Eskom	Report	Transmission

Title: Ariadne Eros 2 400/132 kV multi-circuit line – Transmission Line Specification

Template Unique Identifier:	240-86978162
Project Unique Identifier:	TX.2014
Document Unique Identifier:	LES 1558
Area of Applicability:	Engineering
Documentation Type:	Report
Revision:	2
Total Pages:	144
Next Review Date:	N/A
Disclosure Classification:	CONTROLLED DISCLOSURE

Revision Control

Revision	Change Log	Date
0	First Issue	June 2015
1	Updated with new addendum showing updated specifications, and division of line into Section A and B	Feb 2021
2	Template updated to current line specifcation template , changes to co-incide with TRMSCAAC rev 6 and latest standards. Technical tender returnables have been removed from the specification and are now a separate document .	May 2022

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1. PROJECT DESCRIPTION

The Ariadne Eros 400/132 kV overhead line has the following characteristics:

(Note: This Specification is valid for a period of 12 months and if the project is not executed within the year then a new specification document will be required.)

Due to the terrain covered by the length of this transmission line access will be challenging in some sections and alternative construction methods maybe required.It should be noted that a portion of the multicircuit line has already been constructed .

Table 1.1: Project Details

Line route	The Ariadne-Eros multi-circuit line will run from Ariadne near Pietermaritzburg to St Faiths near Oribi. The 400kV line will then continue onwards to Eros Substation near Harding. *The complete design accommodates for the end stage of the project* .The scope of this specification is limited to the 105km 400/132kV of multi-circuit line starting at Ariadne and switching over to 400kV structures for 55km to Eros . The turn ins to St Faiths Substation will be completed at a later stage .
Line length	Approximately 175 km
Conductor for 2 Ari- Ero 400/132kV	Triple IEC315,(IEC Code 315-A1/S1A-45/2.99+7/1.99) will be used on the 400kV circuit Single IEC 315,(IEC Code 315-A1/S1A-45/2.99+7/1.99) will be used on the 132kV circuit Line will be template @ 60 degrees Rate A = 1433MVA Rate B = 1991MVA C – Value: 1800 m (Some sections required a lower C value please see staking tables for full details) Conductor weights were required on some sections of the line to reduce blow out . *Ensure that when stringing, particular emphasis* is placed on the condition of rollers, stringing equipment, handling of conductor to ensure no nicks or scratches are made on the conductor. Repair sleeves on conductors to be painted in high visibility RED.
Conductor and Jumpers for line deviations	Tern ACSR (IEC Code 403.77-A1/S1A-45/3.38+7/2.25) will be used on the Ariadne – Hector 1. Kingbird ACSR (IEC Code 323.01-A1/S1A-18/1/1/4.78) will be used on the Ariadne-Eros 1 section that will be part of the line swap. Repair sleeves on conductors to be painted in high visibility RED.

Groundwire for 2 Ari- Ero 400/132kV	12kA OPGW Horse ACSR Conductor C – Value: 2100 m
Groundwire for Deviations	19/2.65 for Ari-Ero 1 line swap
Insulators	120kN and 210kN Composite long rod (31 mm/kV creepage) will be used throughout the line. 120kN Composite longrod insulators will be used for the Earthwire where required. On site, insulators be wrapped in canvas sheet with the use of Velcro for protection during dressing of a tower.
Hardware	Standard I-assembly and strain structure hardware.(400kV circuit) Standard I -assembly,V-assembly and strain structure hardware. (132 kV circuit) (As per SANS 10280:2013) with live line fittings. **Take note that:** Corona-free washers or similar hardware must be used for spacer dampers, vibration dampers and jumper flags. To reduce the adverse impact of bird streamers: The smallest grading rings that a hardware supplier has available must be used. Ensure preformed Fittings (not bolted) are used for spacers , warning spheres and other accessories All major road crossings, shall have aircraft warning spheres at the respective crossing spans. Use of "Belleville" washers or similar hardware must be used for spacer dampers, vibration dampers and jumper flags. (as per SANS 10280:2013) with live line fittings.

Towers types	New Fall Arrest Anchors (FAA) to be used on all towers and towers to be fitted with "DANGER" signs in high public exposure areas. The following tower family will be used: • 527 A Self-supporting Suspension • 527 C Self-supporting Angle Strain towers (0°-30°) • 527 D Self-supporting Angle Strain (35°-60°) and (0°-45°) terminal • 515 A Self-supporting Suspension • 515 C Self-supporting Angle Strain towers (0°-45°) • 515 D Self-supporting Angle Strain (15°-35°) • 515 E Self-supporting Angle Strain (35°-60°) and 0 ° terminal • 518 C Self-supporting Angle Strain towers (0°-45°) • 518 D Self-supporting Angle Strain (45°-70°) • 518H Self-supporting Heavy Suspension • Inline strain towers to have two long crossarms. • Fall arrest anchors (FAA) and access ladders must be installed on towers. • The fall arrest system must be removed upon completion of construction. • H-poles, cranes with wooden frame net and cranes with netted running blocks may be used for road, Distribution line crossings. • Nylon ropes must be used as pilot wires during the stringing of ground wires. • During tower erection the contractor must **use anchor blocks on sledges for backstaying. It is the contractor's responsibility to ensure that the number of anchor blocks is adequate.** • No trucks, tractors and other vehicles must be used for backstaying or for hoisting components. Winches must be used. • 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). • Swage type anti-vandal bolts must be installed up to and including the level of the anti-climb device. All anti-vandal bolts must be installed prior to stringing. 60% of all plates and one hole per member to be changed. (As per Anti-vandal guideline for overhead powerlines :240-147174608) • Tower drawings will reflect more information on items like Eskom anti-theft marking and anti-climb distances etc. • Towers will be fitted with Arial warning lights and/or warning spheres as deemed necessary by the CAA civil aviation authority, during its evaluation of the line route.

	Contractor to be aware that all come along clamps and other rigging equipment must have necessary certificates. Prototypes must be done for each tower type as per TRMSCAAC Rev 6.
Foundations	Self-Supporting type towers: • Spreader type: Pad and Pier foundations • Pile type: augured piles (vertical only), micropiles, grouted driven piles etc. • Some towers will require extended stubs to reach the required conductor attachment height due to undulating terrain. Take note that: An on-site laboratory must be installed for the curing and testing of concrete cubes. Proof load tests must be conducted on a minimum of 5% of all installed anchors. Foundations will be raised to 650mm to prevent accumulation of soil at concrete –steel interface.. It is compulsory for contractors to price on conventional (pier and pad) and piles (augured, micropile, grouted driven piles etc.). For piles ensure that the bill contains six soil types and should indicate installed cost per tower. Although piles could be used, the option still exists for a cheaper rock anchor. Contractor to ensure that concrete poker vibrating, back filling and compaction of foundations to be done according to the standard 240-47172520, latest revision. Soil sampling during soil nomination phase – Add a bill item for contractor to take samples of minimum of 2% of the line and send to an approved scientific soil sampling lab for evaluation of specific geotechnical properties (e.g. modulus of elasticity, rate of consolidation under loads, rebound curves etc). Soil resistivity checks should be considered at this point.. Geotech should be done according to the spec so that rock is not encountered by surprise. If for some reason rock is encountered (e.g. large boulders) incorporate the rock in to the foundation design, consult LES during construction.
Corrosion protection	• *Refer to 240-75655504 for Corrosion Protection Standard for New* Indoor and Outdoor Eskom Equipment, Components, Materials and

	Structures Manufactured from Steel Standard, specifically section 3.8.2 on Performance Guarantee and TRMSCAAC Rev 6. • Additional Galvanizing (Minimum of 105μm) on Towers and Hardware. Defined by SANS 121. • Case 2 greasing (IEC 61089) of Conductors and Groundwires. • Bitumen coating at the corrosion zone (500mm below and 500mm above the concrete-steel interface of the foundation stub). • Thermal diffusion coating on bolts including holding down bolts and corrosion protection paint on tower (Coastal section).
Tower Footing	• First tower footing measurement done by contractor must be witnessed by Eskom lines Designer. • Contractor to stipulate the means of measurements (with earthwires connected or with tower but no earthwires connected). • Less than or equal to 20 Ohm tower footing should be targeted. • Towers 2-5 outside the substations need to be between than 10 Ohm and 20 Ohm. • If >20 Ohm and higher seek advice from LES design engineer before implementing any solution. • Device to measure should have a filter and high current features to enable valid earth testing in difficult situations. • Earth resistance range of 0.010 Ohms to about 19.99 kilo Ohms. Contractor to provide specification for the equipment that will be used for testing.
Ground Clearance and Templating	• Minimum 10m ground clearance maintained throughout line • 16m ground clearance is maintained over sugarcane. • 14m ground clearance is maintained through game reserves for Giraffes • All conductors templated @60 °C
Animal Guards	• The contractor shall install the anti bird perch devices in accordance to the guideline that is stated in Eskom specification 240-126259196.
Anti-Climb & Anti-Theft	• Anti-climb devices to be installed on all towers. • Anti-climb devices as per manufacturing drawings (palisade type). • Swage type anti-vandal bolts must be installed up to and including the level of the anti-climb device. All anti-vandal bolts must be installed prior to stringing. 60% of all plates and one hole per member to be changed. (As per Anti-vandal guideline for overhead powerlines :240-147174608)

	• All steel members up to anti-climb device level shall be stamped with the word "ESKOM" at 300mm - 500mm intervals as mentioned in the Tower section above.
Line Impedance Measurement	Line impedance measurements to be done prior to energising utilising specification 240-143268945.
Line Labels	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. Install High Voltage danger signs for towers as per NRS041-1-2013 and DST-34-1168.
As-Built Spec	As Built information to be provided as per Eskom requirements (As-Built Document 240-72252925). This must include Aerial Laser survey.
Fall Arrest Systems	• Fall Arrest system must be removed after construction. • Make use of horizontal fall arrest system in beam of towers.
Safe Working Procedures	No construction work will be done until all such safe working procedures of sound logic are reviewed and accepted by LES.
Risk and Hazard Identification	• Electrocution risk due to induction, electromagnetic fields and static (mitigate using proper earthing practices). • Public Unrest (Designer unable to mitigate). • Areas prone to erosion, erosion on access roads, • Access to some tower positions is limited due to terrain • Rigging equipment must be tested timeously and valid certificates must be available. • Alternative construction methods, such a gin pole/helicopter or similar will be required in some areas. • Refer to generic risks contained in the "Construction Risk and Mitigation Plan" in this addendum.
QITP	Sample QITPs are provided in **Appendix H** containing some of the minimum requirements
Tower Test Loads	All tower test loads to be adhered to during construction. These loads must be used when calculating back-stay requirements.
Bush Clearing	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 EA, EIA, EMPr and Construction and Operation EMP.

Crossings	**The multicircuit section has** 2 TX crossings (275kV- Georgedale Venus 1 & 2) 5 Dam crossings(300m,60m,138m,200m and 200m respectively) Approx. 72 Dx crossings (11kV-22kV) (See templating report for Details on all crossings) **The single circuit section has** 1 major highway crossing (N2) 2 minor river crossings (10m and 20m respectively) 2 major river crossings (40m and 100m respectively) Approx. 25 Dx crossings,(11kV-88kV) (See templating report for Details on all crossings)
Environmental	The number of berms required will be commented on by the LES Civil Engineer. The Design Leader will coordinate this meeting between the Environmental Practitioner and the LES Civil Engineer.
Ice Loading	The line falls outside the areas that pose a risk to ice/snow loading. No additional ice loading criteria was applied to the design. Only the standard 10mm radial ice was applied to calculate the wind and weight spans that were used.
Line Construction Tender Evaluation Process	This scope of work will be split into 3 sections 1- Tower Steel Supply 2- Survey and Foundation Construction 3- Tower Assembly , Tower Erection and Stringing The separate evaluation criteria to be used can be found in **Appendix I.**
Health and Safety Plan	Contractor to submit a Health and Safety Plan. All Safe Work Procedures to be drafted and approved by a suitably qualified person from their company with powerline experience for acceptance by Eskom LES. All necessary temporary works to be signed off by a appointed temporary works engineer. SWP's include: 1. Foundation construction (min Pr Eng Civil) 2. Tower assembly 3. Tower erection 4. Stringing and regulating 5. Major crossings and electrified railway crossing.

Major Deviations	There are two major deviations on this line. Both of these deviations are required to be completed early in the construction phase, or as soon as outages can be obtained. 1 ARI/HEC · The terminal tower of the1 Ari / Hector Double Circuit line will be replaced due to space constraints around the Ariadne Substation. The current tower will be dismantled, foundations removed if needed and a new tower (523C) will be built and the last two spans restrung. 1 ARI/ERO · To avoid the crossing of the existing Ariadne Eros 1 and the new Ariadne Eros 2 a line swap for a short section of the line is necessary. · Ariadne Eros 1 will be deviated from tower 1 A/E 5 to new structures and cut back in on to existing structures at tower 1 A/E 9. · Ariadne Eros 2 will then use the existing Ariadne Eros 1 towers 6 -8 before returning to new structures.
Construction Challenges	Extremely undulating terrain is prevalent over certain sections off the single circuit and multi-circuit line. Alternative construction methods to a conventional crane such as helicopter,gin pole etc. will be necessary.

1.1. TOWER DRAWINGS

527A	Self-Supporting Suspension Structure – 400/132kV Tower Type 527A (outline drawing)
527C	Self-Supporting 0°- 30° Strain Structure – 400/132 kV Tower Type 527C (outline drawing)
527D	Self-Supporting (35°- 60°) Angle Strain &(0°-5°) Terminal Structure– 400/132kV Tower Type 527D (outline drawing)
515H	Self-Supporting Heavy Suspension Structure – 400kV Tower Type 515H (outline drawing)
515C	Self-Supporting 0°- 15° Strain Structure – 400kV T ower Type 515C (outline drawing)
515D	Self-Supporting 15°- 35° Strain Structure – 400kV Tower Type 515D (outline drawing)
515E	Self-Supporting (35°- 60°) Angle Strain &(0°) Ter minal Structure– 400kV Tower Type 515E (outline drawing)
518H	Self-Supporting Heavy Suspension Structure – 400kV Tower Type 518H (outline drawing)
518C	Self-Supporting 0°- 45° Strain Structure – 400kV T ower Type 518C (outline drawing)
518D	Self-Supporting (45°- 70°) Angle Strain &(0°) Ter minal Structure– 400kV Tower Type 518D (outline drawing)

Table 1.2: List of Tower Drawings

These tower drawings can be found in **Appendix B**.

