.3.	Power Meter Results and OTDR Reports	
E.4.	Splice Performance Summary	
E.5.	Power Line Carrier Frequencies	
E.6.	Joint Box Positions	
E.7.	Assembly Drawings	
E.8.	OPGW Specification	
<b>F.</b>	<b>Electrical Line Parameters</b>	Contractor
<b>G.</b>	<b>Drawings</b>	
G.1.	Tower Outline Drawings	Contractor
G.2.	Hardware drawings and OPGW Hardware	Supplier/Contractor
G.3.	Manufacturers Insulator Drawings	Supplier/Contractor
G.4.	Grading Rings	Supplier/Contractor
<b>H.</b>	<b>Foundations</b>	
H.1.	Foundation Drawings	Contractor

H.2.	Setting Out Drawings	Contractor
H.3.	Excavation Photos	Contractor
<b>I.</b>	<b>Hardware</b>	
I.1.	Insulators	Supplier/Contractor
I.2.	Midspan Joints	Contractor
I.3.	Spacers/Spacer Dampers	Contractor
I.4.	Insulated Earth Wire Assemblies and Non-Standard Assemblies	Contractor
I.5.	Damping Devices	Contractor
I.6.	Miscellaneous Items (Aircraft warning spheres, bird diverters, warning lights, etc.)	Contractor
I.7.	Hardware Type/Sample Test Records	Supplier/Contractor
I.8.	Hardware Problems and Non-Conformances during Construction (Fitment Issues, Failures, etc.)	Contractor
I.9.	On-Site conversions to cater for Special Requirements	Contractor
<b>J.</b>	<b>Free Issue Material Control Sheet</b>	Contractor
<b>K.</b>	<b>Line Profiles</b>	Contractor
<b>L.</b>	<b>Landowner Details</b>	Project Manager
<b>M.</b>	<b>Aerial Laser Scan</b>	Eskom Survey
<b>N.</b>	<b>HD Visuals and Corona Checks from Flyover</b>	Contractor
N.1.	HD Visuals	Contractor
N.2.	Corona Checks	Contractor
N.3.	Tripod Camera Records	Contractor
N.4.	Helmet Mounted Camera Records	Contractor
N.5.	Drone Inspections	Contractor
<b>O.</b>	<b>Line Walkdown and Line Audit</b>	Contractor
O.1.	Line Walkdown and Line Audit Findings	Contractor/Eskom
O.2.	Tower Top Inspection Sheets	Eskom
<b>P.</b>	<b>Handover Certificates</b>	Project Manager
<b>Q.</b>	<b>Permits</b>	
Q.1.	Statutory Permits	Project Manager
<b>R.</b>	<b>Incident Reports</b>	Contractor
R.1.	Incident, Injury and Fatality Reports Related to Hardware/Mechanical Failure	
R.2.	Non-Conformance Reports	
R.3.	Concessions	
<b>S.</b>	<b>Orange Site File Inspection Reports</b>	Contractor
<b>T.</b>	<b>TxSIS</b>	
T.1.	TxSIS Upload Form	Project Manager
T.2.	TxSIS Input from Contractor	Contractor
T.3.	TxSIS Data	Project Manager

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U.	Learning Points	Design Leader
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### 13. APPENDIX G: CONSTRUCTION RISK AND MITIGATION PLAN

General High Level Risk Assessment for High Voltage Overhead Line Construction								
Priority/order	Job	Activity steps	Critical steps	Status	Activity Specific Risk	Mitigation	Accountability	Responsible
<b>Generic risk:</b>								
All activities	Site establishment and general work at site camp and each construction site.		Proper establishment of a construction site camp, material storage facility, construction site at each structure for construction of foundations and erection of structure, construction site at each tensioner- / puller station.  Access roads to tower locations and working in rocky areas	Not complete	Consider the generic risk in the separate risk and mitigation reference.	Consider the generic risk in the separate risk and mitigation reference.	Principal contractor	Site Manager
<b>Foundation construction:</b>								
<b>Obtain an Eskom Permit for activities listed below</b>								
Soil classification.	Excavate trial pits for soil nomination.	Use an excavator to excavate to a founding depth of approximately 3m if possible. Perform and document the soil profile. Backfill the excavation.	The position and number of trial pits should be as shown in TRMSCAAC and documented on the soil nomination list and profile sheet. The backfilling must occur directly after the profiling is completed and before continuing to excavate the next test pit.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation Plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Geotech engineer
Hold	This is an engineering hold point in the inspection and test plan. Until the soil type nomination has been approved by the LES or nominated representative, no construction shall continue.							

Excavation and pile- or rock anchor drilling.	Excavate holes for the structure foundations according to the approved design chosen for the nominated soil profile.	Excavate holes to full dimensions required as per the approved design. Stockpile topsoil separately so as to maintain a clean subgrade. If the bottom of the excavation is below the water table, the water shall be pumped out and the excavation kept dry and free from water during construction.	Submit a schedule of structure leg ground levels and proposed leg extensions to the client. Have the approved soil type nomination and appropriate approved foundation designs on site. Excavate as close as is reasonably practicable to the exact dimensions as stipulated in the foundation design applied to the chosen soil nomination. In case of over-excavation the foundation shall be fixed as stipulated in TRMSCAAC. Ensure a clean subgrade.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> <li>- Unstable soil after blasting.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation Plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Or
Placing of reinforcing steel, stubs, anchor links.	Assemble the reinforcing steel, stub / anchor and concrete slabs in the excavation. Earth the foundation.	Reinforcing steel shall be fabricated and bent according to approved foundation design drawings. Before placement the steel shall be thoroughly cleaned of mill scale and any coatings that may destroy or weaken the bond. The reinforcing steel shall be placed according to the approved foundation design drawings. The minimum cover to the main reinforcing bars shall be as per TRMSCAAC standard. Cover blocks shall be placed at the bottom of the excavation and the bottom steel reinforcing placed on top to ensure the clearance. A concrete slab of 300 x 300 x 75 shall be placed at the bottom of the excavation in the position where the leg stub or anchor plate should sit. The stub or link plate shall be fixed to the rebar so that its position does not change during the pouring of the concrete. The reinforcing shall be properly constructed according to the design and fixed together with 18 gauge annealed wires. Connect the earthing wire to the stub	Installation of shoring / bracing if necessary (see CR 13). Retaining clearance to overhead electrical lines during moving of material. Maintaining the minimum cover to the reinforcing steel by use of suitable spacers. Accurate placement of anchor link / stub on appropriate cover block ensuring adequate stability to remain within tolerance of position during casting of concrete. (Use of adequate designed temporary works) Connection of earthing by connecting earth wire lug bolted connection to the stub / anchor link and the opposite end to the reinforcing steel with Crosby clamps or suitable approved means.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> <li>- Unstable soil after blasting.</li> <li>- Upsetting of cranes.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation Plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Principal Contractor

		with a bolted connection and to the rebar with Crosby clamps as per TRMSCAAC standard.						
Hold	This is an engineering hold point in the inspection and test plan. Until the reinforcing and stub / anchor links and earthing has been approved by the client, no construction shall continue.							
Slump test- and concrete cube samples.	Perform slump test. Prepare test cubes.	Perform slump test. Prepare cube test samples.	Slump tests shall be performed as per SANS 862. Test cubes shall be prepared in accordance with SANS 863.	Not complete	Incorrect handling of concrete may lead to incorrect test results.	Adequate supervision.	Principal Contractor	Principal Contractor
Hold	This is a construction hold point in the inspection and test plan. Until the slump test is performed and concrete cube samples taken, no casting of concrete shall continue. (Repeat and document for each casting)							
Cast concrete for first pad of foundation	Cast concrete from the concrete mixer truck into the excavation to cover the first pad of the reinforcing steelwork.	Position the concrete mixer truck. Position the concrete chute and lengthening chutes as needed. Pour the concrete into the excavation to cover the first pad of the foundation in case of a conventional pad and pier foundation. Enter the excavation with vibrators to vibrate the concrete to ensure it removal of voids and adequate compaction. Float concrete surface (finishing).	Ensure excavation approach limit is not exceeded and that additional discharging chute lengthening is used as needed. Ensure sufficient stability of the rebar and stub assembly so that it doesn't shift during the pouring process. Guide the concrete chute during the pouring to ensure even spreading of the concrete over the pad. Vibrate the concrete adequately to ensure removal of voids and good compaction of the concrete. Stop vibrating before separation of aggregate occurs.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Hold	This is a construction hold point. Until the bottom pad in the pad and pier foundation is adequately cured to support placement of shuttering, no foundation construction shall continue. (Repeat for each casting)							

