

 <b>Eskom</b>	<b>Report</b>	<b>Technology</b>
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Title: **Detailed Design Report for  
Athene Hillside Impala 1 &  
2 132kV Bypass  
Refurbishment**

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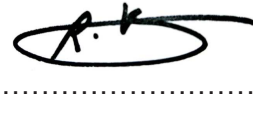


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Date: **24 June 2020**



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## Foreword

This document was compiled to list the requirements for the refurbishment of the Athene Hillside Impala 1 & 2 132kV lines. These lines play an important role in the network as the lines were constructed as a contingency. If a fault were to occur at either of the Hillside 1 & 2 feeder bays at Athene Substation, load can be swung over from Impala via the bypass to provide continuity of supply to the customer, Hillside. This detailed design report is also compiled to list the detailed requirements for the refurbishment of these lines due to corrosion degradation of the towers.

## Revision history

Date	Rev.	Compiled by	Clause	Remarks
27 March 2017	0	RB Pillay	All	New document
15 May 2020	1	RB Pillay	All	Updated document

## Acceptance

This document has been seen and accepted by:

Name	Designation
Bharat Haridass	Senior Consultant
Riaz Vajeth	Senior Manager

## Development team

Ricarlin B Pillay – Mechanical Engineer

Bharat Haridass – Senior Consultant

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## 1. Executive Summary

The Athene Hillside Impala 1 & 2 132kV Bypass Lines are situated in the Richards Bay area, a marine and industrial environment (highly corrosive), resulting in the tower members, bolts and hardware being heavily corroded. Some of the members have corroded to the extent that some members have actually fallen off the tower. Corrosion of the tower members, bolts and hardware decreases its mechanical strength thus decreasing the mechanical integrity of tower as a whole which in turn increases the risk of hardware failure and tower failure.

In order to eliminate the aforementioned risk it was decided that the Athene Hillside Impala 1 & 2 132kV Bypass Lines be refurbished. The scope of the refurbishment will include replacement of six towers (four 224 C towers and two 224B towers), refurbishment of two beams (433D tower type) and the replacement of all insulators and selected hardware. The existing quad tern conductor will be maintained. No new joints or conductor will be required. The existing towers will be removed in stages as the new towers will be erected.

Line 1 has 2 x 48 core long span ADSS installed which will be re-routed, via an acceptable design, during the replacement of the towers. The aim is to replace both existing ADSS fibre with new from Tower 2 to Gantry at Impala. This report highlights the current state and recommended processes to be further designed for the refurbishment.

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## **2. Supporting Clauses**

### **2.1 Scope**

#### **2.1.1 Purpose**

This document was compiled to detail the refurbishment of the Athene Hillside Impala 1 & 2 132kV Bypass Lines

#### **2.1.2 Applicability**

This document shall apply throughout Eskom Holdings Limited, its divisions, subsidiaries and entities wherein Eskom has a controlling interest.

### **2.2 References**

Parties using this document shall apply the most recent edition of the following documents:

#### **2.2.1 Normative References**

- [1] SANS 10280-1:2013 – Overhead power lines for conditions prevailing in South Africa
- [2] 240-47172520 – The Standard for the Construction of Overhead Powerlines (TRMSCAAC 5.2-1)
- [3] SANS 121:200 - Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods
- [4] SANS 9001:2008 Quality Management Systems –Implementation and Evaluation
- [5] SANS 53811:2006 Sherardizing — Zinc diffusion coatings on ferrous products — Specification
- [6] 240-105506494 Standard Line Construction Method

#### **2.2.2 Informative references**

- [1] Occupational Health and Safety Act, 1993 (Act No. 85 of 1993)
- [2] Electrical Machinery Regulations, 2011. Government Notice No. 250 of 25 March 2011
- [3] Construction Regulations, 2014. Government Notice No. 37305 of 7 February 2014
- [4] 240-53458961 – Process Control Manual (PCM) for Perform Line Engineering
- [5] 240-71380115 – Routine Inspection and Maintenance of Transmission lines

### **2.3 Definitions and abbreviations**

#### **2.3.1 Definitions**

N/A

#### **2.3.2 Abbreviations**

None



### 3. Document Content

#### 3.1 Scope of work

In November 2014, Transmission East Grid compiled an Engineering Report (TRERP1406) detailing the condition of the lines and basic scope of work for the refurbishment. This report highlights some salient issues and solutions for the refurbishment.