1.2. HARDWARE DRAWINGS

TOWER TYPE	HARDWARE	DRAWING NUMBER
515H	Suspension V-String Suspension I-String	V SUSP ASSY 4xxxxx 120kN 380mm I SUSP ASSY 4xxxxx 120kN 380mm
515H	Earthwire Suspension Assembly	30-120kN_ESUS1-001
515C,D,E	Strain Assembly Compression Slack Span Assembly Bolted Slack Span Assembly	S STR ASSY 4xxxxx 300kN 380mm COMP SLACK SPAN ASSY 4xxxxx 300kN 380mm BOLTED SLACK SPAN ASSY 4xxxxx 300kN 380mm
515C,D,E	Earthwire Strain Assembly	Earthwire str assy
518H	Suspension V-String	V SUSP ASSY 4xxxxx 120kN 380mm 518H
518H	Earthwire Suspension Assembly	30-120kN_ESUS1-001
518C ,D 518D	Strain Assembly Compression Slack Span Assembly Bolted Slack Span Assembly	S STR ASSY 4xxxxx 300kN 380mm COMP SLACK SPAN ASSY 4xxxxx 300kN 380mm BOLTED SLACK SPAN ASSY 4xxxxx 300kN 380mm
518C,D	Earthwire Strain Assembly	Earthwire str assy

527A	Suspension I-String (400kV) Suspension I-String (132kV) Centre Phase Suspension I-String (132kV) Outer Phase Suspension V-String (132kV) Suspension 132kV Phase Arrangement	I SUSP ASSY 4xxxxx 120kN 380mm I SUSP ASSY 4xxxxx 120kN 527 CP I SUSP ASSY 4xxxxx 120kN 527 OP V SUSP ASSY 4xxxxx 120kN 132kV Phase ARR ASSY 4xxxxx 120kN
527A	Earthwire Suspension Assembly	30-120kN_ESUS1-001
527C,D	400kV Strain Assembly 400kV Compression Slack Span Assembly 400kV Bolted Slack Span Assembly 132kV Strain Assembly 132kV Compression Slack Span Assembly 132kV Bolted Slack Span Assembly	S STR ASSY 4xxxxx 300kN 380mm COMP SLACK SPAN ASSY 4xxxxx 300kN 380mm BOLTED SLACK SPAN ASSY 4xxxxx 300kN 380mm S STR ASSY 4xxxxx 120kN COMP SLACK SPAN ASSY 4xxxxx 120kN BOLTED SLACK SPAN ASSY 4xxxxx 120kN
527C,D	Earthwire Strain Assembly	Earthwire str assy

Table 1.3: List of Hardware Drawings

These 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. 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. TOWERS

The Ariadne –Eros 2 multi-circuit overhead transmission line has been designed and profiled using the 527 series of towers, 515 series and the 518 series. Due to undulating terrain guyed structures that were considered in the preliminary stages of the design were considered to be not technically feasible and omitted from the final profiles

2.2. GENERAL LINE DETAILS

The Ariadne –Eros 2 line is split into two major sections. The first section is from Ariadne to the St Faiths turn-ins which is a multicircuit line consisting of one 400kV circuit and one 132kV circuit .The second section from St Faiths turn- ins to Eros is a 400kV line consisting of a single 400kV circuit. Allowances have been made for the turn-ins in tower orientation but the scope of this project is to build the line from Ariadne to Eros .

Table 2.1: General Line Details Section 1

Section 1 : Ariadne – St.Faiths		
Line voltage phase-to-phase	400/132 kV	
Three-phase; single or double circuit	Three Phase; Multicircuit	
Phase configuration	Delta/Flat	
Number of conductors per phase	Three/One	
Number of earth conductors	Two	
Minimum clearance from lowest conductor to earth:	≥ 10 m	
Minimum clearance from conductor envelope to earthed metal:		
Voltage	400kV	132kV
(a) Under still air conditions:	3.2 m	1.45m
(b) Under every day wind conditions to tower steelwork:	2.9 m	1.3m
(c) Under high wind conditions to tower steelwork:	1.0 m	0.35
Dimensions of hardware assemblies:	See separate hardware drawings	

Table 2.2 General Line details Section 2

Section 1 : Ariadne – St.Faiths	
Line voltage phase-to-phase	400
Three-phase; single or double circuit	Three Phase; Single Circuit
Phase configuration	Flat
Number of conductors per phase	Three
Number of earth conductors	Two
Minimum clearance from lowest conductor to earth:	≥ 10 m
Minimum clearance from conductor envelope to earthed metal:	
Voltage	400kV
(a) Under still air conditions:	3.2 m
(b) Under every day wind conditions to tower steelwork:	2.9 m
(c) Under high wind conditions to tower steelwork:	1.0 m
Dimensions of hardware assemblies:	See separate hardware drawings

2.2.1. Wind Loading

A 10 minute wind speed of 29 m/s at a height of 10m 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.

Wind data was obtained from the Durban weather station over a 12 year period from 1995 to 2006 .The maximum wind speed recorded was 19.4m/s which is well below the 29m/s for which the towers were designed.

2.3. CORROSION PROTECTION

The line will run close to the coastline where there is high marine pollution. Corrosion protection should be specified for a very high corrosive area (corrosion category C5) with an expected corrosion rate of ≤ 200μm/yr. The required guarantee period of the paint is 10 - 15yrs.

Refer to 240-75655504 for Corrosion Protection Standard for New Indoor and Outdoor Eskom Equipment, Components, Materials and Structures Manufactured from Steel Standard, specifically section 3.8.2 on Performance Guarantees.

Additional Galvanizing (Minimum of 105μm) to be used on Towers and Hardware for marine environment as defined by SANS 121. Case 2 greasing (IEC 61089) of Conductors and Groundwires will be required.

Bitumen coating at the corrosion zone (500mm below and 500mm above the concrete-steel interface of the foundation stub) must be enforced.

Thermal diffusion coating on bolts including holding down bolts and corrosion protection paint on towers must be enforced for coastal regions..

2.4. PHASE CONDUCTOR AND GROUNDWIRE DETAILS

2.4.1. Phase Conductor

The phase conductor and conductor for jumpers used on the Ariadne-Eros 2 line will be IEC 315 ACSR. The same conductor will be utilised for all circuits on both the multicircuit section and the 400kV section of the line. The details for the conductors to be used on the Ariadne Eros Line Swap and the Ariadne Hector 1 Line Deviation can also be found below. These lines will use Kingbird ACSR and Tern ACSR respectively.

Table 2.3: Conductor for Ariadne Eros 2 (IEC 315 ACSR)

Conductor type 400kV	3 x "IEC 315" ACSR, IEC Code 315-A1/S1A-42/2.99+7/1.99
Conductor type 132kV	"IEC 315" ACSR, IEC Code 315-A1/S1A-42/2.99+7/1.99
Conductor overall diameter (mm)	23.9
Area aluminium (mm²)	315
Area Total (mm²)	337
Aluminium wires (mm)	45/2.99
Steel wires (mm)	7/1.99
Conductor linear mass (kg/km)	1039.6
Ultimate Tensile strength (kN)	79.03
Resistance dc @ 20 °C (Ohms/km)	0.0917
Modulus elasticity final (GPa)	66.6
Coefficient of Linear expansion (1/°C)	21.12×10^{-6}
Greased conductor requirements	Greased (Case 2)

Table 2.4:Conductor for Ariadne Hector 1 lIne Deviation (Tern ACSR)

Conductor type	"Tern" ACSR, IEC Code 403.77-A1/S1A-45/3.38+7/2.25
Conductor overall diameter (mm)	27.00
Area aluminium (mm²)	403.77
Area Total (mm²)	431.60
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)	21.12×10^{-6}
Greased conductor requirements	Greased (Case 2)

Table 2.5. Conductor for Ariadne-Eros 1 line swap (Kingbird ACSR)

Conductor type(400kV)	3 x "Kingbird" ACSR,(IEC Code 323.01-A1/S1A-18/1/4.78)
Conductor type (132kV)	"Kingbird" ACSR,(IEC Code 323.01-A1/S1A-18/1/4.78)
Conductor overall diameter (mm)	23.9
Area aluminium (mm²)	323.01
Area Total (mm²)	340.96
Aluminium wires (mm)	18/4.78
Steel wires (mm)	1/4.78
Conductor linear mass (kg/km)	1038
Ultimate Tensile strength (kN)	71.32
Resistance dc @ 20 °C (Ohms/km)	0.0891
Modulus elasticity final (GPa)	66.2
Coefficient of Linear expansion (1/°C)	21.69×10^{-6}
Greased conductor requirements	Greased (Case 2)

2.4.2. Earth Wire

Table 2.6: Earthwire for Ariadne-Eros 2 (Horse ACSR)

Conductor type	Horse
Conductor overall diameter (mm)	13.95
Area Total (mm²)	73.36
Steel wires (mm)	42.80
Conductor linear mass (kg/km)	541
Ultimate Tensile strength (kN)	60.7
Resistance dc @ 20 °C (Ohms/km)	0.3939
Modulus elasticity final (GPa)	108
Coefficient of Linear expansion (1/°C)	1.58×10^{-5}
Short circuit current rating for 1 s (kA)	8.1
Greased conductor requirements	Greased (Case 4)
Conductor cladding requirements	Steel core to be aluminium clad

Table 2.7: Earthwire for Ariadne Hector 19/2.7 Steel Earth Wire Details

Conductor type	19/2.7
Conductor overall diameter (mm)	13.48
Area Total (mm²)	261.54
Steel wires (mm)	19/2.7
Conductor linear mass (kg/km)	857.00
Ultimate Tensile strength (kN)	142.1
Resistance dc @ 20 °C (Ohms/km)	1.794
Modulus elasticity final (GPa)	193
Coefficient of Linear expansion (1/°C)	1.15×10^{-5}
Short circuit current rating for 1 s (kA)	8.1
Greased conductor requirements	Greased (Case 2)
Conductor cladding requirements	Steel core to be aluminium clad

2.4.3. OPGW

A 12 kA OPGW will be used. See OPGW specification. The OPGW must have the following characteristics:

Table 2.8: OPGW Details

Short circuit current rating for 1 s (kA)	12
Cable diameter (mm)	14.9 - 15.9
Cable mass (kg/m)	496 - 697
Cable ultimate tensile strength (kN)	54 -107
Resistance dc @ 20 °C (Ohms/km)	0.2 – 0.285
No. of fibres	48
Greased conductor requirements	Greased (Case 2)

2.5. DETAILS OF TOWERS TO BE USED

2.5.1. Details of Suspension and Strain Towers for 527 Series

(As per original the design specification for 527 tower series)

Table 2.9: 518 Series Tower Details

Nominal design span:	400 m	
Final phase conductor sag at 50°C for design span :	12.9m	
Minimum clearance from lowest phase conductor to earth:	10 m	
Height of lowest phase conductor attachment point above earth :	21 m	
Minimum clearance from conductor envelope to earthed metal: (a) *Under still air conditions:* (b) Under 15° swing conditions to tower steelwork: (c) Under 55° swing conditions to tower steelwork:	400kV 4.2m 4.2m 1m	132kV 1.45m 1.3m 0.35m
Design angle of swing of single suspension assembly from vertical :	55	
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 b) Minimum	0.425 m 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:	26°
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: b) Below the horizontal:	5° 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: b) angle between the normal to the tower cross-arm and closing span:	0° 35°

2.5.2. Details of Suspension and Strain Towers for 518 Series

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

Table 2.10: 518 Series Tower Details

Nominal design span:	450 m
Final phase conductor sag at 50°C for design span :	14m
Minimum clearance from lowest phase conductor to earth:	10 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: (b) Under 15° swing conditions to tower steelwork: (c) Under 55° swing conditions to tower steelwork:	 3.2 m 2.9 m 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 : c) Maximum d) Minimum	0.425 m 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: b) Below the horizontal:	5° 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: b) angle between the normal to the tower cross-arm and closing span:	0° 35°

2.5.3. Details of Suspension and Strain Towers for 515 Series

(As per original the design specification for 515 tower series)

Table 2.11: 517 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 m
Height of lowest phase conductor attachment point above earth :	18.0 m
Minimum clearance from conductor envelope to earthed metal: (a) Under still air conditions: (b) Under 15° swing conditions to tower steelwork: (c) Under 55° swing conditions to tower steelwork:	 3.2 m 2.9 m 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 :	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: b) Below the horizontal:	 5° 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: b) angle between the normal to the tower cross-arm and closing span:	 0° 30°

2.5.3.1. Tower Installation

According to the Test and Inspection Plan witnessing of the first off erection 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 for Eskom review.Prototype tower assembly of each tower type must be done as per TRMSCAAC 6.

2.6. PROFILING DETAILS

The profiling details of the towers as used in this contract are as follows:

Table 2.12: Wind and Weight Spans as per Profile

DESCRIPTION OF TOWER TYPE	TOWER TYPE NAME	MAXIMUM WIND SPAN (m)	MAXIMUM WEIGHT SPAN (m)
Double Circuit 400/132kV Self Supporting Suspension	527 A	468	500
Double Circuit 400/132kV Self Supporting Strain (0°- 30°)	527C	545	850
Double Circuit 400/132kV Self Supporting Strain (35°- 60°) and (0°- 5°) Terminal	527D	500	850
Self Supporting Heavy Suspension 400kV	515H	500	700
Self Supporting Angle Strain 400kV (0°- 15°)	515C	500	1200
Self Supporting Angle Strain 400kV (15°-35°)	515D	500	1200
Self Supporting Angle Strain 400kV (35°-60°) and (0°) Terminal	515E	500	1200
Suspension, Self-Supporting	518 H	680	1000
0°- 45° Angle Strain	518 C		
0°- 45° Angle Strain		500	1200
0°- 45° Angle Strain(Inline Strainer)		900	1200
45°-70° Angle Strain & 0° Terminal	518 D		
a.) 45°- 70° Angle Strain		500	1200
b.) Inline Strainer		1000	1200
c.) 0° Terminal		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. The spans above were calculated according to the loading code as per SANS 10280-1:2013.

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 in order 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 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.

The values indicated for the strain towers in the transverse and vertical direction are the maximum for a single side of the landing plate. If additional information is required, please contact the design engineer.