Formwork / shuttering.	Place formwork / shuttering in excavation. Seal gaps in shuttering and between shuttering and cast concrete.	Enter excavation on top of adequately cured concrete of the first pad. Position shuttering for the second pad. Shuttering should be lowered into the foundation by a truck-mounted crane or similar equipment. Seal the gaps in the concrete formwork / shuttering with an appropriate waterproof sealant.	Check if concrete has adequately cured before entering to ensure no damage to concrete cast in first pad. Ensure excavation approach limit is not exceeded and that truck mounted crane boom has adequate reach so that the stability of the excavation wall is not compromised. Spacers should be used to ensure adequate coverage over reinforcing steel. Seal the gaps between formwork with a waterproof sealant.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Repeat the casting process								
Repeat the shutter / formwork placement process for chimney of foundation.								
Repeat the casting process								
Removal of shuttering and backfilling.	Remove the shuttering on the foundation. Backfilling of the new foundation's excavation in two phases: Fill up, level and compact the substrate in layers. Fill up, level and compact the topsoil in layers.	Enter excavation on top of cast concrete. Remove shuttering from concrete and evaluate for signs of honeycombing or other non-conformities. Exit excavation and remove shuttering. Fill up, level and compact the substrate in layers. Fill up, level and compact the topsoil in layers.	Ensure excavation approach limit is not exceeded and that truck mounted crane boom has adequate reach so that the stability of the excavation wall is not compromised. Enter excavation and remove shuttering from cured concrete; evaluate for signs of non-conformities. Exit the excavation and pour, level and compact the substrate in layers. Pour, level and compact the topsoil in layers. Ensure homogenous material is used for backfilling to ensure the best possible degree of compaction and stability. Ensure that the surface level of the backfill shall be at such an elevation that water will not accumulate.	Not complete	<ul style="list-style-type: none"> <li>- Ground line instability or movement.</li> <li>- Excavations collapsing on assets, people or animals.</li> <li>- Detrimental impact of excavation or excavating on third party services or assets.</li> <li>- Waterlogging of Excavations.</li> <li>- Unrestricted access to, exiting and egressing from excavations.</li> <li>- Work in an unmonitored / unsupervised excavation.</li> <li>- Uncertainty over the stability of the soil.</li> <li>- Inadequate shoring.</li> <li>- Equipment falling into excavation.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Excavation plan in accordance with CR 13</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Hold	This is an engineering hold point in the inspection and test plan. Until the prototype of the first of each structure type has been inspected and approved by the client at the factory, no construction shall continue.							
Structure assembly:								



Structure assembly	Assemble the structure on cribbing on the ground according to the relevant approved structural detail drawings. Tighten, punch and paint bolts.	Offload the structural steel at the structure position. Place cribbing in appropriate selected positions to be able to assemble the structure on the cribbing and off the ground and to be able to assemble the structure plumb and stable. Pick up the members by hand / truck mounted crane, hold in position according to the appropriate approved drawing and bolt together. Punch and paint bolts / nuts.	Ensure planned layout of structural section complies with the lifting plan / rigging study of the crane operator / lifting foreman to ensure all sections will be within reach of the crane and be safely lifted into place. Assemble structure steelwork in strict accordance with approved structural drawings. Use adequately sized bolts and nuts. Punch and paint bolts.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Work on an unmonitored / unsupervised structure.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11.</li> <li>- Temporary works in accordance with CR 12.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
	Install anti-vandal bolts.	Loosen normal bolts and replace with anti-vandal fasteners as per anti-vandal standard.	Ensure structural stability while replacing normal bolts with anti-vandal fasteners to ensure pieces of the structure doesn't collapse on workers.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Work on an unmonitored / unsupervised structure.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11.</li> <li>- Temporary works in accordance with CR 12.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> <li>- Compliance with anti-vandal standards.</li> </ul> <p>NOTE: Consider the generic risk mitigation in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Hold	This is an engineering hold point in the inspection and test plan. Until the first of each structure type has been inspected and approved by the client at the construction site, no construction shall continue.							
Hold	This is an engineering hold point in the inspection and test plan. Until a sample of each type of hardware assembly for both the phase- and earth conductor has been inspected at the site camp (assembled as per supplier's drawing and hung from a wooden pole), no construction shall continue.							
Hold	This is an engineering hold point in the inspection and test plan. Until the destruction test of guy wire samples complete with structure- and anchor plate attachment mock-ups has been completed and passed, no construction shall continue.							
Structure erection:								
Structure erection	For a self-supporting structure: Attach slings to structural sections in sequence and lift and attach	Position the mobile crane in a position where it will have adequate reach to all sections of the structure as assembled on the ground. Lift the structure legs and attach to the leg stubs (all bolts fastened) on the foundations. Back-stay the legs to ensure appropriately stable structures before	Confirm distance from crane to sections and section weights are within capacity of lifting chart as per rigging study. Earth the crane and make sure all outriggers are on stable soil. Ensure sling capacity for each section weight is adequate as per rigging study. Ensure back-stays are as per design of	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and</li> </ul>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12</li> <li>- Compliance with all standards as specified in the applicable Line Specification</li> </ul>	Principal Contractor	Temporary Works Engineer



	each section until all sections are attached to the main structure.	any climbing of the structure to disconnect rigging equipment. Lift the body sections and connect and fasten all bolts to all legs of the structure before climbing and removing rigging equipment. Lift K-frames of structure and connect and fasten all bolts to the body before climbing and removing the rigging equipment. Ensure lever hoists and slings are attached to the top of the K-frames as temporary works for positioning of the structure beam. Lift the structure beam and position onto the K-frames with temporary works. Connect and fasten all bolts before removing rigging equipment.	temporary works. Concrete blocks must be on a wedged sled. Ensure all rigging equipment is certified.		certified safe for use. - Upsetting of crane. - Inadequate / unsafe rigging practice.  NOTE: Consider the generic risk in the separate risk and mitigation reference.	and latest revision of TRMSCAAC. - Compliance with anti-vandal standard. - Consider generic risk mitigation regarding cranes including SANS standards.  NOTE: Consider the generic risk in the separate risk and mitigation reference.		
	For a guyed V or guyed cross-rope suspension structure: Attach slings to the structure and lift the structure as a whole (complete with hardware and insulators), position the structure on the centre stubs and connect the guy ropes to the anchor links.	Position the mobile crane(s) in a position where it will have adequate reach to position the structure (at tallest attachment point) on the centre pegs while no clashing between the structure and the crane boom will occur when the structure is plumb. Lift the structure while coordinating with the movement of the bottom of the masts towards the centre pegs. Ensure the hardware and insulators and running blocks lift in unison without snagging on the ground. Lift the structure above the centre pegs and lower onto the pegs. Pull the guy wires towards the corresponding anchor link plates and connect the guy wires and plumb the structure. Climb the structure and disconnect the rigging equipment.	Confirm distance from crane to centre pegs, and structure weight is within capacity of lifting chart as per rigging study. Earth the crane and make sure all outriggers are on stable soil. Ensure sling capacity for structure weight is adequate as per rigging study. Ensure all rigging equipment are certified.	Not complete	- Uncontrolled collapse of structure. - Damage of structural members and galvanizing due to poor handling. - Inadequate use of temporary works. - Overloading of structural members. - Inadequately maintained structure. - Structure not inspected and certified safe for use. - Upsetting of crane. - Inadequate / unsafe rigging practice.  NOTE: Consider the generic risk in the separate risk and mitigation reference.	- Structure plan in accordance with CR 11 - Temporary works in accordance with CR 12  - Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC. - Compliance with anti-vandal standard. - Consider generic risk mitigation regarding cranes including SANS standards.  NOTE: Consider the generic risk in the separate risk and mitigation reference.	Principal Contractor	Temporary Works Engineer