The current line consists of the following:

**Table 1: Line Specifications**

	Tower Types	Conductor Type	Hardware	Insulators	Foundations	Fibre
<b>Line 1</b>	T1- 433D , T-2 224B, T3&T4 - 224C	Quad Tern	Standard Strain Assemblies	Glass – 2 x 300kN per phase. 1 x 210kN per phase for slack span.	Standard Pad and Chimney	2x 48 Core Long Span ADSS (Install Date 2003)
<b>Line 2</b>	T1- 433D , T-2 224B, T3&T4 - 224C	Quad Tern	Standard Strain Assemblies	Glass – 2 x 300kN per phase. 1 x 210kN per phase for slack span.	Standard Pad and Chimney	No Fibre

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<b>Action</b>	Complete replacement of Towers 2-4 from stub upwards and refurbishment of beams on Tower 1 for both lines.	No action	Replace all with new – like for like	Replace all with new – like for like	Redo foundation caps from below key point to 300mm above ground.	Restraining new 2x 48 Core ADDS Fibre
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### 3.1.1 Tower Details

Athene Hillside Impala Bypass consists of 224B, 224C and 433D strain towers with no earthpeaks on towers 1, 2 and 3. This was done to maintain clearances between the Athene Hillside lines and the bypass lines and as well as to ensure that the towers were not overloaded. The lines were originally strung with twin wolf and in 1996 the lines were reconducted with quad Tern ACSR conductor. This increased the loading on the towers significantly.

**Table 2: Tower Specifications**

Tower Number	Tower Type	Conductor Attachment Height (m)	Estimated Weights Based on Standard Tower Heights (Steel, Plates, Nuts and Bolts)(Contractor to verify weights)
1	433D (no earthpeak)	17.3	13 tonne
2	224B (no earthpeak)	14.9	5.2 tonne
3	224C (no earthpeak)	14.9	10.88 tonne
4	224C	14.9	11.2 tonne





**Figure 1: 433D Tower Type**



**Figure 2: 224B Tower Type**



**Figure 3: 224C Tower Type (Without Earthpeaks)**





Figure 4: 224C Tower Type (With Earthpeaks)

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### 3.1.2 Hardware

Both lines consist mainly of standard strain assemblies. Selected hardware is to be replaced. Provision will be made to have spares for the jumper rigid spacers, spacer dampers, and dropper clamps.

Basic breakdown of assemblies per line:

**Table 3: Hardware Specifications**

Tower Number	Assembly Type	Items to be Replaced (Starting from landing plate)	Quantity per Tower (3 Phases)	
1	Strain (see Figure 5)	1 - Ball Oval Eye (300kN)	Item no.	Quantity
		2 - Live Line Socket Tongue (300kN)	1	6
		3 - Double Extension Link (300kN)	2	6
		4- Triangular Yoke Plate (300kN)	3	3
		5- Shackle(210kN)	4	3
		6- Twisted Shackle (210kN)	5	12
		7- Sag Adjuster (210kN)	6	12
		8 - Shackle (210kN)	7	6
		9 - Cranked Extension Link (300kN)	8	12
		10- Compressed Dead End Assembly with Jumper Flags for Tern	9	6
			10	12

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2	Strain (see Figure 6)	1 - Ball Oval Eye (300kN) 2 - Live Line Socket Tongue (300kN) 3 – Double Extension Link (300kN) 4- Triangular Yoke Plate (300kN) 5- Shackle(210kN) 6- Twisted Shackle (210kN) 7- Sag Adjuster (210kN)  8 - Shackle (210kN) 9 – Cranked Extension Link (300kN)  10- Compressed Dead Assembly with Jumper Flags for Tern	Item no.	Quantity
			1	12
			2	12
			3	6
			4	6
			5	24
			6	24
			7	12
			8	24
			9	12
			10	24
3	Strain (see Figure 6)	1 - Ball Oval Eye (300kN) 2 - Live Line Socket Tongue (300kN) 3 – Double Extension Link (300kN) 4- Triangular Yoke Plate (300kN) 5- Shackle(210kN) 6- Twisted Shackle (210kN) 7- Sag Adjuster (210kN)  8 - Shackle (210kN) 9 – Cranked Extension Link (300kN)  10- Compressed Dead Assembly with Jumper Flags for Tern	Item no.	Quantity
			1	12
			2	12
			3	6
			4	6
			5	24
			6	24
			7	12
			8	24
			9	12
			10	24