Table 2.13: Tower Test Loads

TOWER TYPE	Transverse (kN)	Longitudinal(kN)	Vertical(kN)
518H Earthwire	15.18	30	18.3
Conductor	91	74.31	159
518C Earthwire	18.66	28.1	7.5
Conductor	145.1	218	64
518D Earthwire	25.9	25.3	11.3
Conductor	214	196	96
518E Earthwire	12.72	30	8.74
Conductor	75.4	74.2	95
515C Earthwire	20.81	31.04	15
Conductor	92.04	114.3	58.46
515D Earthwire	32.48	30.53	15
Conductor	139.5	111.9	58.46
515H Earthwire	12.26	31	35
Conductor	62.3	53.4	80
527A Earthwire	7.3	18	3.6
Conductor (400kV)	31	57	40
Conductor (132kV)	10	19	16
527A Earthwire	12.7	20.08	7.1
Conductor (400kV)	90	89.66	50
Conductor (132kV)	30	29.89	16.66
527A Earthwire	39.48	38.39	4.75
Conductor (400kV)	160.62	156.67	33.67
Conductor (132kV)	53.54	52.06	11.28

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 so as to prevent the nut from working loose. Confirmation of tower shackle sizes is to be obtained by the contractor before manufacturing starts. **All tower shackles are considered part of the tower and have to 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 2.14: Tower Shackle Details

Tower Type	Shackle		
	Attachment	**Capacity(kN)**	**Bolt Diameter(mm)**
518C	Earth Wire	210	20
	Phase Conductor	450	30
518D	Earthwire	210	20
	Phase conductor	450	30
518H	Earth Wire	120	16
	Phase Conductor	300	24
515C	Earth Wire	120	16
	Phase Conductor	600	36
515D	Earth Wire	120	16
	Phase Conductor	600	36
515E	Earth Wire	120	16
	Phase Conductor	600	36
515H	Earth Wire	120	16
	Phase Conductor	200	20
527A	Earth Wire	120	16
	Phase conductor 400kV	120	16

	Phase Conductor 132kV	120	16
527C	Earth Wire	120	16
	Phase conductor 400kV	300	24
	Phase Conductor 132kV	120	16
527D	Earth Wire	120	16
	Phase conductor 400kV	300	24
	Phase Conductor 132kV	120	16

3. FOUNDATIONS, CIVIL AND GEOTECHNICAL SPECIFICATIONS

All foundations shall be constructed in accordance with Eskom Technical Instruction 240-47172520 (latest revision).

3.1. 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.

These additional partial load factors could, for example, allow for strength and performance inconsistencies in the various construction materials used, associated construction difficulties and human error, impairment of long-term performance due to creep, inconsistencies within the soil or rock to which the applied load will be transferred, etc.

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. The long-term performance is affected by:

a) Creep and variations within the soil or rock, and
b) Inconsistencies in the various construction materials used, which are associated with construction difficulties, soil erosion, chemically aggressive founding material, human error, etc.

3.2. FOUNDATION LOADS

All αd values provided in the tables below are indicative and must be confirmed with the appropriate leg drawings for their respective body extensions before construction .

3.2.2 The 515 Series Towers

Factored Foundation Reactions for Critical Loading Conditions:

Table 3.1: Factored Foundation Reactions for the 515 Series Towers

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)			
TOWER TYPE 515A	**TOWER TYPE 515C**	**TOWER TYPE 515D**	**TOWER TYPE 515E**
COMPRESSION			
C = 660	C = 884	C = 892	C = 1171
X = 106	X = 44	X = 40	X = 79
Y = 100	Y = 29	Y = 28	Y = 41
UPLIFT			
U = 458	U = 692	U = 770	U = 960
LEG SLOPE & STUB SIZE			
αd = 11.58°	αd = 16.86°	αd = 18.10°	αd = 20.13°
A = L120x120x10	A = L150x150x12	A = L150x150x12	A = L150x150x18

load factor applied in table above = **1.2**

C = Compression load acting in direction of tower leg
U = Uplift load acting in the direction of the tower leg
X = Horizontal residual shear load acting in the transverse direction
Y = Horizontal residual shear load acting in longitudinal direction
αd = True angle of tower leg measured from vertical along the tower diagonal plane
A = 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.

3.2.3 The 518 Series Towers

Factored Foundation Reactions for Critical Loading Conditions:

Table 3.2: Factored Foundation Reactions for the 518 Series Towers

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)			
TOWER TYPE 518C	**TOWER TYPE 518D**	**TOWER TYPE 518E**	**TOWER TYPE 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
LEG SLOPE AND STUB SIZE			
αd =17.98 A =L 200x 200x 16	αd =19.29 A = L 200x 200x 16	αd =11.97 A = L 150x 150x 10	αd =15.48 A = L 120x 120x 12

load factor applied in table above = **1.2**

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)		
TOWER TYPE 518C **Sugarcane (Body Extenison 12 m, 18m, 24m)**	**TOWER TYPE 518D** **Sugarcane (Body Extenison 12 m, 18m, 24m)**	**TOWER TYPE 518H** **Sugarcane (Body Extenison 12 m, 18m, 24m)**
COMPRESSION		
C = 1728	C =2359	C = 95
X = 100	X = 115	X = 30
Y =72	Y = 114	Y =25
UPLIFT		
U = 1392	U = 1886	U = 608
LEG SLOPE AND STUB SIZE		
αd =17.98 A =L 200x 200x 16	αd =19.29 A = L 200x 200x 16	αd =15.48 A = L 120x 120x 12

load factor applied in table above = **1.2**

C = Compression load acting in direction of tower leg
U = Uplift load acting in the direction of the tower leg
X = Horizontal residual shear load acting in the transverse direction
Y = Horizontal residual shear load acting in longitudinal direction
αd = True angle of tower leg measured from vertical along the tower diagonal plane
A = 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.

3.2.4 The 527 Series Towers

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)		
TOWER TYPE 527AM	**TOWER TYPE 527CM**	**TOWER TYPE 527DM**
COMPRESSION		
C = 758	C =1750	C = 1728
X = 67	X = 61	X = 53
Y = 40	Y = 44	Y =52
UPLIFT		
U = 637	U = 1565	U = 1488
LEG SLOPE AND STUB SIZE		
αd =11.11	αd =10.69	αd =15.08
Stub size refer to tower drawings as stub sizes may vary between body extensions		

load factor applied in table above = **1.2**

SELF-SUPPORTING TOWERS (ALL LOADS IN kN)		
TOWER TYPE 527AM **Sugarcane**	**TOWER TYPE 527CM** **Sugarcane**	**TOWER TYPE 527DM** **Sugarcane**
COMPRESSION		
C = 876	C =1838	C = 1829
X = 38	X = 104	X = 61
Y = 29	Y = 70	Y =53
UPLIFT		
U = 704	U = 1608	U = 1560
LEG SLOPE AND STUB SIZE		
αd =11.11	αd =10.69	αd =15.08
Stub size refer to tower drawings as stub sizes may vary between body extensions		

load factor applied in table above = **1.2**

C = Compression load acting in direction of tower leg
U = Uplift load acting in the direction of the tower leg
X = Horizontal residual shear load acting in the transverse direction
Y = Horizontal residual shear load acting in longitudinal direction
αd = True angle of tower leg measured from vertical along the tower diagonal plane
A = 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 GENERIC SPECIFICATION INFORMATION

The contractor is to have their own concrete cube testing facility (site laboratory) on site and is to test the cubes in accordance with TRMSCAAC 6 240-47172520.

At least 5% of all guy tower foundations along the line need to be proof load tested in accordance with the specification stipulated in TRMSCAAC 6 240-47172520. This is to ensure quality of work and to determine that the correct soil nominations.

For other specifications information see **Appendix E**.

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. Should a null balance insulation tester be used, 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 TST41-321 – "Earthing of Transmission Line Towers" standard for the method of testing to be employed.

4.2 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.

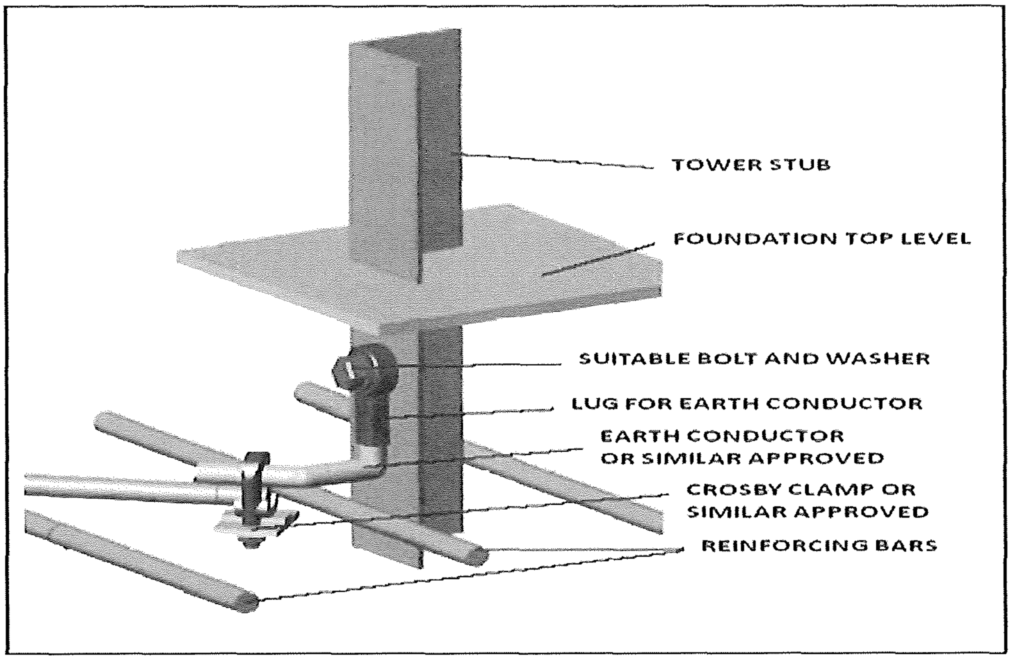


Figure 4.1: Connection between Self Supporting Tower Steel and Main Reinforcing Bar

4.3 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 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) of a terminal structure are always bonded to the earth-peaks of a substation. In addition to bonding tower top geometries, the footing resistances of the terminal structures should be less than 10Ω.

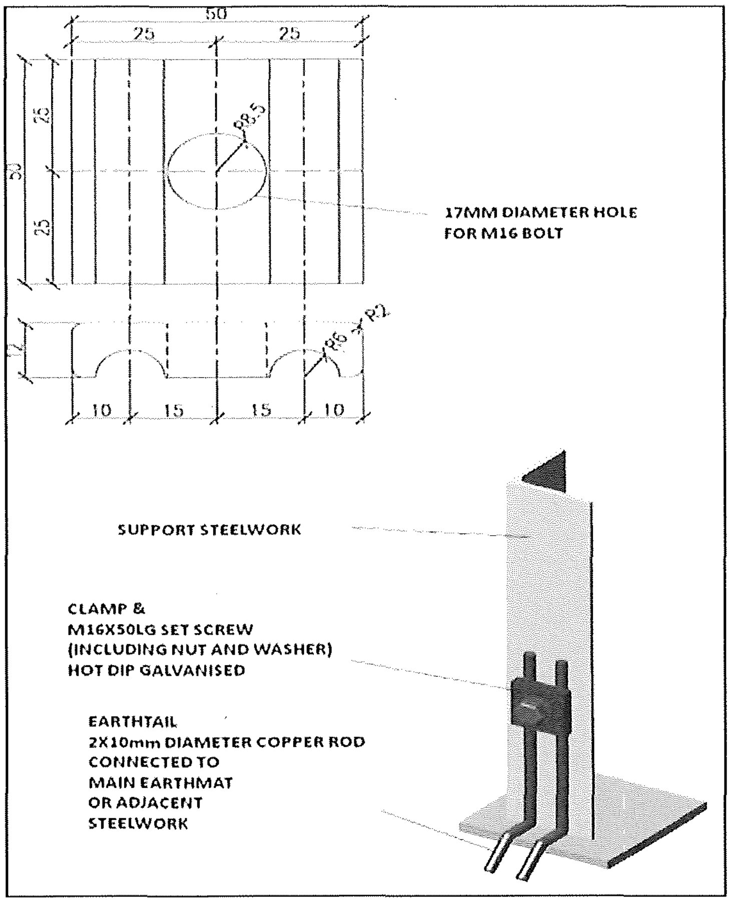


Figure 4.2: Terminal Tower Leg and Copper Conductor Connections

4.4 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.

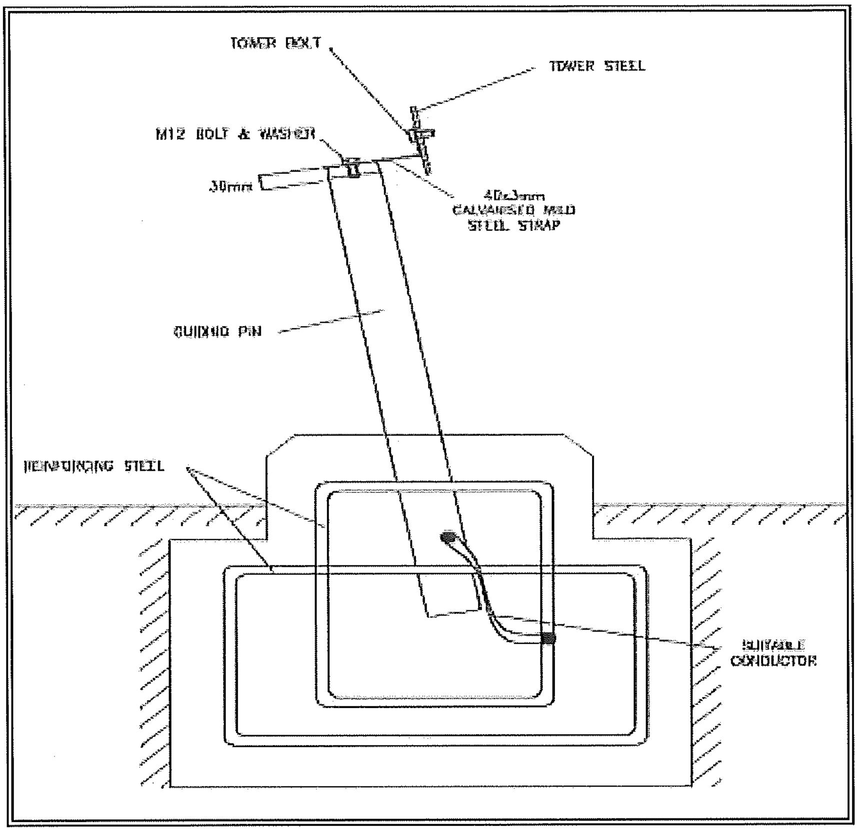


Figure 4.3: Tower Leg, Locating Pin and Foundation Rebar Connection

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.

4.5 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. However, if a null balance insulation tester is to be used, 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. The footing resistances of the second, third, fourth and fifth towers from the substation should be greater than or equal to 10 Ω and should be less than or equal to 20 Ω. If, however, a case is encountered, where the footing resistance of such a structure of a strain type is less than 10 Ω, then jumper leads must be fitted across the structure.

The tower footing resistance is 30 Ohm as a target for each tower, although for the range 40 Ohm to 70 Ohm – use "crows foot" type counterpoise must be implemented reducing the tower footing depending on the soil conditions. If 70 Ohm and higher is found, seek advice from the LES design engineer before implementing any solution.

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

4.6 ADDITIONAL EARTHING REQUIREMENTS

The main path of an earthing system is between the main base of the structure and earth. In situations where the main earthing path is inadequate, the need to enhance the earthing system by ensuring broad and deep contact between every structure and earth should be considered. 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 taken 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. All counterpoise must be configured as 40 mm x 3 mm galvanized mild steel straps. An alternative to counterpoise installation that should be considered is the use of micro pile foundations where counterpoise is required.