	For a monopole structure: Hydraulically jack the sections of the pole together. Attach slings to the structure and lift the structure as a whole, position the structure on the flange bolts. Plumb the structure and fasten with bolts.	Use a crane to position sections of the pole on adequate cribbing. Connect the hydraulic jacks to the appropriate jacking lugs on the sections. Jack the sections together in compliance with the approved structure design drawings. Lift the structure into position and plumb the structure on the holding down bolts and bolt the flange according to the design drawings. Climb the structure using the structure ladders and disconnect the crane and rigging equipment. Alternative: Lift the bottom section into position on the holding down bolts; plumb and tighten. Lift the second section over the bottom section and lower into position, connect the hydraulic jacks and rigging equipment onto the appropriate lugs and jack into position according to the approved design requirements. Repeat until the structure is complete and plumb.	Confirm distance from crane to centre pegs, and structure weight is within capacity of lifting chart as per rigging study. Earth the crane and make sure all outriggers are on stable soil. Ensure sling capacity for structure weight is adequate as per rigging study. Ensure all rigging equipment is certified. Ensure the hydraulic jack is of adequate capacity as per structure design requirements. Use cherry picker / bucket trucks of appropriate size to access attachment points and lugs on structure and consider the possible servitude constraints.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane.</li> <li>- Inadequate / unsafe rigging practice.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> <li>- Compliance with anti-vandal standard.</li> <li>- Consider generic risk mitigation regarding cranes including SANS standards.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Hold	This is an engineering hold point in the inspection and test plan. Until the first of each structure type erection has been inspected and approved by the client at the construction site, no construction shall continue.							
<b>Dressing:</b>								
Structure dressing	For a self-supporting structure							
Hold	This is an engineering hold point in the inspection and test plan. Until the structure earth footing resistance has been measured, no stringing shall continue.							
Hold	This is an engineering hold point in the inspection and test plan. Until the conductor- and earth wire sample destruction testing has been completed, no stringing shall continue.							
<b>Stringing and regulating:</b>								

String earth wire and OPGW	Pull pilot cable between tensioner- and puller stations.	Position pilot cable on drums at puller station. Connect the pilot cable(s) to a tractor (or adequate pulling vehicle). Pull the pilot cable(s) along the line until it passes underneath supporting structures. Pull at least twice the attachment height past the structure. Disconnect the pilot cable(s) from the pulling vehicle and connect to the guide ropes that run through the running blocks. Pull the pilot cable(s) through the running blocks and reconnect the pilot cable to the pulling vehicle. Continue pulling the pilot cable(s) and repeat the process.	Create a stringing plan (for approval by the engineer) to check the tension of the conductor that will be pulled, ensure an adequate size pilot cable is used, ensure adequate size- and material running blocks are used. Back-stay the double bull-wheel tensioner and puller to adequately designed back-stays (concrete blocks on a wedged frame) to counter the tension in the conductor as calculated in the stringing plan. Ensure the pilot cable doesn't pass between guy wires as it is pulled as it will damage and cut the guy wire. Back-stay terminal structures to counter the tension in the conductor as calculated in the stringing plan. Angle running blocks and position pull-down running blocks (to counter uplift of pilot cable out of running blocks) as required.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection of pilot cables, headboard and running blocks for the chosen conductor to be strung.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
	String the earth conductor / OPGW	Connect the earth conductor / OPGW to a head board and swivels to ensure possible rotation of the pilot cable while keeping the conductor / OPGW stable. Lift the pilot cable off the ground by gently increasing the tension from the pulling- / winch station. Pull the conductor (under tension and off the ground) from the tensioner station to the puller station.	Ensure free movement of the headboard through the running blocks throughout the pulling process. Ensure adequate earthing of the puller- and tensioner and running blocks with running earths and earthing plates for operators to mitigate electrocution caused by electromagnetic- and electrostatic induction.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection of pilot cables, headboard and running blocks for the chosen conductor to be strung.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296,</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer

	Regulate and clamp in earth conductor and OPGW	Measure the conductor temperature as per TRMSCAAC. Pull the conductor until the tension is as per indication on the stringing- and regulating charts provided by engineering for the associated temperature. Lift the earth conductor / OPGW out of the running block. Disconnect the running block and lower it to the ground. Clamp the earth conductor / OPGW into the hardware clamps / dead-ends and connect to the structure attachment points.	Measure conductor temperature as per TRMSCAAC standard. Conductors should be lifted from the running blocks with adequate designed temporary works and closed loop slings to ensure conductors cannot fall to the ground.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection / clear marking of come-along clamps.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
	Install secondary equipment	Install vibration dampers / aerial warning spheres / bird flight diverters.	Vibration damper placement as per supplier specification.	Not complete	<ul style="list-style-type: none"> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Unsupervised work on suspended platform.</li> <li>- Collapse / failure of the suspended platform.</li> <li>- The suspended platform system is not certified for use by a Pr.Eng. / Pr. Tech..</li> <li>- The suspended platform system does not: <ul style="list-style-type: none"> <li>- have an operating plan and competent operators.</li> <li>- The outriggers fail.</li> <li>- The stop devices fail.</li> <li>- Is not suspended below the ropes.</li> <li>- Is not thoroughly examined.</li> </ul> </li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Suspended platform in accordance with CR 17.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
Hold	This is an engineering hold point in the inspection and test plan. Until the earth wire and OPGW is strung no stringing of the phase conductor shall continue.							

String phase conductor(s)	Pull pilot cable between tensioner- and puller stations.	Position pilot cable on drums at puller station. Connect the pilot cable(s) to a tractor (or adequate pulling vehicle). Pull the pilot cable(s) along the line until it passes underneath supporting structures. Pull at least twice the attachment height past the structure. Disconnect the pilot cable(s) from the pulling vehicle and connect to the guide ropes that run through the running blocks. Pull the pilot cable(s) through the running blocks and reconnect the pilot cable to the pulling vehicle. Continue pulling the pilot cable(s) and repeat the process.	Create a stringing plan (for approval by the engineer) to check the tension of the conductor that will be pulled, ensure an adequate size pilot cable is used, ensure adequate size- and material running blocks are used. Back-stay the double bull-wheel tensioner and puller to adequately designed back-stays (concrete blocks on a wedged frame) to counter the tension in the conductor as calculated in the stringing plan. Ensure the pilot cable doesn't pass between guy wires as it is pulled as it will damage and cut the guy wire. Back-stay terminal structures to counter the tension in the conductor as calculated in the stringing plan. Angle running blocks and position pull-down running blocks (to counter uplift of pilot cable out of running blocks) as required.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection of pilot cables, headboard and running blocks for the chosen conductor to be strung.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296,</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
	String the phase conductor(s)	Connect the conductor(s) to a head board and swivels to ensure possible rotation of the pilot cable while keeping the conductor(s) stable. Lift the pilot cable off the ground by gently increasing the tension from the pulling- / winch station. Pull the conductor(s) (under tension and off the ground) from the tensioner station to the puller station.	Create equal tension between all conductors in a bundle. Ensure and document that all conductors in a bundle are from the same machine. Ensure free movement of the headboard through the running blocks throughout the pulling process. Ensure adequate earthing of the puller- and tensioner and running blocks with running earths and earthing plates for operators to mitigate electrocution caused by electromagnetic- and electrostatic induction.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection of pilot cables, headboard and running blocks for the chosen conductor to be strung.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296,</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul>	Principal Contractor	Temporary Works Engineer

						NOTE: Consider the generic risk in the separate risk and mitigation reference.		
	Regulate and clamp in phase conductor(s) in suspension assemblies.	Measure the conductor temperature as per TRMSCAAC. Pull the conductor until the tension is as per indication on the stringing- and regulating charts provided by engineering for the associated temperature. Lift the phase conductor(s) out of the running block. Disconnect the running block and lower it to the ground. Clamp the conductors into the hardware clamps and connect to the hardware attachment points in suspension clamps.	Measure conductor temperature as per TRMSCAAC standard. Conductors should be lifted from the running blocks with adequate designed temporary works and closed loop slings to ensure conductors cannot fall to the ground. Sag conductors with the help of sagging boards and levelling scopes.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection / clear marking of come-along clamps.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296,</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer



	Regulate and clamp in phase conductor(s) in strain assemblies.	Attach adequate number of block-and-tackle to the structure cross-arms and to adequately anchored winches on the ground. Attach the tackle to come-along clamps on the conductor. Pull the conductor(s) with the winches and regulate with sagging boards and levelling scopes. Measure and cut the conductor(s) taking into account the strain assembly and insulator length. Crimp the conductor dead-ends onto the conductors. Attach the conductors to the hardware and insulators and attach to the structure spreading the load evenly across the assembly.	Use correct come-along clamps designed for ACSR conductor and suitable for the diameter of conductor used. Measure and document the across flat widths of crimped fittings. Adjust sag adjusters and adjustable extension links to spread loads evenly throughout the assembly and conductors.	Not complete	<ul style="list-style-type: none"> <li>- Uncontrolled collapse of structure.</li> <li>- Damage of structural members and galvanizing due to poor handling.</li> <li>- Inadequate use of temporary works.</li> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Upsetting of crane / tensioner / puller.</li> <li>- Inadequate / unsafe rigging practice and backstay of tensioner and puller and structures.</li> <li>- Inadequate selection / clear marking of come-along clamps.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296,</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Principal Contractor
	Install secondary equipment	Install jumper assemblies with rigid spacers as per TRMSCAAC standard. Install spacer dampers.	Spacer damper placement as per supplier specification / spacing charts. Measure clearance from the jumpers to the structure to ensure adequate clearance. Crimp jumper flags onto the jumper conductors and attach the jumper flags as per TRMSCAAC standard to the dead-ends.	Not complete	<ul style="list-style-type: none"> <li>- Overloading of structural members.</li> <li>- Inadequately maintained structure.</li> <li>- Structure not inspected and certified safe for use.</li> <li>- Unsupervised work on suspended platform.</li> <li>- Collapse / failure of the suspended platform.</li> <li>- The suspended platform system is not certified for use by a Pr.Eng. / Pr. Tech..</li> <li>- The suspended platform system does not: <ul style="list-style-type: none"> <li>- have an operating plan and competent operators.</li> <li>- The outriggers fail.</li> <li>- The stop devices fail.</li> <li>- Is not suspended below the ropes.</li> <li>- Is not thoroughly examined.</li> </ul> </li> </ul> <p>NOTE: Consider the generic risk in</p>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11</li> <li>- Temporary works in accordance with CR 12.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Suspended platform in accordance with CR 17.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer

					the separate risk and mitigation reference.			
<b>Demolition / decommission:</b>								
Demolition	Remove phase- and earth conductors.	Remove secondary equipment, Unclamp conductors, Cut jumpers.	Checking integrity of structure before any work and applying necessary temporary reinforcement. Removing secondary equipment.	Not complete	<ul style="list-style-type: none"> <li>- No appointed demolition supervisor.</li> <li>- Uncontrolled collapse of structure due to no detailed structural engineering survey and safe work procedure.</li> <li>- Damage of structure due to poor intermittent supervision.</li> <li>- Parts of the structure overloaded with debris.</li> <li>- Accidental collapse due to inadequate shoring.</li> <li>- Collapse of the structure on a person.</li> <li>- Collapse of adjacent structures affected by the demolition of a structure.</li> <li>- Persons being struck by falling objects.</li> <li>- Collapse of the structure due to overloading by equipment weight.</li> </ul>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11.</li> <li>- Demolition in accordance with CR 14.</li> <li>- Temporary works in accordance with CR 12, SANS 4308-1.</li> <li>- Cranes, tensioners, pullers in accordance with CR 22, SANS 4308-1, IEEE 524.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24, IEEE 524.</li> <li>- Communication plan in accordance with SANS 10296.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
					<ul style="list-style-type: none"> <li>- Hazard to the public by debris left on site for extended periods of time.</li> <li>- Contact with dangerous electrical potential overhead or underground.</li> <li>- Restricted access to a site</li> <li>- Work on an unmonitored / unsupervised structure.</li> <li>- Inadequate use of temporary works.</li> <li>- Upsetting of crane / tensioner / puller.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>			



	Lattice structure demolition.	Decommission structure in sections.	Checking integrity of structure before any work and applying necessary temporary reinforcement.	Not complete	<ul style="list-style-type: none"> <li>- No appointed demolition supervisor.</li> <li>- Uncontrolled collapse of structure due to no detailed structural engineering survey and safe work procedure.</li> <li>- Damage of structure due to poor intermittent supervision.</li> <li>- Parts of the structure overloaded with debris.</li> <li>- Accidental collapse due to inadequate shoring.</li> <li>- Collapse of the structure on a person.</li> <li>- Collapse of adjacent structures affected by the demolition of a structure.</li> <li>- Persons being struck by falling objects.</li> <li>- Collapse of the structure due to overloading by equipment weight.</li> </ul>	<ul style="list-style-type: none"> <li>- Structure plan in accordance with CR 11.</li> <li>- Temporary works in accordance with CR 12.</li> <li>- Demolition in accordance with CR 14.</li> <li>- Cranes in accordance with CR 22.</li> <li>- Electrical installation and machinery management plan in accordance with CR 24.</li> <li>- Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>	Principal Contractor	Temporary Works Engineer
					<ul style="list-style-type: none"> <li>- Non-adherence to explosive regulations / safe work procedure.</li> <li>- Hazard to the public by debris left on site for extended periods of time.</li> <li>- Contact with dangerous electrical potential overhead or underground.</li> <li>- Restricted access to a site</li> <li>- Work on an unmonitored / unsupervised structure.</li> <li>- Inadequate use of temporary works.</li> <li>- Upsetting of crane / tensioner / puller.</li> </ul> <p>NOTE: Consider the generic risk in the separate risk and mitigation reference.</p>			
Earth mat connections								

Cable trenches from terminal structure to substation earth mat connection point.	Build/install cable trenches and ramps in new section	Excavate with mini excavator, install pre cast Kerb. Bond the curbs as per design. Backfilling and compacting.	Operating mini excavator Move pre-cast segments into the work site	Not complete	- Contact with dangerous electrical potential overhead or underground.	- Cat excavator with maximum reach 1.8 m to be used only.  - Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.  NOTE: Consider the generic risk in the separate risk and mitigation reference.	Principal contractor.	Temporary Works Engineer
Provide bonding from the new structure earthing and the substation earth mat points.	Providing earth tails from the earth mat to the future structures.	Excavation to place new earth tails with mini excavator and install earth tails. Crimpets to be used.	Maximum lift of any conductive part will be limited to 3 meters from ground level retaining a minimum clearance of 5 m to any conductive part. Approach limit markers (made of nonconductive material) will be introduced with warning labels that indicate the danger of exceeding a height of the marker. The induction of construction vehicle operation and control as anticipated in Construction Regulation 23.	Not complete	- Contact with dangerous electrical potential overhead or underground. - Electrocutation due to potential differences (static or inductive).	- Electrical installation and machinery management plan in accordance with CR 24  - Compliance with all standards as specified in the applicable Line Specification and latest revision of TRMSCAAC.  NOTE: Consider the generic risk in the separate risk and mitigation reference.	Principal contractor / Eskom.	Temporary Works Engineer

**14. APPENDIX H: INSPECTION AND TEST PLAN**

It is required that the Eskom Engineering hold points, witness points and surveillance points be incorporated into the contractor's test- and inspection plan as indicated below for all the relevant line construction activities.