For example, **Figure 4.4** 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 [3]. 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 4.5** shows the parts of the tower and of the foundations that the bitumastic compound must be applied to.

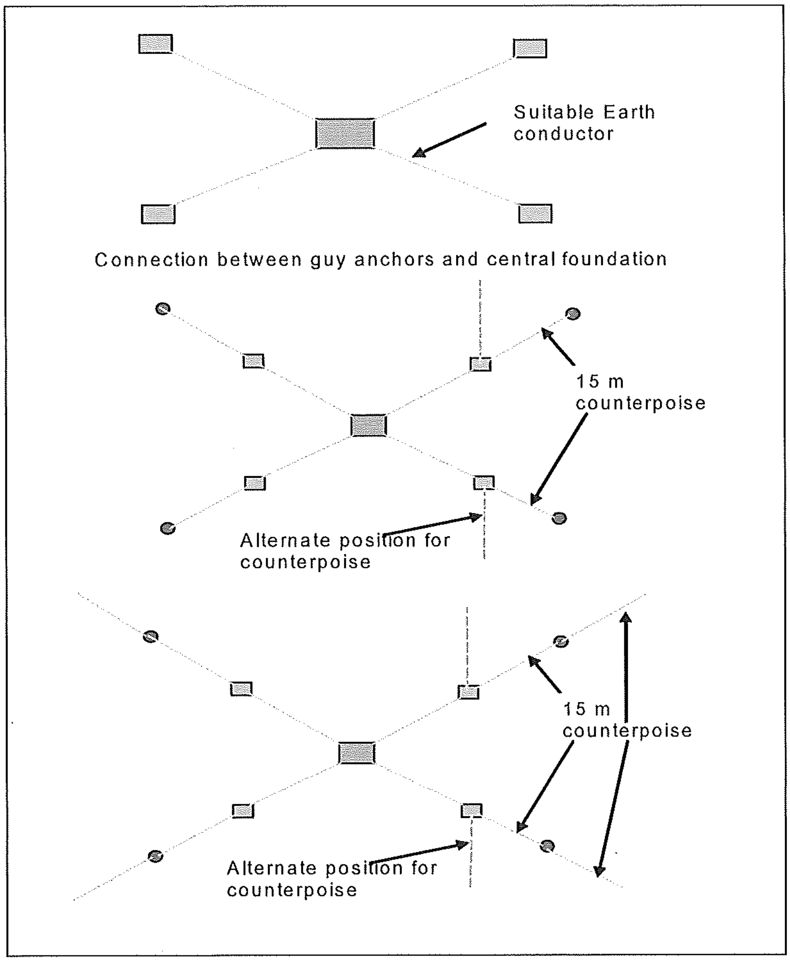


Figure 4.4: Additional Earthing for Guyed "V" and Cross Rope Suspension Towers

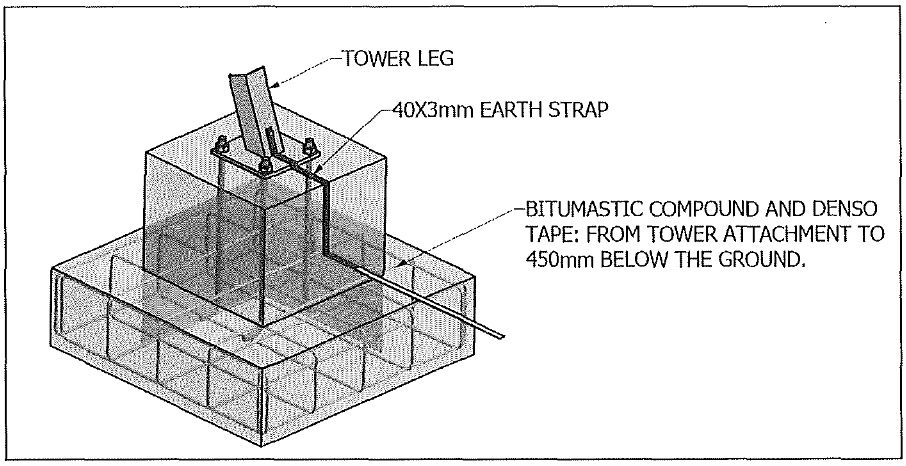


Figure 4.5: Paint Detailing of Counterpoise

4.7 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.

4.8 EXCEPTIONAL CASES

Structures which are within 800 m of, and that either cross or run parallel to, electrified 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

Table 5.1: Requirements for Composite Insulators

INSULATOR MATERIAL	LONG-ROD COMPOSITE(400kV)		LONG-ROD COMPOSITE(132kV)
Insulator strength [kN]	120	210	120
Dry-arcing distance [mm]	≥ 3200		≥1450
Specific creepage [mm/kV]	31		31
Total creepage distance [mm]	≥ 13020		≥4495
Connecting length [mm]	Shortest possible		±1480
BIL (+) – (@1500 m altitude) [kV]	1425		550
SIL (+) – (@ 1500 m altitude) [kV]	1050		-
End fitting size [mm]	16	20	16
60 sec power frequency withstand voltage (kV)			230

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^2 each
Arcing horn gap size	8 (± 2) mm fixed

For the earth wire insulator assemblies, i.e. both suspension and strain, only 120kN 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.

The grid (KZN) must advise on the preferred material within the materials approved by Eskom. All tower labels shall be made of a material approved by Eskom. Preference is given to the use of vitreous enamel, but if any other material offers the same or higher quality than the preferred listed above, then this new material will be considered.

6.2 LINE DESIGNATION LABELS LAYOUT AND WORDING

The section from Ariadne to Eros will have the following labelling (at Ariadne and Eros Substations) These line labels will be changed to incorporate the St Faiths Loop-Ins once Construction has been completed on the Loop-ins.

2 ARI/ ERO

6.3 TOWER LABELS

Ariadne – Eros 2 Multicircuit Line (X = total number of towers on the line)

2 A R I / E R O 1	**TO**	**2 A R I / E R O X**

6.4 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

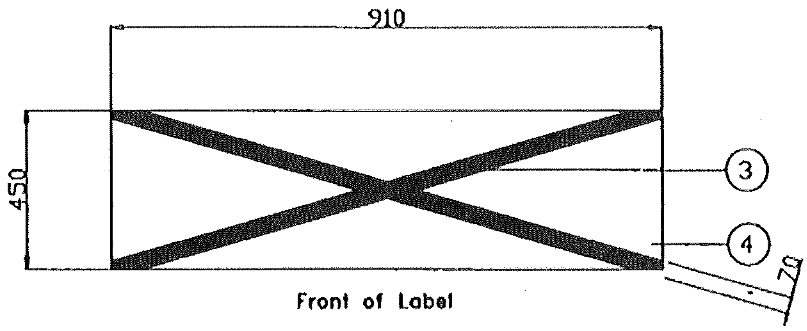


Figure 6.1: Crossing Label

6.5 PHASE DISK LABELS

a) All Terminal Towers shall be fitted with phase disk labels.
b) All Transposition Towers shall be fitted with phase disk labels on both sides.
c) All bypass terminal structures shall be fitted with phase disk labels.
d) All structures for every 20km along the line shall be fitted with phase disk labels.

Refer to **Appendix C**, section 9.4 for the conceptual phase disk label detail

6.6 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: 2013, section 14. See SANS 10280-1: 2013 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 300mm x 300mm with strap holes to fit onto 200mm leg.

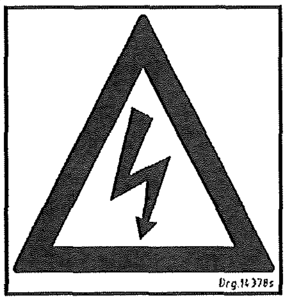
WW 7		Beware of electric shock

Figure 6.2: Warning Signs

7 APPENDIX A: STANDARDS AND SPECIFICATIONS

7.2 STANDARDS

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

IEC 60652	*Load tests of transmission towers.*
CSIR: 1990	Transmission Line Loading Part 1: Recommendations and commentary - 1990
ASCE – 10	Guide for design of steel transmission towers.
OHS Act and Regulations	OHS Act and Regulations (latest revision)
SANS 50196-21 - 1989	Methods of testing cement Part 21: Determination of the chloride, carbon dioxide and alkali content of cement
IEC 60888 Ed. 1.0 b:1987	Zinc-coated steel wires for stranded conductors
SANS 10111-1	Engineering drawing Part 1: General principles 1993 3.01
SANS 1556-1,2,3 - 1994	ISO Metric screw threads
SANS 1491-1,2,3 - 1989	Portland cement extenders
SANS 1355-3 - 1989	ISO metric machine screws and nuts, hexagon socket screws and set-screws (coarse thread series) Part 3: Set-screws
SANS 10044-1,2,3,4,5 – 1973 – 1983	Welding
SANS 1391-1 - 1983	Thermally sprayed metal coatings
ISO 1461 / SANS 121:2000	Specification for hot dip galvanized coatings on iron and steel articles.
SANS 935 - 1993	Hot-dip (galvanized) zinc coatings on steel wire
SANS ISO 4998 - 1996	Continuous hot-dip zinc-coated carbon steel sheet of structural quality
SANS 10144 (1995)	Detailing of steel reinforcement for concrete
BS 5835: 1980	Compatibility test for graded aggregates.
BS 6949: 1991	Specification for bitumen based coatings for cold application excluding use in contact with potable water.
SABS EN 795 **SABS EN 353-1**	Code of practice for ground anchorages.
SANS ISO 9001:2000	Quality Management Systems Requirements.

SANS EN 10025	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
BS EN 10210:	*Hot finished structural hollow sections of non-alloy and fine grain structural steels.*
SABS ISO 5177 **SABS ISO 6520** **SABS ISO 4136** **SABS 0443-3 (1987)** **SABS 0443-6 (1985)**	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.
SABS 1033 (1982) **SABS 864,** **SABS 1293,** **SABS 1370 (1982)**	Specification and approval of welding procedures for metallic materials. Part 3: Welding procedure tests for the arc welding of steels.
BS4482: 1985	Specification for cold reduced steel wire for the reinforcement of concrete.
SANS 50197-1,2 - 2000	*Cement composition specification and conformity criteria* – Part 1: Common cements
SANS 5860, 5861, 5862, 5863, 5865 - 1994	Concrete tests
SANS 10162 - 2005	The structural use of steel
SANS 1431 - 1997	Weldable structural steels
SABS 0100	Part I: The structural use of concrete. Part II: Materials and execution of work
IEC 60120:	Dimensions of ball and socket couplings of string insulator units.
IEC 61089:	Round wire concentric laid overhead electrical stranded conductors.
IEC 61284:	Overhead lines – Requirements and tests for fittings.
IEC 60372:	Locking devices for ball and socket couplings of string insulator units.
IEC 60383:	Insulators for overhead lines with nominal voltage above 1000V.
IEC 60471:	*Dimensions of clevis and tongue couplings of string insulator units.*
IEC 60826:	Loading and strength of overhead transmission lines.
BS 2874:	Specification for wrought steel for mechanical and applied engineering purposes.

ISO 14399:	ISO Metric screw threads.
BS 4190:	Specification for ISO metric black hexagon bolts, screws and nuts.
BS 7668:	Specification for weld able structural steels. Hot finished structural hollow sections in weather resistant steels.
BS EN 10137:	Plates and wide flats made of high yield structural steels in quenched and tempered or precipitation hardened conditions.
BS EN 10029:	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick or above.
BS 970:	Specification for wrought steel for mechanical and applied engineering purposes.
BS EN ISO 9001: 9002	Quality systems model of quality assurance in design, development, production, installation and servicing.
BS EN 10025:	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
BS EN 10163:	Specification for delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
BS EN 287-1:1992:	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.
BS EN 288-3:1992	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.

7.3 SPECIFICATIONS

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

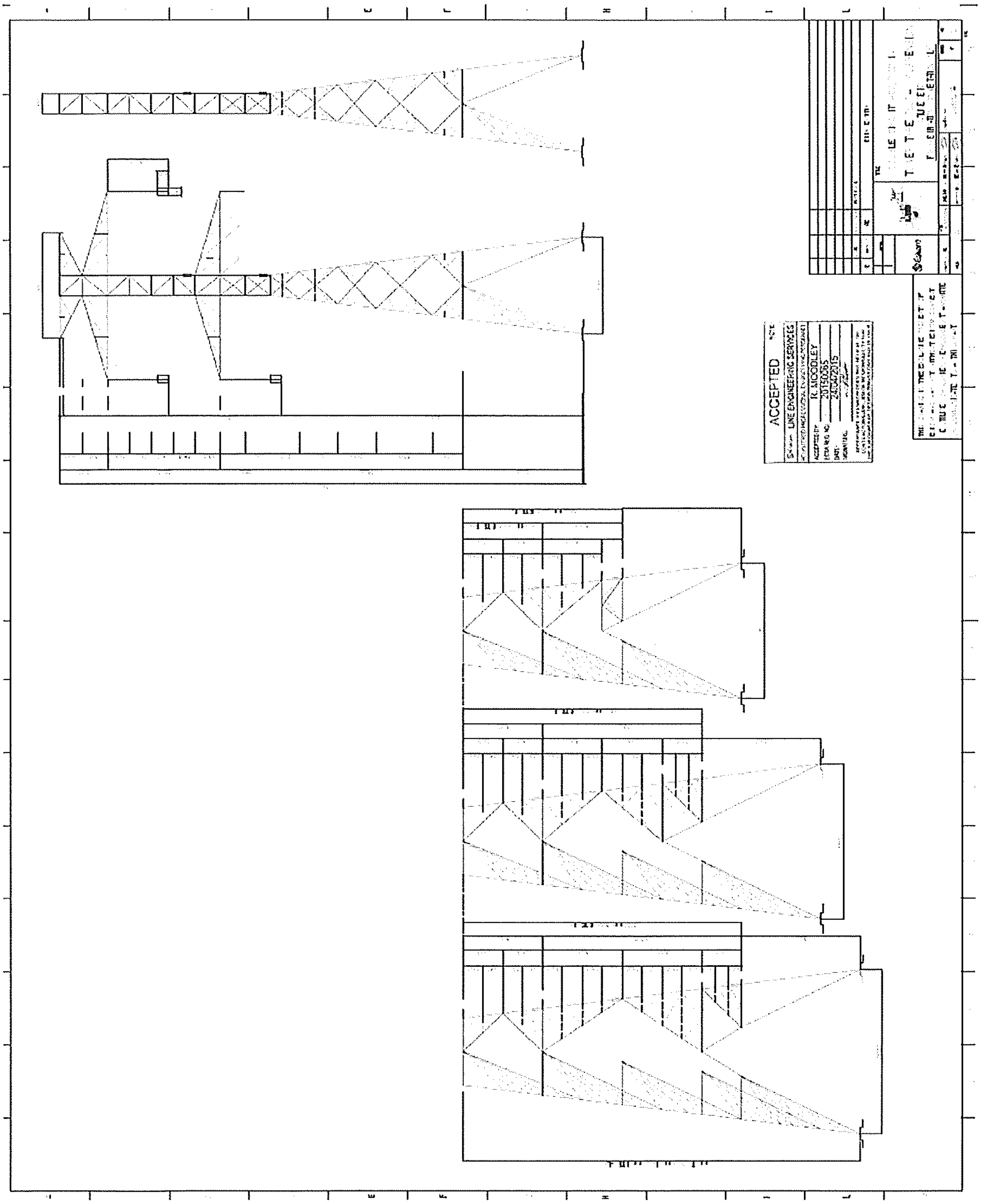
PHASE CONDUCTOR AND GROUNDWIRE	
IEC 60888	Zinc-coated steel wires for stranded conductors.
TST41-168	Quality requirements for the procurement of quality related assets, goods and services.