INSPECTION AND TEST PLAN (ITP) FOUNDATION CONSTRUCTION																		Document No.							
																		Revision:							
CONTRACTOR: LOCATION :																		Page:		1 of 1					
CLIENT : Eskom Holdings Limited																									
CLIENT ORDER No:																									
CONTRACT TITLE:																									
OPERATION No.	PROCESS / ACTIVITY	PROCEDURE / FORM / DOCUMENT REFERENCE	REVISION	ACTIVITY / CONTROL										INSPECTION RESULTS											
				INSPECTION REVIEW					TYPE OF CONTROL																
				SURVEILLANCE WITNESS/HOLD BY					REQUIRED																
				Contractor	Site Sup	EO	Client Engineer (LES)	Other	DESTRUCTIVE TEST	NON-DESTRUCTIVE TEST	DIMENSIONAL	VISUAL	CERTIFICATE	REPORT / RESULTS	ACCEPT	ACCEPT	REJECT / NCR	Contractor	Client Site Representative	Client Engineer	Date	Remarks			
1	Surveying and Pegging	Report (Contractor)		W		R	H					X	X		X										
2	Bush Clearing			I		I							X		X										
3	Soil / Rock Classification	Geotech Investigation Report proposed by contractor and Approved by Eskom		W	R		H						X		X	X									
4	Foundation	SABS 862:1994 / 240-47172520 / TRMASAAJ7 Rev. 2 / Drawings	All 1st off each type that requires an inspection notification (Hold Point), shall be witnessed and signed by the responsible Client Engineer																						
4.1	Inspection Notification (1st of each type)			H			H					X		X	X										
4.2	Concrete mix design and trial mix	240-47172520		H	I		H					X		X											
4.3	Accept foundation drawings & Design calculations	Customer release, record drawing number, 240-47172520		H			H								X	X									
4.4	Setting out of foundations	Foundation Set out Drawings, Stacking Table, 240-47172520		H	W						X														
4.5	Check Excavations	240-47172520 cl 6.2.2		H	I						X														
4.6	Check reinforcing & stub setting & earthing	240-47172520 cl 6.2.4.8-9		H			H					X													
4.7	Check and record concrete batching	240-47172520 cl 6.2.4.6-7		H	R									X											

**H - Hold Point:** A predetermined stage beyond which work shall not proceed without the attendance/go-ahead of the client engineering representative. **I - Inspection Point:** A predetermined stage where a check or measurement must be performed to verify parameters and specification requirements. **S - Surveillance:** General Observation. **R - Review:** mean the review of results or records. **W- Witness:** A point in the process that needs to be witnessed by the party indicated.

INSPECTION AND TEST PLAN (ITP) TOWER ASSEMBLY AND ERECTION																		Document No.				
CONTRACTOR: LOCATION :																		Revision: 1				
CLIENT : Eskom Holdings Limited CLIENT ORDER No:																		Page: 1 of 1				
CONTRACT TITLE:																						
<div style="display: flex; justify-content: space-between;"> <div> I = INSPECTION R = REVIEW S = SURVEILLANCE W = WITNESS POINT H = HOLD POINT </div> <div>Tower Number:</div> </div>																						
<div style="display: flex; justify-content: space-between;"> <div> Tower Type: </div> </div>																						
OPERATION No.	PROCESS / ACTIVITY	PROCEDURE / FORM / DOCUMENT REFERENCE	REVISION	ACTIVITY / CONTROL												INSPECTION RESULTS						
				INSPECTION REVIEW SURVEILLANCE WITNESS/HOLD BY					TYPE OF CONTROL REQUIRED							SIGNATURE			Date	Remarks		
				Contractor	ESKOM	EO	Client Engineer	Other	DESTRUCTIVE TEST	NON-DESTRUCTIVE TEST	DIMENSIONAL	VISUAL	CERTIFICATE	REPORT / RESULTS	ACCEPT	ACCEPT	REJECT / NCR	Contractor			Client Site Representative	Client Engineer
<b>5 Assembly and Erection</b>		TRIMSCAAC5 Rev.2 / TRMASAAJ7 Rev. 2 / Drawing	All 1st off each type that requires an inspection notification (Hold Point), shall be witnessed and signed by the responsible Client Engineer																			
5.1	Prototype Inspection (1st of each type)	Safe Work Procedure		H	I		H					X		X								
5.2	Erection Inspection	Safe Work Procedure		I	I		H					X		X								
5.3	Earth Resistance Measurement	Safe Work Procedure		H	S					X	X			X								
5.4	Guy wire test	Safe Work Procedure		H			H				X			X								
5.5	Check Guy rope lengths	Safe Work Procedure		H							X			X								
5.6	Check perpendicularity	Safe Work Procedure		H							X											
5.7	Final Inspection and document review	Safe Work Procedure		H										X								
5.8	Erection Complete	Drawing and Review of Documents		I	R							X		X								
Released by Contractor				Accepted by Client QC								Template Accepted by Client Engineer				Accepted by Client PM						
Signature				Signature					Signature					Signature								
Name				Name					Name					Name								
Date				Date					Date					Date								

**H - Hold Point:** A predetermined stage beyond which work shall not proceed without the attendance/go-ahead of the client engineering representative. **I - Inspection Point:** A predetermined stage where a check or measurement must be performed to verify parameters and specification requirements. **S - Surveillance:** General Observation. **R - Review:** mean the review of results or records. **W- Witness:** A point in the process that needs to be witnessed by the party indicated

INSPECTION AND TEST PLAN (ITP) STRINGING AND REGULATING																		Document No.			
																		Revision:			
																		Page:			
CONTRACTOR:				LOCATION :								Tower Number:									
CLIENT : Eskom Holdings Limited								I = INSPECTION													
CLIENT ORDER No:								R = REVIEW													
CONTRACT TITLE:								S = SURVEILLANCE				Tower Type:									
								W = WITNESS POINT													
								H = HOLD POINT													
OPERATION No.	PROCESS / ACTIVITY	PROCEDURE / FORM / DOCUMENT REFERENCE	REVISION	ACTIVITY / CONTROL										INSPECTION RESULTS							
				INSPECTION REVIEW SURVEILLANCE WITNESS/HOLD BY					TYPE OF CONTROL REQUIRED					SIGNATURE			Date	Remarks			
				Contractor	ESKOM	EO	Client Engineer	Other	DESTRUCTIVE TEST	NON-DESTRUCTIVE TEST	DIMENSIONAL	VISUAL	CERTIFICATE	REPORT / RESULTS	ACCEPT	ACCEPT			REJECT / NCR		
																				Contractor	Client Site Representative
6	Stringing and Regulating Conductor and Earth wire	240-47172520/ TRMASAAJ7 Rev. 2 / Drawing / SAG Chart		All 1st off each type that requires an inspection notification (Hold Point), shall be witnessed and signed by the responsible Client Engineer																	
6.1	Inspection Notification (For making of joints and Tests)			H	S							X		X							
6.1	Destructive Test on Conductor / EW Test Piece	Report (CSIR/Contractor)		H	R		H		X		X			X	X						
6.2	Line Hardware Assembly Inspection Before Use	Report (Line Engineering)		H	I		H					X		X	X						
6.3	Crossing Location Record	Site Report		I	I							X		X							
6.4	Inspection Notification before lifting of assy. For each tower type	Safe Work Procedure		H	W		H					X		X							
6.5	Inspect dressing	Safe Work Procedure		S	W									X							
6.6	Record Drum No. for the applicable span (conductor)			H	W									X							
6.7	Record conductor temperature			H	I					X				X							
6.8	Record SAG	Record form		H	S									X							
6.9	Check Clearance			H	W							X		X							
6.10	Check Jumper Clearance			H	W							X		X							
6.11	Record Joint Type and position (conductor)			H	W							X		X							

6.12	Record compression equipment No.	Record form		H	S								X		X								
6.13	Record Joint Type and position (earth wire)	Record form		H	S								X		X								
6.14	Stringing Complete			I	I							X	X		X								
Released by Contractor			Accepted by Client QC										Template Accepted by Client LES				Accepted by Client PM						
Signature				Signature																			
Name				Name																			
Date				Date																			
<b>H - Hold Point:</b> A predetermined stage beyond which work shall not proceed without the attendance/go-ahead of the client engineering representative. <b>I - Inspection Point:</b> A predetermined stage where a check or measurement must be performed to verify parameters and specification requirements. <b>S - Surveillance:</b> General Observation. <b>R - Review:</b> mean the review of results or records. <b>W- Witness:</b> A point in the process that needs to be witnessed by the party indicated.																							