240-75521456	Phase conductor for Eskom Overhead Lines
HARDWARE	
SANS 10280	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.
240-75521456	Phase conductor for transmission lines.
240-60777474	Specification for suspension and strain assemblies and for hardware for transmission lines.
TRMSCAAJ2 Rev 0	Requirements and tests for Stockbridge type Aeolian vibration dampers.
240-16259196	Transmission Bird Guard and installation
EARTHING REQUIREMENTS	
240-130615862	Earthing of transmission line towers
IEEE 524	Guide to the Installation of Overhead Transmission Line Conductors
TOWERS	
240-47172520 – latest version	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

527A



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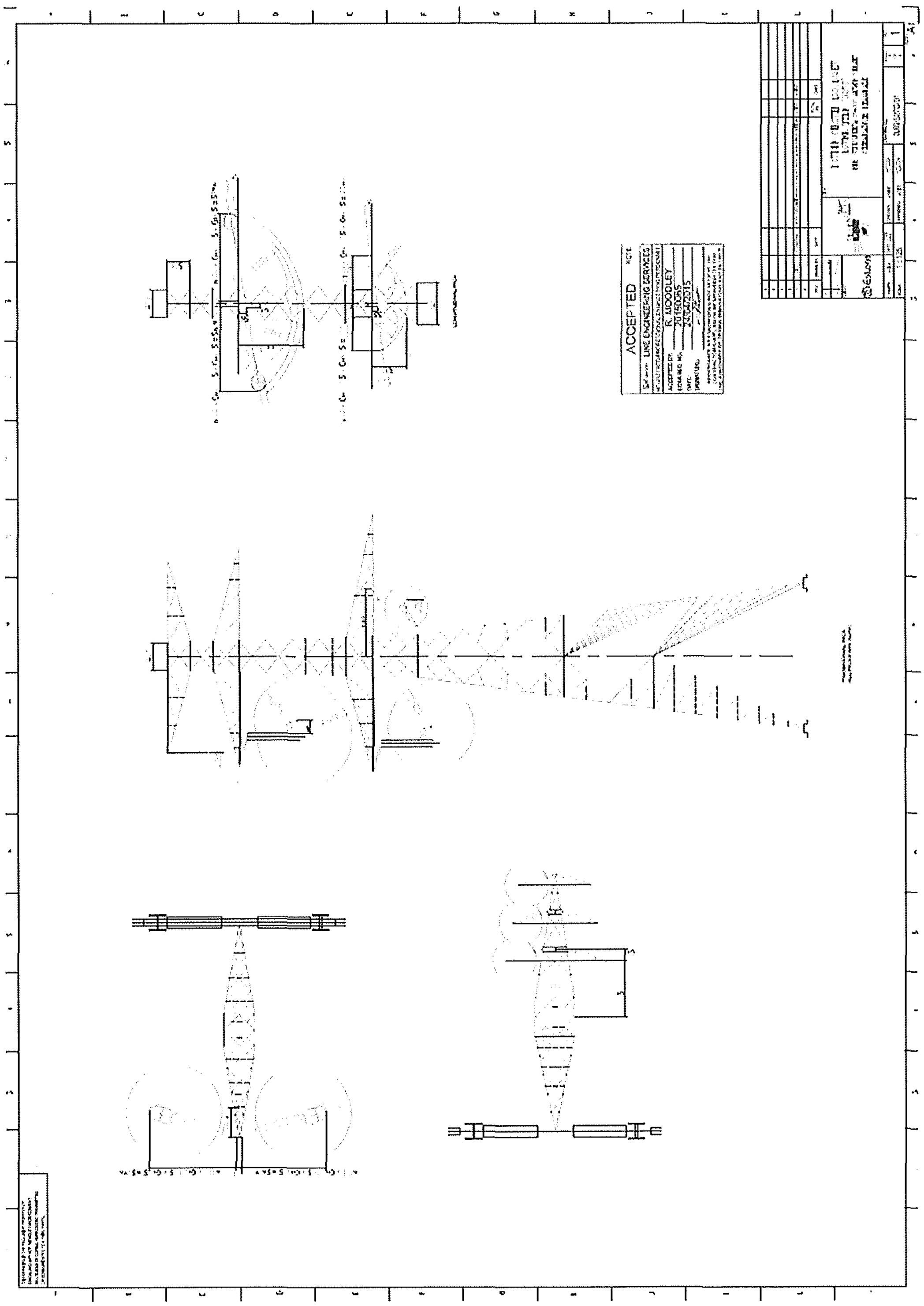

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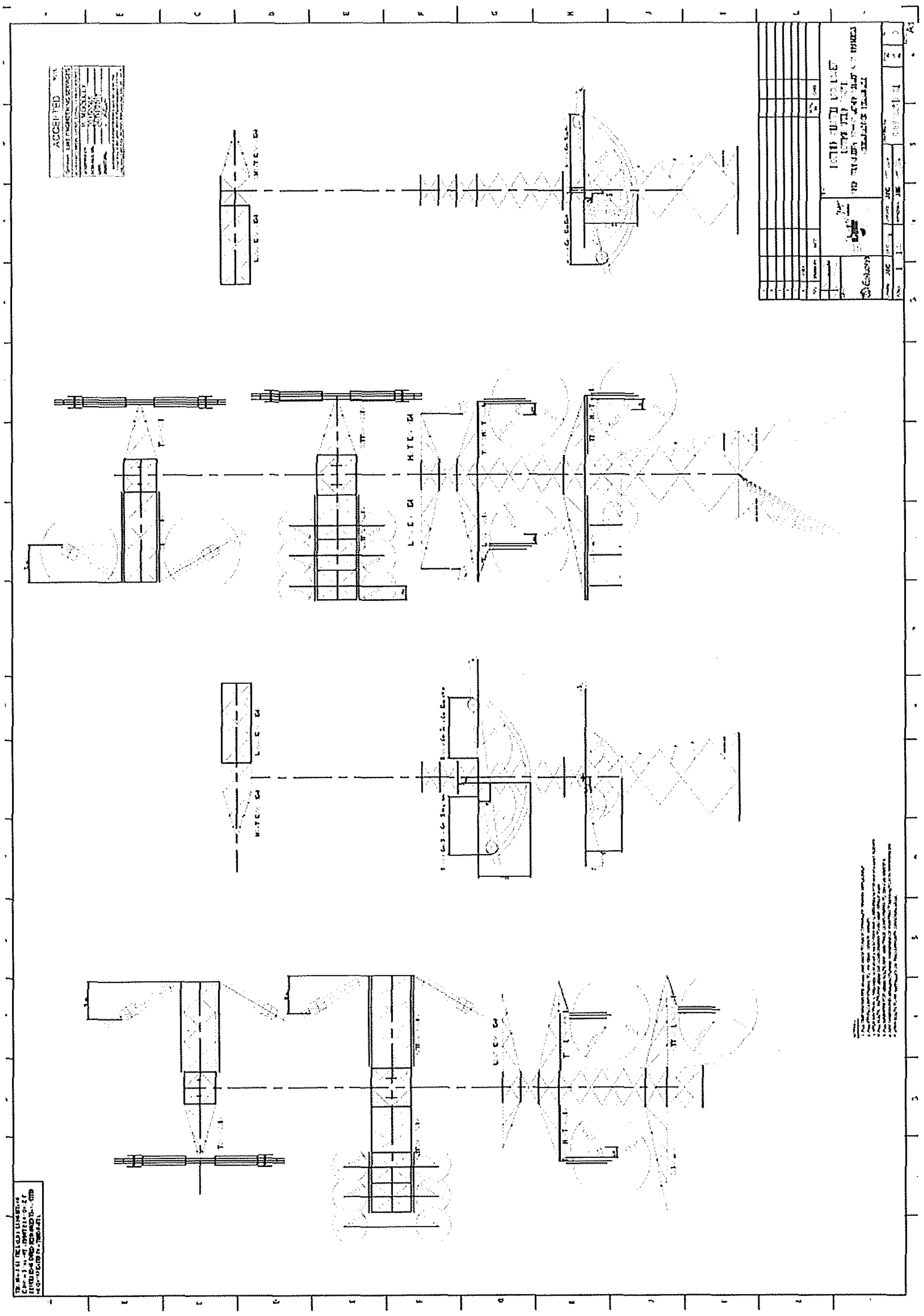

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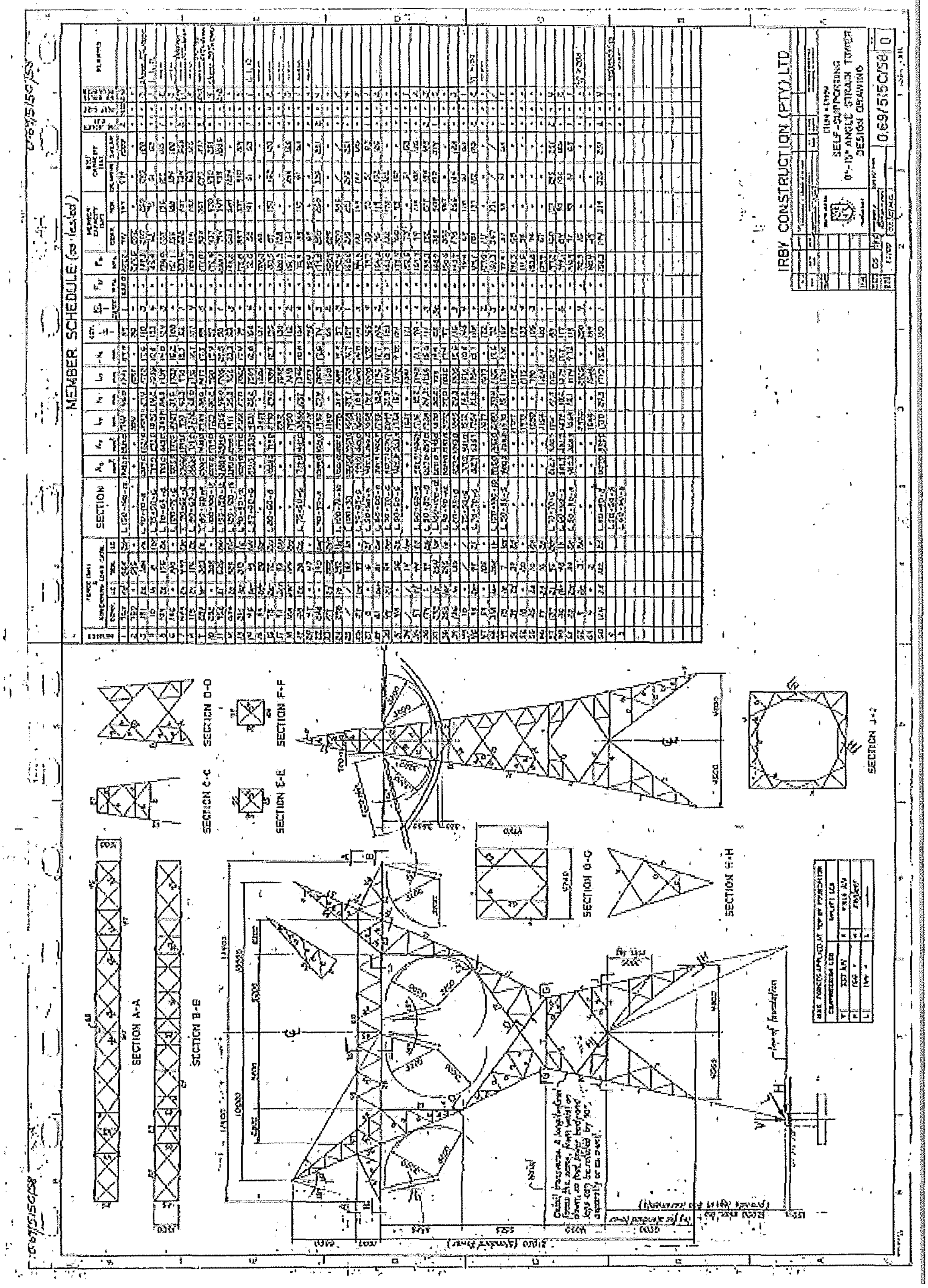
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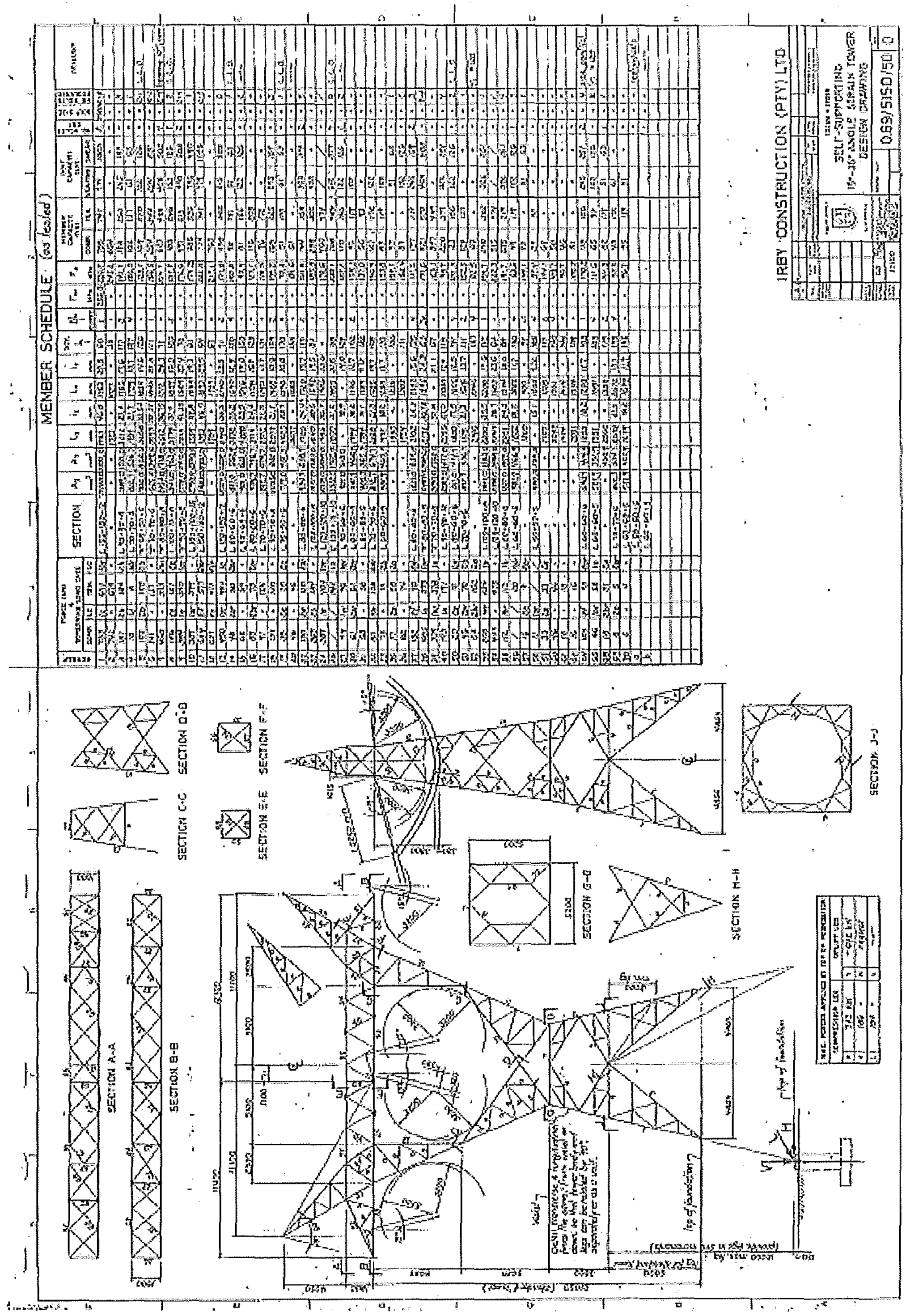
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
SECTION J-J