<b>INSPECTION AND TEST PLAN (ITP)</b> <b>MISCELLANEOUS</b>														<b>Document No.</b>			
														<b>Revision:</b>			
<b>CONTRACTOR:</b> <b>LOCATION :</b>														<b>Page:</b>		1 of 1	
CLIENT : Eskom Holdings Limited								I = INSPECTION									
CLIENT ORDER No:								R = REVIEW									
CONTRACT TITLE:								S = SURVEILLANCE									
								W = WITNESS POINT									
								H = HOLD POINT									
OPERATION No.	PROCESS / ACTIVITY	PROCEDURE / FORM / DOCUMENT REFERENCE	REVISION	ACTIVITY / CONTROL								INSPECTION RESULTS					
				INSPECTION REVIEW SURVEILLANCE WITNESS/HOLD BY						TYPE OF CONTROL REQUIRED							
				Contractor	Eskom Site Supervisor	EO	Client Engineer / LES	Other	VISUAL	DIMENSIONAL	DOCUMENT	NON DESTRUCTIVE EXAMINATION	SIGNATURE			Date	Remarks
													Contractor	Client Site Representative	Client Engineer		
7	Miscellaneous	Safe Work Procedure and Specification. 240-47172520															
7.1	Step bolts and anti-climbing device installation	Safe Work Procedure and 240-47172520		I	S		S		X								
7.2	Anti-bird perch device installation	Safe Work Procedure		I	S		S		X		X						
7.3	Line identification labels installation	Design, manufacturing and installation specification for transmission line labels – 240-120804300		I	S		S		X		X						
7.4	Tower labels installation	Design, manufacturing and installation specification for transmission line labels – 240-120804300		I	S		S		X		X						
7.5	Crossing labels installation	Design, manufacturing and installation specification for transmission line labels – 240-120804300		I	S		S		X		X						
7.6	Clean and rehabilitate tower site	Environmental requirements		I	S		S		X								
7.7	Line impedance measurements	Line impedance measurement specification, 240-143268945		H	S		W		X		X						
Released by Contractor			Accepted by Client QC							Template Accepted by Client LES			Accepted by Client PM				
Signature			Signature							Signature				Signature			
Name			Name							Name				Name			
Date			Date							Date				Date			

**H - Hold Point:** A predetermined stage beyond which work shall not proceed without the attendance/go-ahead of the client engineering representative. **I - Inspection Point:** A predetermined stage where a check or measurement must be performed to verify parameters and specification requirements. **S - Surveillance:** General Observation. **R - Review:** mean the review of results or records. **W- Witness:** A point in the process that needs to be witnessed by the party indicated.

## 15. APPENDIX I: TECHNICAL TENDER SCHEDULE AND RETURNABLES

### SCHEDULE A: PURCHASER'S SPECIFIC REQUIREMENTS

Description	Schedule A	Schedule B
<b>Structures</b>		
	List of subcontractors to be used on this project supplied?	No <input type="checkbox"/> Yes <input type="checkbox"/>
	Name of tower manufacturer supplied?	No <input type="checkbox"/> Yes <input type="checkbox"/>
	Name of steel supplier supplied?	No <input type="checkbox"/> Yes <input type="checkbox"/>
Steel Lattice Structures	529A, 518H, 518J, 518C, 518D, 518E, 517A, 517E, 517F, 520B, 523A, 523B, 531ED, 540B, 248B	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>
Steel grade	S355JR used on all steel lattice structures	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>
Conductor tension limits	As specified	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>
Tower shackles	As specified	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>
Bolts	As specified	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>
Guys	N/A	As specified <input type="checkbox"/> Other (provide details) <input type="checkbox"/>

Description		Schedule A	Schedule B
<b>Earthing Requirements</b>			
	Compliance to specification as described in <i>Section 4 : Earthing Requirements</i>	No <input type="checkbox"/> Yes <input type="checkbox"/>	
	Subcontractors utilized?	No <input type="checkbox"/> Yes <input type="checkbox"/> If yes, please provide details of subcontractor.	
	Will exoweld or Brazing techniques be employed for electrical connections?	No <input type="checkbox"/> Exoweld <input type="checkbox"/> Brazing <input type="checkbox"/>	
	Are qualified personnel available to perform the work required (exoweld/Brazing)?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
	If exoweld technique is to be used, is validation certificate provided?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
	Is earth tester equipment calibration certificate provided?	No <input type="checkbox"/> Yes <input type="checkbox"/>	
	Alternative earthing designs are to be submitted with drawings for acceptance	No <input type="checkbox"/> Yes <input type="checkbox"/>	

## LIST OF RETURNABLES

Please submit all Engineering documentation described in the tables below in a separate file.

The file must be clearly marked **Engineering Tender Returnables – :**

The documents must be submitted in a **numbering** sequence as described in the tables.

Please note that the minimum score to qualify for further evaluation is **80%**. This evaluation will be done purely on the documentation provided.


Certain documents are compulsory, and indicated as such in the table. The percentage score allocated to each section are shown in brackets.

**Please note the following are Free-issue items:**

- Phase conductor
- Ground wire
- Insulators
- Hardware
- Hardware fittings including aircraft warning spheres and bird diverters

**The listed free issue items are as per LES (Eskom Line Engineering Services) Transmission Line Specification**

Table 15-1: Tender evaluation criteria

 <b>Engineering Tender Evaluation Returnable Form</b> (for a Transmission Powerline)		Template No.:	240-141157901				
		Template Rev:	3				
		Document No:	LES XXX				
		Document Rev:	1				
Name of Project:	Name of line	Name of Supplier:					
Item	Description	Select Option	Tick Applicable Box	Score by Evaluator	Weighting	Details to be submitted in engineering returnable file	Comments from Evaluator
1	Provide SURVEYOR to be used	No Registration (0)		5	5%	. Have an inhouse surveyor or access to a surveyor	
		Registered with no power line experience (2)					
		Registered with one power line project experience (4)					
		Registered with two or more power line project experience (5)					

2,1	Provide a <b>SOIL PROFILER</b> to be used.	No Registration (0)		5	10%	Provide name of the person and list power line projects as soil profiler. In house or external	
		Registered with no power line projects experience (2)					
		Registered with one or more power line projects experience (5)					
2,2	Provide a <b>FOUNDATION Designer</b>	No Registration (0)		5	10%	In house or access to a foundation designer	
		Registered (2)					
		Registered with one power line project experience (4)					
		Registered with two or more power line projects experience (5)					
2,3	Provide a Foundation Supervisor	No experience (0)		5	5%	In house or access to foundation supervisor	
		Two power line projects (4)					
		Three or more power line projects (5)					
3,1	Provide a <b>TOWER ASSEMBLY &amp; ERECTION SITE SUPERVISOR</b>	No experience (0)		5	5%	In house or access to tower assembly and erection site supervisor	
		Two power line projects (4)					
		Three or more line project (5)					

3,2	Provide the Temporary Works Engineer	No Registration (0)		5	8%	In house or access to a temporary works engineer	
		Registration with no experience (2)					
		Registered with one power line project experience (4)					
		Registered with two or more power line projects experience (5)					
3,3	Provide signed letter of commitment from the proposed supplier/fabricator for tower or steel pole	No submission (0)		5	5%	Provide signed letter of commitment from the supplier/fabricator	
		Signed letter of commitment provided (5)					
4	Provide earthing <b>safety supervisor</b>	No Certification (0)		5	8%	In house or access to earthing safety supervisor	
		Certified with no experience (2)					
		Certified with one power line project experience (4)					
		Certified with two or more power line projects experience (5)					
5,1	Provide a DRESSING, STRINGING & REGULATION SITE SUPERVISOR.	No experience (0)		5	4%	In house or access to a dressing ,stringing and regulation supervisor	
		Two power line projects (4)					
		Three or more power line projects (5)					

5,2	Provide a temporary works designer	No Registration (0)		5	8%	In house or access to a temporary works designer	
		Registration with no experience (2)					
		Registered with one power line project experience (4)					
		Registered with two or more line project experience (5)					
6	Provide a suitable support structure that will be used to cross over other power lines, roads and railways (system to cater for impact load in case of failure as well as maintaining sufficient electrical clearance). System shall be suitable to perform the crossing under live or dead conditions	No (0)		5	8%	List details on the different types of crossing support structures to be used indicating <u>dead and live line</u> applicability	
		Only dead conditions (2)					
		Dead and live conditions (5)					
7,1	Please indicate experience in transmission lines construction	No (0)		5	14%	Provide list of power line projects where, foundations, towers and stringing has been performed as well as the role (main contractor/sub-contractor)	
		Yes, as a subcontractor (2)					
		Yes, as a main contractor (5)					



7,2	Provide a project manager	No Registration (0)		5	5%	In house or access to a project manager	
		Registered with no experience (2)					
		Registered with one power line project experience (4)					
		Registered with over two power line project experience (5)					
7,3	Provide a construction site manager	No Registration(0)		5	5%	In house or access to a construction site manager	
		Registered with no experience (2)					
		Registered with one power line project experience (4)					
		Registered with over two power line project experience (5)					
				100%	100%		
A total of 80% or higher is required to pass this engineering tender evaluation							

<b>I HAVE READ AND UNDERSTOOD ALL REQUIREMENTS OF THE TRANSMISSION LINE SPECIFICATION, TRMSCAAC AND OTHER REFERENCED SPECIFICATIONS AND AGREE TO ADHERE TO THESE.</b>					
<b>Technical Tender Returnable Form Populated by:</b>					
<b>Signature:</b>					
<b>Date:</b>					
<b>Overall Comments by Evaluator:</b>					
<b>Evaluated by</b>		<b>Reviewed by</b>		<b>Authorised by LES Senior Manager</b>	
<b>Name of Evaluator:</b>		<b>Name of Reviewer:</b>		<b>Name of Authoriser:</b>	
<b>Signature of Evaluator:</b>		<b>Signature of Reviewer:</b>		<b>Signature of Authoriser:</b>	

Date:		Date:		Date:	
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Score	(%)	Definition
5	100	<b>COMPLIANT</b> <ul style="list-style-type: none"> <li>• Meet technical requirement(s) AND;</li> <li>• No foreseen technical risk(s) in meeting technical requirements.</li> </ul>
4	80	<b>COMPLIANT WITH ASSOCIATED QUALIFICATIONS</b> Meet technical requirement(s) with; <ul style="list-style-type: none"> <li>• Acceptable technical risk(s) AND/OR;</li> <li>• Acceptable exceptions AND/OR;</li> <li>• Acceptable conditions.</li> </ul>
2	40	<b>NON-COMPLIANT</b> <ul style="list-style-type: none"> <li>• Does not meet technical requirement(s) AND/OR;</li> <li>• Unacceptable technical risk(s) AND/OR;</li> <li>• Unacceptable exceptions AND/OR;</li> <li>• Unacceptable conditions.</li> </ul>
0	0	<b>TOTALLY DEFICIENT OR NON-RESPONSIVE</b>
Note 1: The scoring table does not allow for scoring of 1 and 3.  Note 2: Foreseen acceptable and unacceptable risk(s), exceptions and conditions shall be unambiguously defined in the relevant Tender Technical Evaluation Strategy.		

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**Clarification Notes:**

1. It is important to file all documents properly, in separate sections of the file. Clearly mark the sections. (Section 1 -7)
2. Not providing the supporting documentation will result in a ZERO score for that particular question.
3. ECSA is preferred but other equivalent (ECSA acceptable) registrations will be considered.
4. SWP - Safe Works Procedure
5. Please note that if the relevant registered professional mentioned above, changes, the profile of the person taking up this post as a replacement must have an equivalent profile as outlined above.



## 16. APPENDIX K: TOWERS AND HARDWARE CORROSION ADDITIONAL INFORMATION

### 16.1. CORROSION PROTECTION SYSTEM STANDARDS

Table 16-1: Corrosion protection system standards

SANS 121:2011 / ISO 1461:2009	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
SANS 10684:2011	Fasteners – Hot dip galvanized coatings
SANS 1471:1-3:2011	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures
BS EN ISO 3882:2003	Metallic and other inorganic coatings – Review of methods of measurement of thickness
BS EN ISO 2178:2016	Non-magnetic coatings on magnetic substrates – measurement of coating thickness
BS EN ISO 1460:1995	Metallic coatings – Hot dip galvanized coatings on ferrous materials – Gravimetric determination of the mass per unit area
BS EN ISO 8504:1-3:2018	Preparation of steel substrates before application of paints and related products – Surface preparation methods
BS EN ISO 12944:1-9:2017	Paints and Varnished – Corrosion protection of steel structures by protective paint systems

### 16.2. CORROSION SYSTEM SELECTION

Currently the primary protection system and the first line of defence against corrosion is galvanizing of tower steel members, fasteners and hardware components. The thickness of the galvanizing and selection of corrosion protective systems is based on the atmospheric environmental conditions and the estimated corrosion category (C1 to CX) specified (ISO 14713-1; ISO 12944-2).

- C1 very low corrosivity
- C2 low corrosivity
- C3 medium corrosivity
- C4 high corrosivity
- C5 very high corrosivity
- CX extreme corrosivity

Table 16-2: Corrosion categories

Selection of Corrosion System					
Corrosion Category	Tower Members	Fastners	Hardware Components	Conductor and EW	Foundations
C1 to C3	Light Duty Galv	Standard Galv	Standard Galvanising	No grease	
C4	Medium Duty Galvanising	*Duplex system or alternative coatings	**Standard Galvanising with alternative coating on fasteners	Case 2	

C5	Heavy Duty Galvanising or Medium duty with *Duplex system	*Duplex system or alternative coatings	**Standard Galvanising with alternative coating on fasteners	Case 4	
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\*Duplex system to be applied to specified components stated in section 18.4.

\*\*The body of the components should be standard galvanising, but the fasteners of the components should be the same system selected for tower fasteners.

### 16.3. GALVANISING

Hot dip galvanising shall be in accordance with the requirements of SANS 121 (ISO 1461) and SANS 10684 for fasteners. A minimum coating thickness specified in **Section 2.3** is described in **Section 18.3.1** below.

#### 16.3.1. Coating classifications

Coating classifications (CC) below indicate the mean coating thickness described in SANS 121 (ISO 1461). **Table 16-38.3** expands on SANS 121 to include medium and heavy duty coatings and their requirements. **Table 16-38.3** should be used in the same manner as Table 3 in SANS 121 (ISO 1461) when inspecting coating thickness. The thickness description next to the coating classification describes the mean coating thickness expected on members greater than 6 mm and is used to refer to a certain coating classification.

Light Duty - 85 µm

Medium Duty - 105 µm

Heavy Duty - 140 µm

**Table 16-3: Minimum coating thickness and mass on samples that are not centrifuged**

Article and its thickness	CC	Local coating thickness (µm)	Local coating mass (g/m <sup>2</sup> )	Mean coating thickness (µm)	Mean coating mass (g/m <sup>2</sup> )
Steel > 6 mm	Light	70	505	85	610
	Medium	90	648	105	755
	Heavy	125	900	140	1008
Steel > 3 mm to ≤ 6 mm	Light	55	395	70	505
	Medium	73	525	88	633
	Heavy	110	792	125	900
Steel ≥ 1.5 mm to ≤ 3 mm	Light	45	325	55	395
	Medium	54	389	69	497
	Heavy	95	684	110	792
Castings ≥ 6 mm	Light	70	505	80	575

**Table 16-4: Minimum coating thickness and mass on samples that are centrifuged**

Article and its thickness	Local coating thickness (µm)	Local coating mass (g/m <sup>2</sup> )	Mean coating thickness (µm)	Mean coating mass (g/m <sup>2</sup> )
Articles with threads:				
> 6 mm diameter	40	285	50	360
Other articles (Including castings)				
≥ 3 mm	45	325	55	395

### 16.3.2. Acceptance and Inspection

Acceptance inspections should be undertaken by the contractor before the material leaves the hot dip galvaniser. Records of these inspections shall be kept for auditing purposes and sent to the project manager for record keeping. The Eskom quality inspector should be notified to verify the measurements obtained by the contractor. The number of articles to be tested in a sample is specified in SANS 121. However, a lot is defined as a single delivery load and the control sample size is based on the number of each component type included in the delivery load. Each component classification forms its own control sample size within the lot e.g. 45x45x3, 50x50x4, etc.

If the thickness on a control sample does not conform to the values stated in **Table 16-38.3** and **Table 18.4**, twice the original sample number of articles shall be taken from the lot. If this larger control sample passes, the component classification for that lot shall be accepted. If the larger control sample does not pass, the component classification for that lot shall not be accepted.

### 16.3.3. Material composition

Certain elements, in particular silicon (Si) and phosphorus (P), in the steel surface can affect hot dip galvanising by prolonging the reaction between iron and molten zinc. Therefore, certain steel compositions can achieve more consistent coatings with regards to appearance, thickness and smoothness. The steel selected for manufacturing purposes of poles and lattice structures should be suitable for hot dip galvanising. In general two steel types are acceptable namely "Aluminium Killed Steel" and "Silicon Killed Steel". **Table 18.3** shown in SANS 14713-2 gives a guidance on steel composition and typical coating characteristics that can be expected.

- For Aluminium Killed Steel: **0.01 ≤ Silicon (Si) ≤ 0.03%** and **Phosphorous (P) < 0.02%** maximum.
- For Silicon Killed Steel: **0.15 ≤ Silicon (Si) ≤ 0.25%** and **Phosphorous (P) < 0.02%** maximum.