515D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15°-30° ANGLE STRAIN TOWER
DESIGN DRAWING
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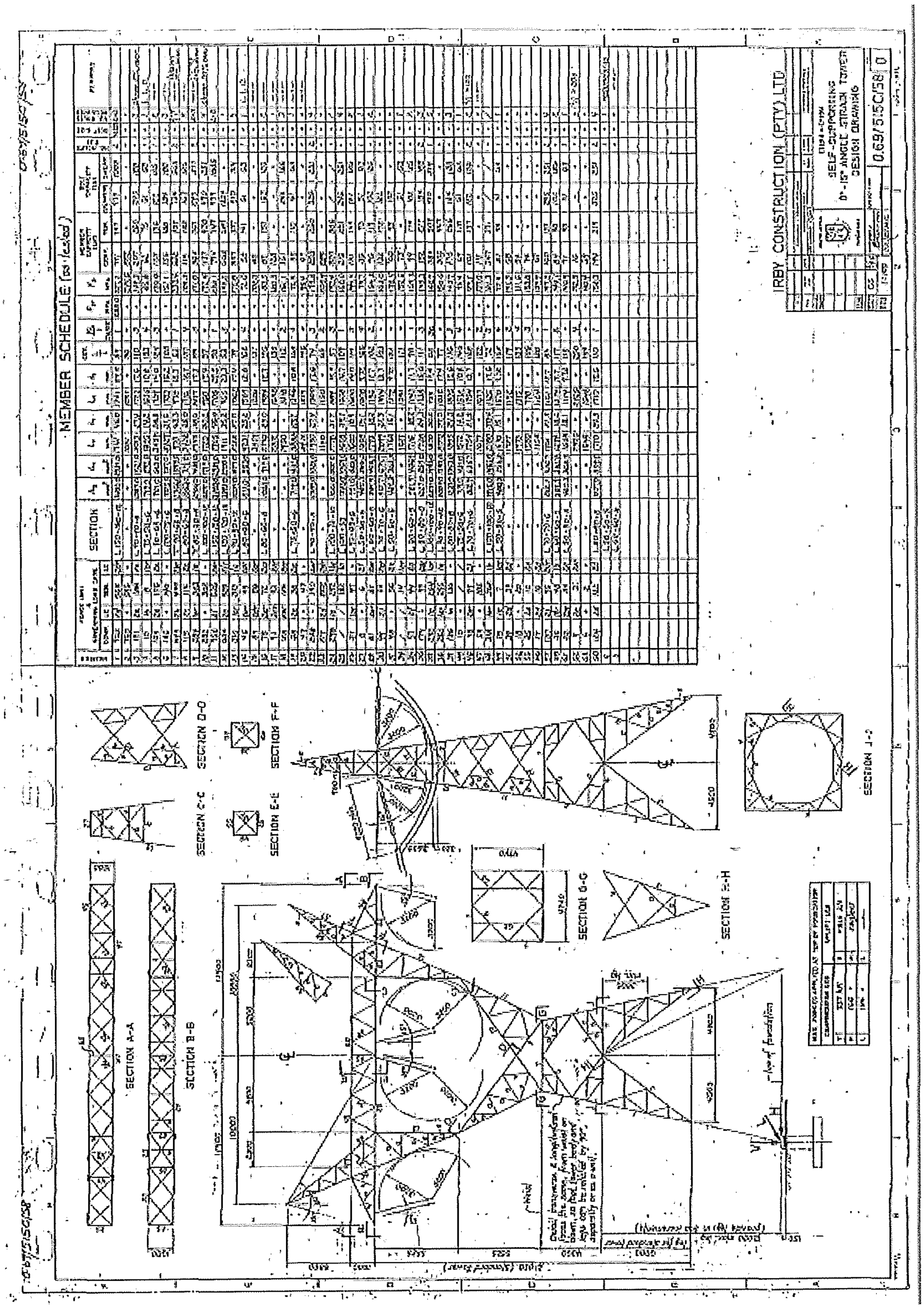
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
SECTION J-J

515C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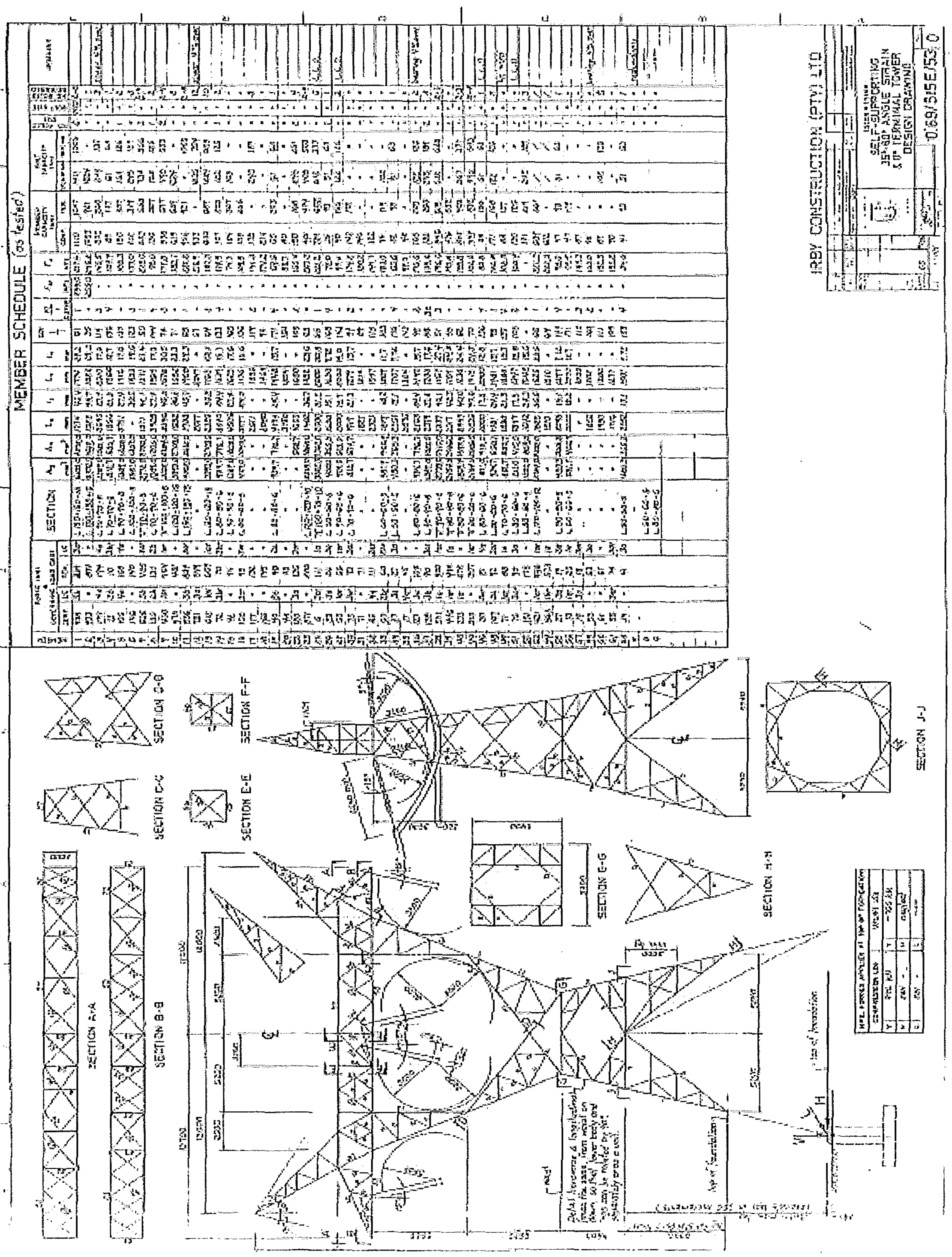
SECTION E-E
SECTION F-F
SECTION G-G
SECTION H-H
SECTION J-J

515E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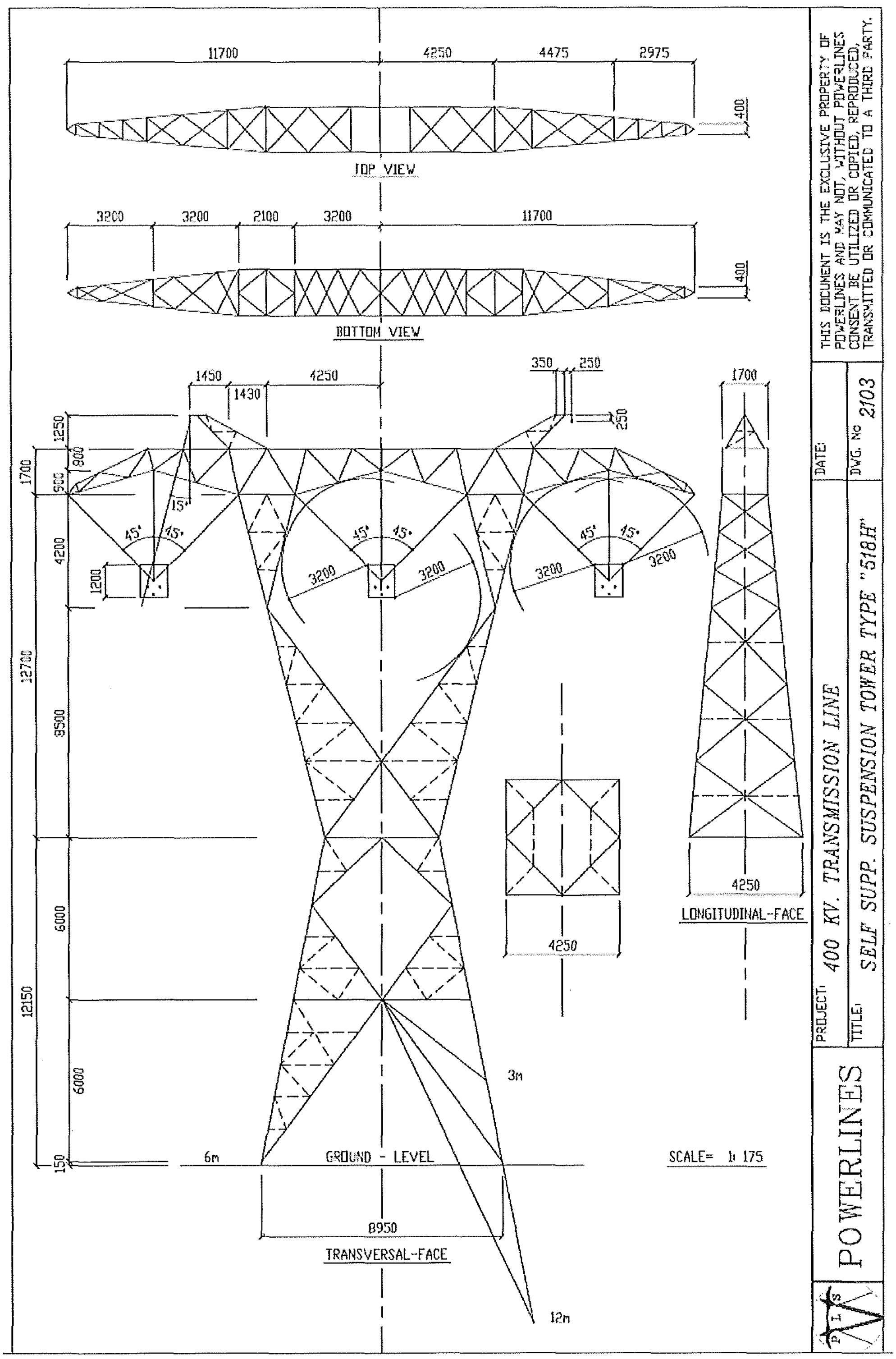
518H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4475
2975
400
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3200
3200
2100
3200
11700
400
BOTTOM VIEW
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1430
4250
350
250
250
1700
1250
800
1700
900
4200
1200
15°
45°
45°
3200
3200
3200
3200
12700
9500
6000
12150
6000
150
6m
3m
12m
GROUND - LEVEL
8950
TRANSVERSAL-FACE
4250
4250
LONGITUDINAL-FACE
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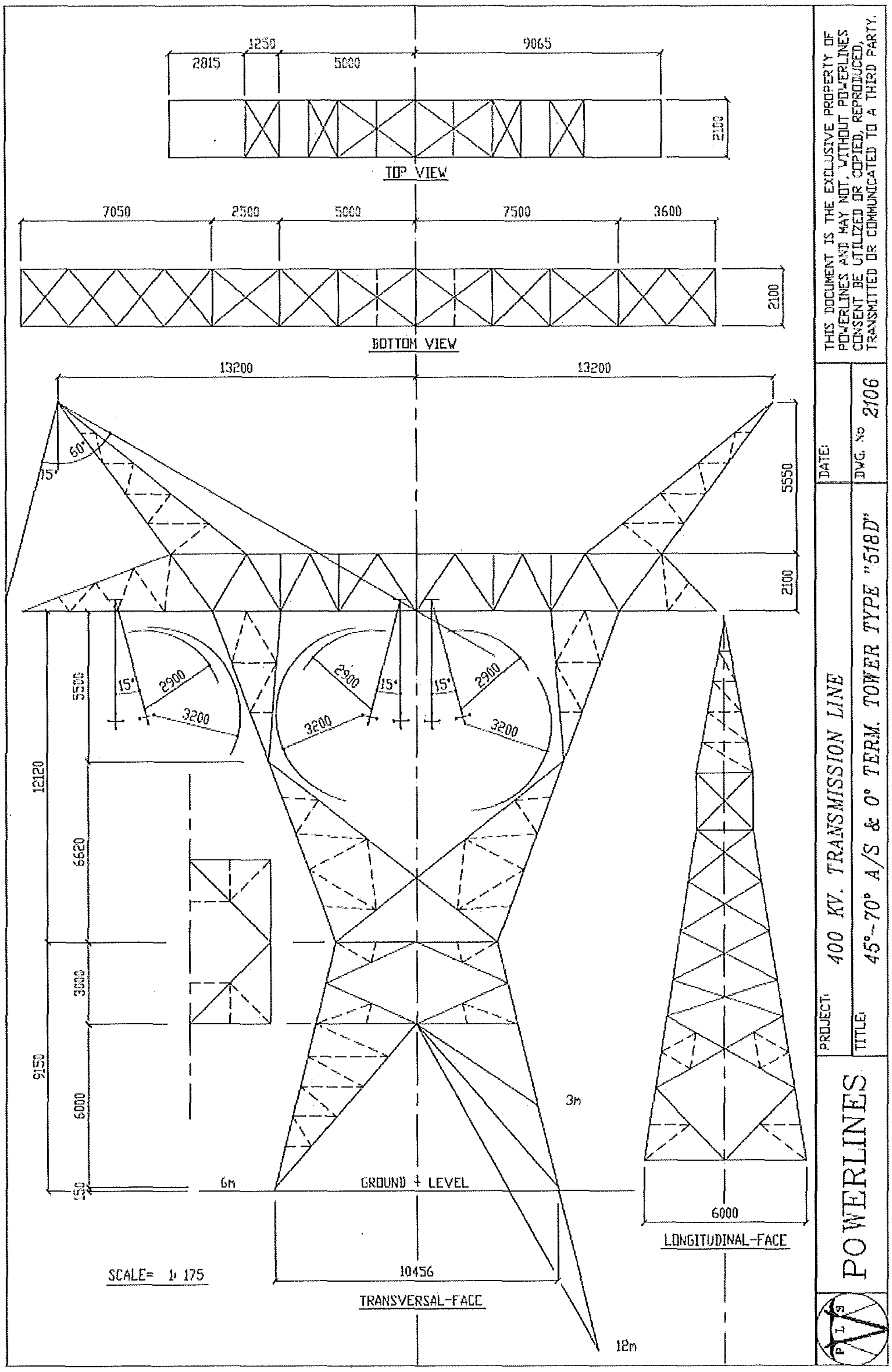
PROJECT: 400 KV. TRANSMISSION LINE
TITLE: SELF SUPP. SUSPENSION TOWER TYPE "518H"
POWERLINES

518D


TOP VIEW
BOTTOM VIEW
LONGITUDINAL-FACE
TRANSVERSAL-FACE
GROUND LEVEL
SCALE= 1: 175
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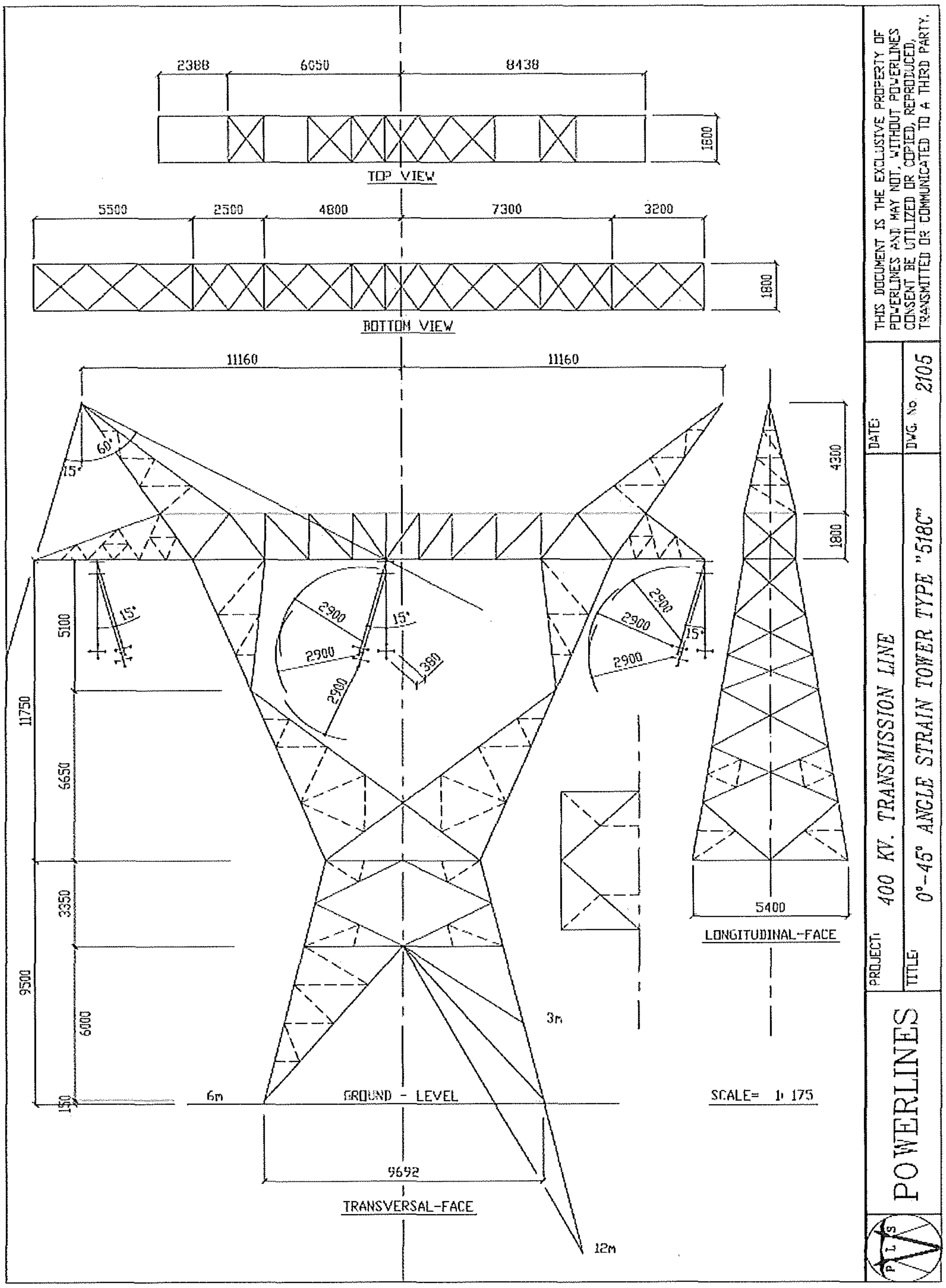
TITLE: 45°-70° A/S & 0° TERM. TOWER TYPE "518D"
POWERLINES

518C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15°
4300
1800
5100
2900
2900
2900
2900
2900
2900
15°
360
11750
6650
3350
9500
6000
150
6m
3m
GROUND - LEVEL
12m
9692
TRANSVERSAL-FACE
5400
LONGITUDINAL-FACE
SCALE= 1: 175
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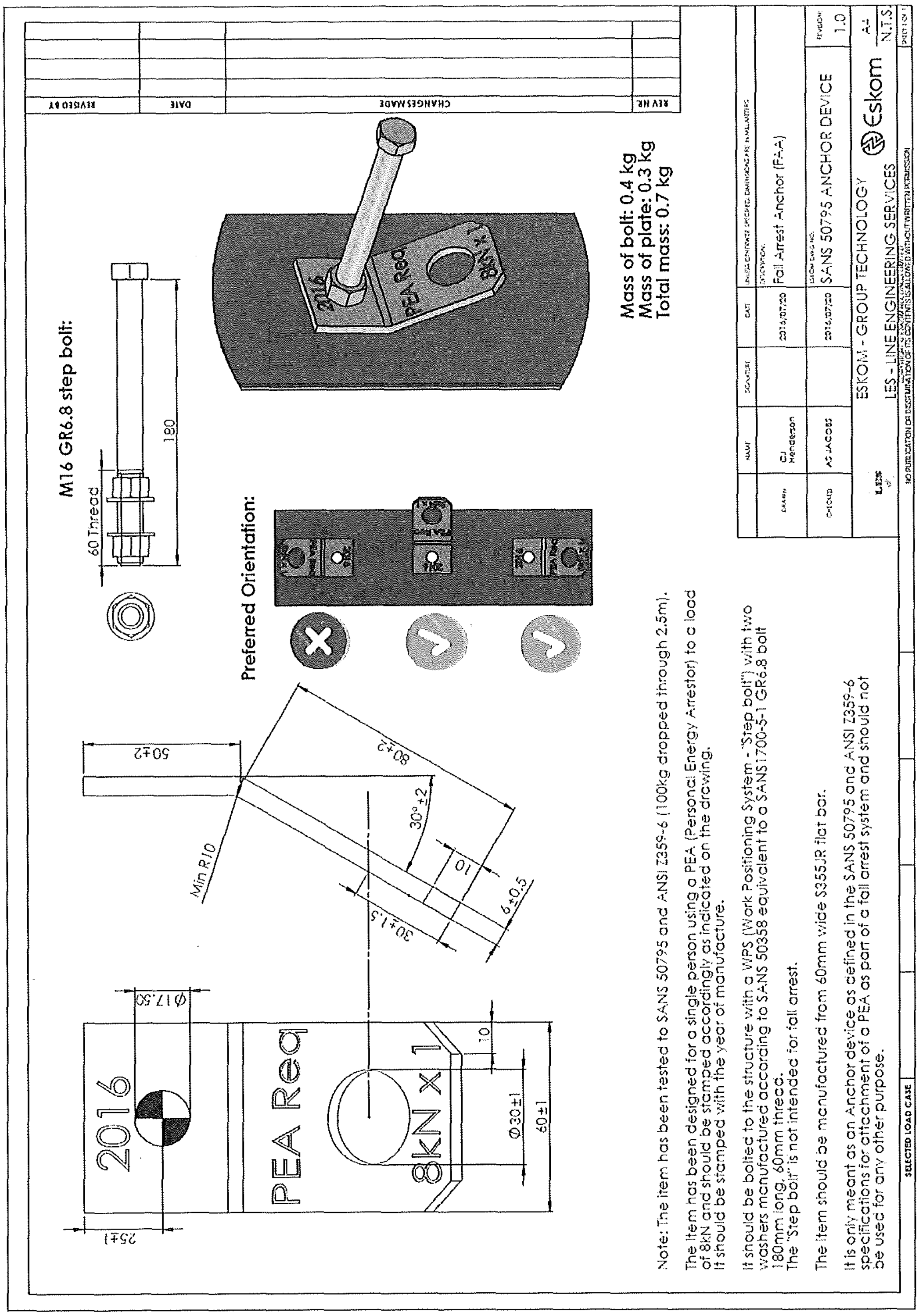
DATE:
DWG. No 2105
PROJECT: 400 KV. TRANSMISSION LINE
TITLE: 0°-45° ANGLE STRAIN TOWER TYPE "518C"
POWERLINES

Fall Arrest Anchor



9 APPENDIX C: HARDWARE ASSEMBLY DRAWINGS AND INFORMATION

9.2 HARDWARE ADDITIONAL INFORMATION

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

Table 9.1: Hardware Standards

IEC 60120:	Dimensions of ball and socket couplings of string insulator units.
IEC 61089:	Round wire concentric lay overhead electrical stranded conductors.
IEC 61284:	Overhead lines – Requirements and tests for fittings.
IEC 60372:	Locking devices for ball and socket couplings of string insulator units.
IEC 60383:	Insulators for overhead lines with nominal voltage above 1000V.
IEC 60471:	Dimensions of clevis and tongue couplings of string insulator units.
IEC 60826:	Loading and strength of overhead transmission lines.
BS 2874:	Specification for wrought steel for mechanical and applied engineering purposes.
ISO 14399:	ISO Metric screw threads.
BS 4190:	Specification for ISO metric black hexagon bolts, screws and nuts.
BS 7668:	Specification for weld able structural steels. Hot finished structural hollow sections in weather resistant steels.
BS EN 10137:	Plates and wide flats made of high yield structural steels in quenched and tempered or precipitation hardened conditions.
BS EN 10029:	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3mm thick or above.
ISO 1461:	Specification for hot dip galvanized coatings on iron and steel articles.
BS 970:	Specification for wrought steel for mechanical and applied engineering purposes.
BS EN ISO 9001: 9002	Quality systems model of quality assurance in design, development, production, installation and servicing.
BS EN 10025:	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
BS EN 10163:	Specification for delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
BS EN 10210:	Hot finished structural hollow sections of non-alloy and fine grain structural steels.
BS EN 287-1:1992:	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.
BS EN 288-3:1992	Specification and approval of welding procedures for metallic materials Part 3: Welding procedure tests for the arc welding of steels.

9.3 HARDWARE SPECIFICATONS

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

Table 9.2: Hardware Specifications

TST41-168	Quality requirements for the procurement of quality related assets, goods and services.
SANS 10280	Code of practice for overhead power lines for conditions prevailing in South Africa.
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.
240-47172520 – latest version	Transmission line towers and line construction.
240-75521456	Phase conductor for transmission lines.
240-60777474	Specification for suspension and strain assemblies and for hardware for transmission lines.
TRMSCAAJ2 Rev 0:	Requirements and tests for Stockbridge type Aeolian vibration dampers.
240-120804300, 240-75660336	Design, Manufacture and Installation specification for transmission line labels.
240-16259196	Transmission Bird Perch Guidelines

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

9.4 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.

9.4.2 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.

9.4.3 Spacer Dampers for Triple IEC 315 Conductor

The conductor spacing for Tern conductor is 380 mm and this should be maintained throughout the spans. Suitable spacer dampers should be installed as per the suppliers recommendations and corresponding spacing for the specified conductor. The spacing chart is to be sourced from the hardware supplier.

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)

9.4.4 Rigid Spacers for Triple Tern Conductors for Jumpers

The jumper spacing is 380 mm and should be kept throughout the jumper. Suitable rigid spacers should be offered to keep the sub-jumper spacing to 450 mm for the specified conductor.