### 16.3.4. Surface Preparation

The surface should be free from defects to ensure a coating of good quality and serviceability. Unless otherwise stated, all galvanised items shall be passivated. The passivating coating shall be applied to the material immediately after galvanising to afford temporary protection to the galvanising surfaces. This coating shall be even, and shall be sufficiently transparent to enable Eskom's appointed inspectors to examine the underlying surfaces for any defects.



#### 16.3.5. White Rust

All material shall be free from excessive white rust and black staining when it is handed over to Eskom. To assist in meeting this requirement, close attention shall be paid to the manner in which the material is stacked and stored at the galvaniser's works and also during its subsequent handling until such time as it is handed over to Eskom. Material which has been inspected at the galvaniser's or manufacturer's works and passed by appointed inspectors will still be liable to rejection if it has been found that excessive white rust has developed between the date of inspection and the date when the material is handed over to Eskom. If the material is affected by excessive white rust the contractor may clean it (using non-metallic brushes) before handing over and if weight of zinc coating still meets the requirements specified in the appropriate tables of the SANS ISO 1461, the material will be accepted.

#### 16.3.6. Site Repairs

The preferred method of repair is by zinc metal thermal spraying, but due to the remoteness of sites and the unavailability of metals spraying equipment, repairs by a zinc-rich epoxy paint (of at least 100 µm or more than specified galvanising thickness) with at least 82% zinc in the dry film can be used. These repairs should be limited to small coating defects not larger than 25 mm diameter. Surface preparation is key and the affected area should be cleaned of contaminants (grease, oil, etc.) by means of approved solvents. The area should then be abraded with abrasive paper (80 grit roughness) or with a stainless steel brush. Dust and debris should be removed, and the area is adequate for repair using an approved product. For convenience of application and accurate mixing of ingredients that make up the zinc rich epoxy, products approved by the HDGASA in a "squish pack" form can be used.

#### 16.3.7. Responsibilities

- a) The contractor shall include the number of the standard i.e. SANS 121 (ISO 1461), in the instruction to the hot dip galvaniser
- b) Thickness requirements indicated in **Section 2.3** shall be clearly communicated to the hot dip galvaniser.
- c) 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. These reports shall be supplied to the hot dip galvaniser to ensure thickness requirements can be achieved.
- d) If the galvaniser receives the composition certificate (stated above), the responsibility will be placed on the galvaniser to ensure the requested thickness is reached (based on data if steel is compatible to reach such thickness).
- e) Pre-treatment requirements, if necessary to achieve thickness requirements, shall be discussed between the contractor and the hot dip galvaniser and clearly indicated to Eskom.
- f) Galvaniser to provide a certificate with regards to work done (avg. thickness achieved, surface preparation, etc.)
- g) The responsibility of releasing the steel from the galvaniser's yard falls on the contractor to check the quality of the galvanising and conduct testing according to SANS 121 and information shared in this document. Eskom quality inspector shall be notified of such testing to be able to verify the contractor's results.

## 16.4. ADDITIONAL COATING SYSTEMS

This section deals with the additional corrosion protection coating (duplex system) to be used where specified for new Eskom equipment exposed to outdoor environments and covers coatings for hot dip galvanised mild steel.

### 16.4.1. Material Selection

#### 16.4.1.1. System

Requirements for an additional coating system will be specified for each component application.

#### 16.4.1.2. Material Supply

- a) All materials, i.e. paint, solvents and cleaning agents for a specific paint system shall be supplied by the same manufacturer.
- b) All coatings, solvents and cleaning materials shall be supplied in sealed, sturdy containers which have been labelled with all the information necessary to ensure proper storage, mixing, application and traceability. The coating containers shall be of a size large enough to allow mixing in the containers themselves.

#### 16.4.1.3. Material Storage

Storage instructions received from the supplier should be followed at all times.

- a) All containers (i.e. coatings, solvents and cleaning materials) shall be kept in a storage area that is completely dry, enclosed, well ventilated, covered and maintained at a temperature compatible with good preservation of the materials.
- b) Should any of the coating containers show traces of leakage prior to use, the contents of that container shall not be used.
- c) Similar to the coatings, all abrasive media shall be stored in an area that is completely dry and covered to allow for good preservation of the materials.

### 16.4.2. Surface preparation

It is extremely important that the Contractor endeavour to achieve the best surface preparation, as described in the manufacturer instruction sheet, possible to ensure proper adhesion. All harmful contaminants such as scale, grease, oil, soil, salt residues, corrosion product and any foreign matter or residues that may affect the performance of the coating system shall be removed, prior to application of the protective system.

### 16.4.3. Guarantees

Since the Contractor is obliged to submit signed product data sheets at the time of the Contract Order Acceptance, in doing so, and by supplying materials to the Contractor, both the Contractor and his paint supplier bind themselves to a minimum guarantee period of 36 months in terms of the performance of the corrosion protection system.

As a minimum, the guarantee regarding the performance of the corrosion protection system is stipulated as follows:

The coating will be considered defective should rusting of the coated surfaces develop within 36 months where it is rated more than Ri 1 or 0.05% (in accordance with ISO 4628-3)

and/or

Blistering, flaking, delamination, cracking, alligatoring, or any other defects not specifically listed, are present that in the opinion of the Project Manager or his coating specialist, reduces the aesthetic appearance or compromises the integrity of the coating system.

#### **16.4.4. Responsibilities**

- a) The contractor is responsible to use the requirements provided in the relevant line specification and submit it to a paint supplier to be used for each activity specified.
- b) The contractor will ensure that all the necessary product documentation requested in the requirements section in the relevant design documentation is sufficient. The contractor will submit these documents to Eskom for review and record-keeping purposes.
- c) The contractor should follow the supplier application instructions on the system to ensure the best possible outcome. Coating thickness will be measured after application following supplier instructions.
- d) Eskom will require the contractor to supply a guarantee certificate at the end of a project for the paint supplier, for each specific system supplied, including the product name, transmission line name, contractor name and guarantee period.
- e) If the contractor cannot provide Eskom with a certificate with the initial durability requirements with stated reason. The contractor should be held liable for maintenance on the system.
- f) It is preferred that the paint system should be applied at the galvanising yard, alternatively it can be applied on site with a clear indication from the supplier how it would affect the guarantee.

#### **16.4.5. Additional Coating System Requirements**

##### **16.4.5.1. Fasteners**

During the punching and painting exercise, the threads on the bolt are damaged using a “punch” to keep the nut from vibrating loose. This however damages the galvanising on the nut and bolt and should be repaired. The painting of the nut and bolt however serves as an additional barrier to the atmospheric conditions that should extend the life of these components. This is necessary as the nut and bolt are seen as the “weak link” on the structure design due to the limitations on coating thickness on galvanising and that the nut thread is cut after galvanising.

There are two possible scenarios with the painting of the nut and bolt.

- Painting of the nut and bolt after punching has occurred to help protect the area where galvanising was damaged (standard method).
- Painting of the complete nut and bolt, including on the inner threads of the nut, as the tower is assembled in C4-C5 environments.

The paint system requirements for this activity are:

**1) Surface**

- Newly or slightly Weathered HDG surface

**2) Coating type**

- Single Stage Application
- Solvent or water-borne base coating

**3) Application method**

- Brush (on site application)

**4) Environment**

- C3
- Surface temperature range of 0 to 50°C (estimated, should be verified with conditions)

**5) Durability**

- Medium (7-10 years)

**6) Guarantee**

- 3 years

**7) Colour Requirements**

- Should stand out for easy inspection e.g. yellow

**8) Supporting Documents**

- Safety Data sheet
- Signed Technical data sheet
- Salt spray Test reports (1000h for C2-C3)
- UV Test reports
- adhesion testing

**9) Material Supply**

- All material shall be supplied by the same manufacturer
- All material shall be properly sealed and stored as per the manufacturer requirements

**Preference will be given to products that minimize the impact on the environment and health, which includes:**

- Toxic or carcinogenic substances;
- Emissions of volatile organic compounds (VOCs);
- Harmful effects of fumes, dust, vapours, as well as fire hazards;
- Protection of water and soil during corrosion protection work;

- 
- Recycling of materials and waste disposal.