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

9.4.5 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. Only pre-formed type attachments to be used and no bolted connections will be allowed.

9.4.6 Bird Guards

Strain towers must be fitted with the approved Eskom bird guards as per Eskom's specification - Bird Guard and installation 240-16259196.

9.4.7 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.

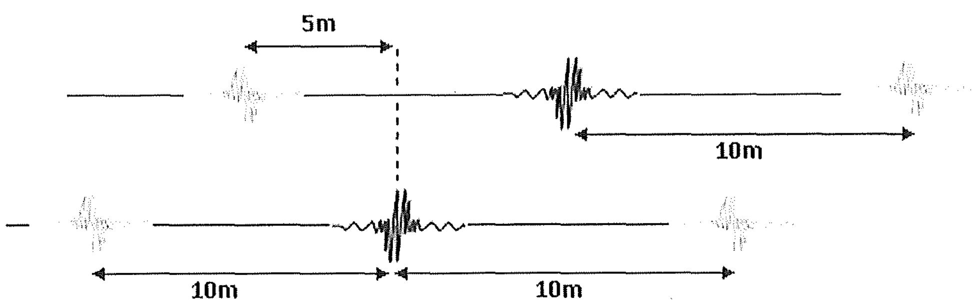


Figure 9.1: Typical Installation of a Bird Flight Diverter

9.4.8 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 25m in such a manner that there is 50m between subsequent units on any phase conductor. LES must be contacted before this is implemented.

9.4.9 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 1.6mm. Any other material shall be subject to approval by Eskom.

The Aerial Warning Sphere must be spherical in shape, with a minimum diameter of 600mm. 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 10mm 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 30m from the tower, and 30m 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.

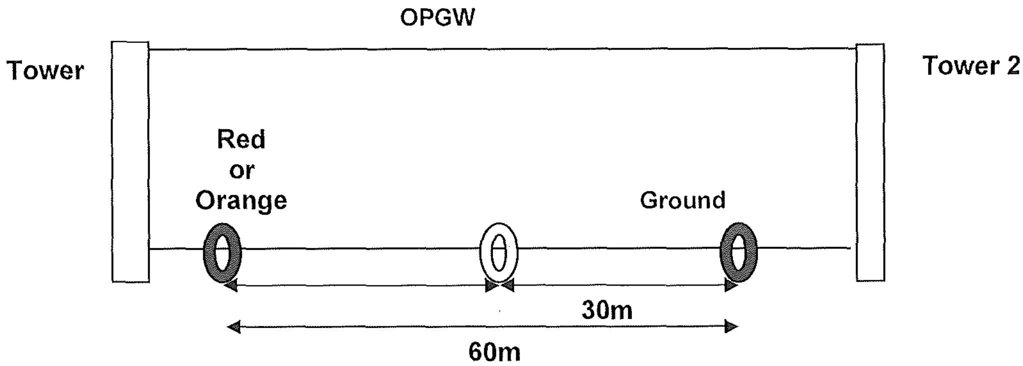
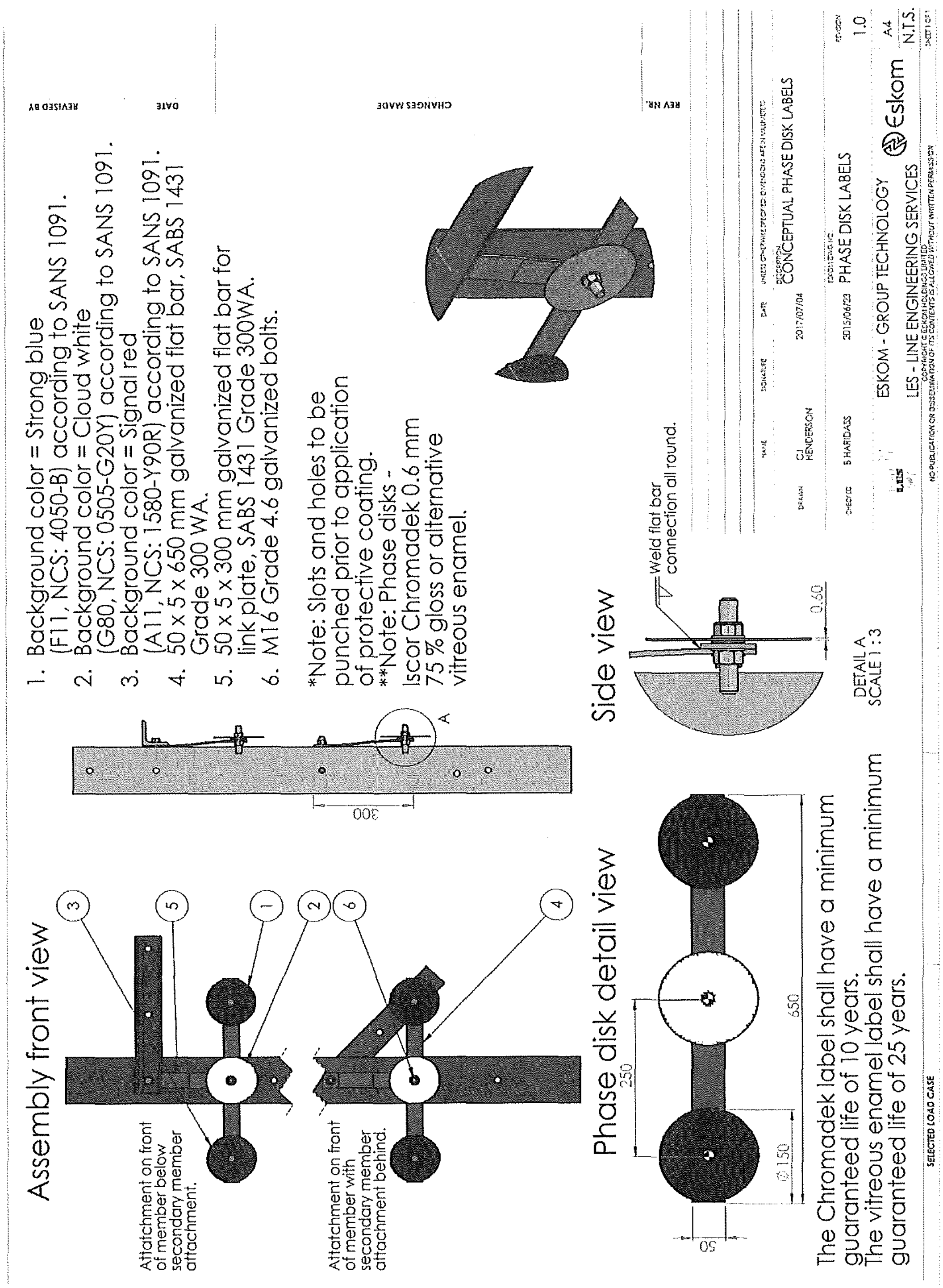


Figure 9.2: Typical Installation of an Aerial Warning Sphere

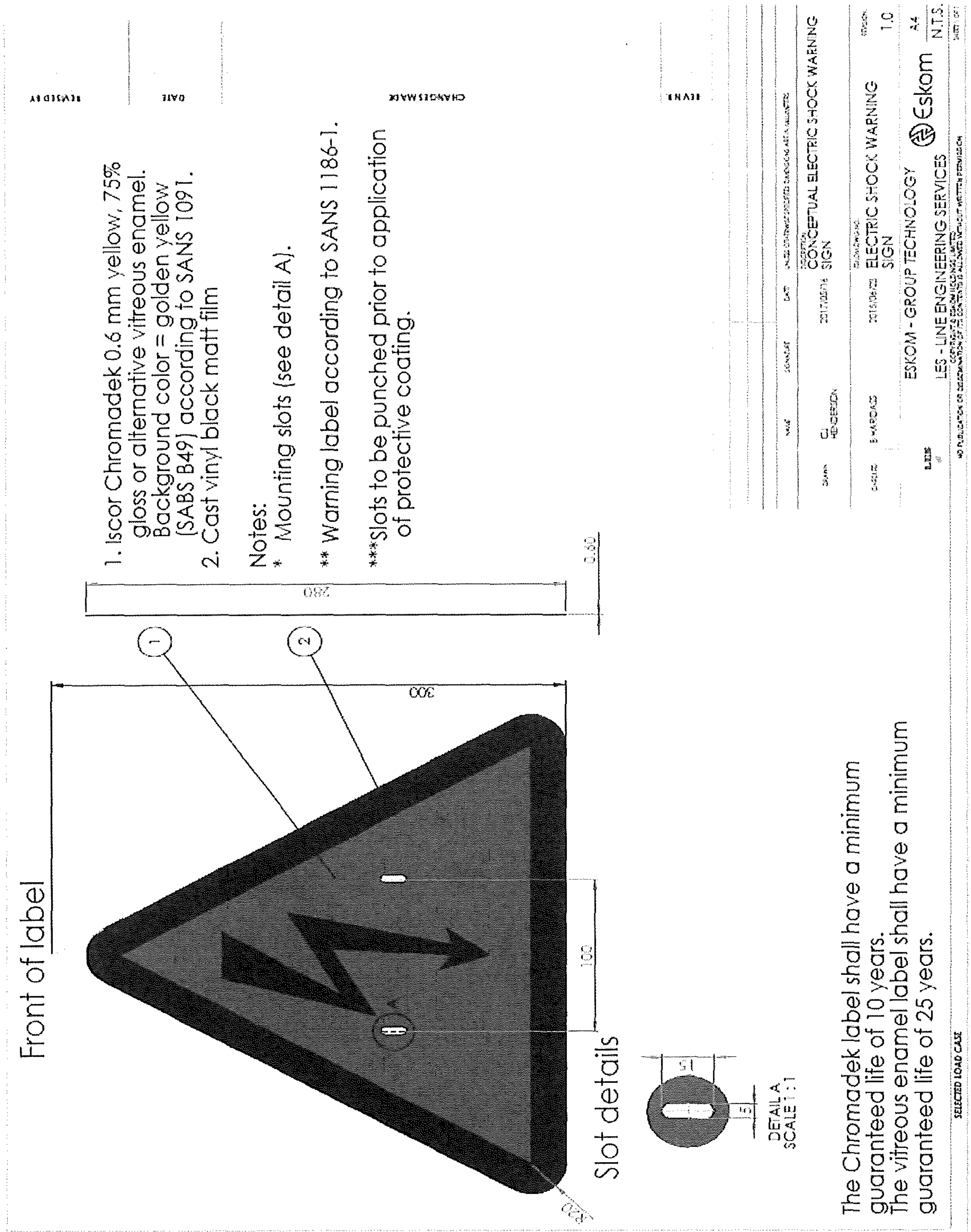
9.4.10 Transport and Packaging

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.

9.5 CONCEPTUAL PHASE DISK LABEL DETAIL



9.6 CONCEPTUAL ELECTRIC SHOCK SIGN DETAIL



9.7 HARDWARE ASSEMBLIES

The Table below shows the towers, with corresponding hardware assemblies and drawing numbers, to be used on the line. The value for X (sub-conductor spacing) is 380mm for Triple IEC 315 conductor.

Table 9.3: Tower Types with Corresponding Hardware Assemblies for Triple IEC315 Conductor

TOWER TYPE	ASSEMBLY TYPE	DRAWING NUMBER	STRENGTH RATING
515H	Suspension V-String	V SUSP ASSY 4xxxxx 120kN 380mm	**120kN**
	Suspension I-String	I SUSP ASSY 4xxxxx 120kN 380mm	**120kN**
	Non-Insulated Earth Wire Suspension Assembly	EW-SUSP-NON	**120kN**
	Insulated Earth Wire Suspension Assembly	EW-SUSP-INS	**120kN**
515C,D,E	Strain Assembly	S STR ASSY 4xxxxx 300kN 380mm	**300kN**
	Compression Slack Span Assembly	COMP SLACK SPAN ASSY 4xxxxx 300kN 380mm	**300kN**
	Bolted Slack Span Assembly	BOLTED SLACK SPAN ASSY 4xxxxx 300kN 380mm	**300kN**
	Earth Wire Strain Assembly	30-120kN_ESTR1-001	**120kN**
518H	V-Suspension Assembly	400-VSUSP-518H&520B-3	**210kN** - BREAKING LOAD 1
	Non-Insulated Earth Wire Suspension Assembly	EW-SUSP-NON	**120kN**
	Insulated Earth Wire Suspension Assembly	EW-SUSP-INS	**120kN**
518E	V-Suspension Assembly	400-VSUSP-517A,G&518E-3	**210kN** - BREAKING LOAD 1
	Non-Insulated Earth Wire Suspension Assembly	EW-SUSP-NON	**120kN**
	Insulated Earth Wire Suspension Assembly	EW-SUSP-INS	**120kN**

517E, F	Strain Assembly with single attachment Earth Wire Strain Assembly	400-SSTRAIN-XXX-3 30-120kN_ESTR1-001	**300kN** - BREAKING LOAD 1 **120kN**
518C, D	Strain Assembly with double attachment Earth Wire Strain Assembly	400-DSTRAIN-XXX-3 30-120kN_ESTR1-001	**300kN** - BREAKING LOAD 1 **120kN**
527A	Suspension I-String (400kV)	I SUSP ASSY 4xxxxx 120kN 380mm	**120kN**
	Suspension I-String (132kV) Centre Phase	I SUSP ASSY 4xxxxx 120kN 527 CP	**120kN**
	Suspension I-String (132kV) Outer Phase	I SUSP ASSY 4xxxxx 120kN 527 OP	**120kN**
	Suspension V-String (132kV)	V SUSP ASSY 4xxxxx 120kN	**120kN**
	Suspension 132kV Phase Arrangement	132kV Phase ARR ASSY 4xxxxx	**120kN**
	Non-Insulated Earth Wire Suspension Assembly	EW-SUSP-NON	**120kN**
	Insulated Earth Wire Suspension Assembly	EW-SUSP-INS	**120kN**
527C,D	400kV Strain Assembly	S STR ASSY 4xxxxx 300kN 380mm	**300kN**
	400kV Compression Slack Span Assembly	COMP SLACK SPAN ASSY 4xxxxx 300kN 380mm	**300kN**

	400kV Bolted Slack Span Assembly 132kV Strain Assembly 132kV Compression Slack Span Assembly 132kV Bolted Slack Span Assembly Earth Wire Strain Assembly	BOLTED SLACK SPAN ASSY 4xxxxx 300kN 380mm S STR ASSY 4xxxxx 120kN COMP SLACK SPAN ASSY 4xxxxx 120kN BOLTED SLACK SPAN ASSY 4xxxxx 120kN 30-120kN_ESTR1-001	**300kN** **120kN** **120kN** **120kN** **120kN**
Gantry	Strain Assembly with single attachment Earth Wire Strain Assembly	400-SSTRAIN-XXX-3 30-120kN_ESTR1-001	**300kN** - BREAKING LOAD 1 **120kN**