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4	Strain (see figure 6)	1 - Ball Oval Eye (300kN) 2 - Live Line Socket Tongue (300kN) 3 – Double Extension Link (300kN) 4- Triangular Yoke Plate (300kN) 5- Shackle(210kN) 6- Twisted Shackle (210kN) 7- Sag Adjuster (210kN)  8 - Shackle (210kN) 9 – Cranked Extension Link (300kN)  10- Compressed Dead Assembly with Jumper Flags for Tern	Item no.	Quantity
			1	6
			2	6
			3	3
			4	3
			5	12
			6	12
			7	6
			8	12
			9	6
			10	12
			4	Strain (see figure 7)
1	3			
2	3			
3	3			
4	3			
5	3			
6	6			
7	6			
Gantry	Strain (see figure 8)	1 – Shackle 210kN 2 – Turnbuckle – Clevis Oval Eye (210kN) 3 – Ball Oval Eye (210kN IEC 20mm) 4- Socket Clevis (210kN) 5- Triangular Yoke Plate (300kN) 6- Shackle (210kN)  7-Compressed Dead End Assembly for Bull	Item no.	Quantity
			1	3
			2	3
			3	3
			4	3
			5	3
			6	6



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			<table><tr><td>7</td><td>6</td></tr></table>		7	6										
7	6															
4	Insulated Earthwire Strain (see figure 9)	1 – Shackle 120kN 2 – Composite Earthwire Insulator (120kN) 3 – Shackle(120kN) 4- Strain Clamp ( 11.5mm-13.5mm) 5- Wire Rope Clamp for 19/2.7	<table><tr><td>Item no.</td><td>Quantity</td></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>2</td></tr><tr><td>3</td><td>2</td></tr><tr><td>4</td><td>2</td></tr><tr><td>5</td><td>4</td></tr></table>		Item no.	Quantity	1	2	2	2	3	2	4	2	5	4
Item no.	Quantity															
1	2															
2	2															
3	2															
4	2															
5	4															
Gantry	Insulated Earthwire Strain (see figure 9)	1 – Shackle 120kN 2 – Composite Earthwire Insulator (120kN) 3 – Shackle(120kN) 4- Strain Clamp ( 11.5mm-13.5mm) 5- Wire Rope Clamp for 19/2.7	<table><tr><td>Item no.</td><td>Quantity</td></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>2</td></tr><tr><td>3</td><td>2</td></tr><tr><td>4</td><td>2</td></tr><tr><td>5</td><td>4</td></tr></table>		Item no.	Quantity	1	2	2	2	3	2	4	2	5	4
Item no.	Quantity															
1	2															
2	2															
3	2															
4	2															
5	4															

Quantities shown above is for Line 1 which is exactly the same for Line 2. Quantities have to be multiplied by two to get the the total quantities. Total quantities can be seen in Table 5.

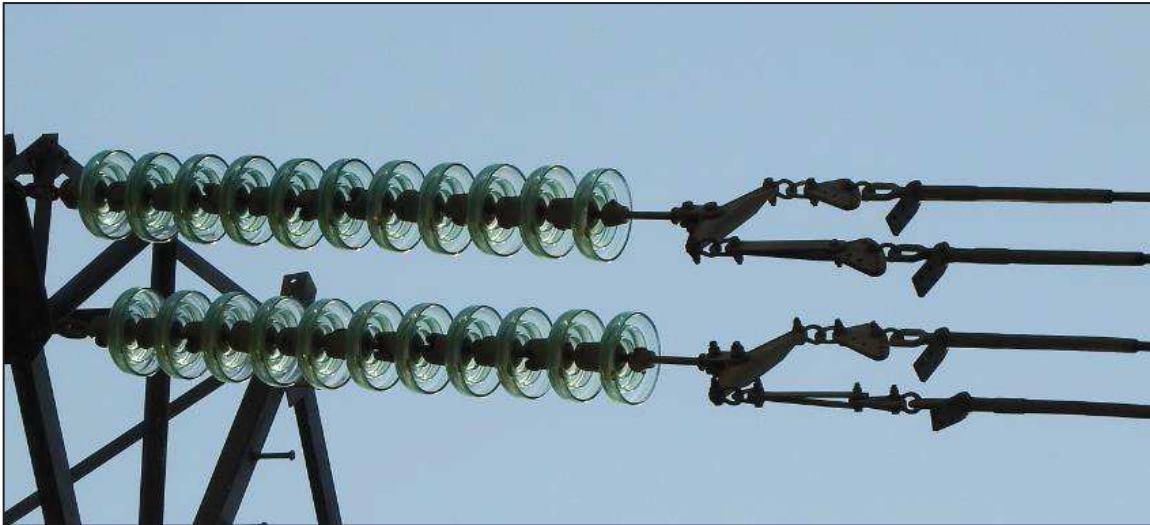


Figure 5: Tower 1 Strain Assembly

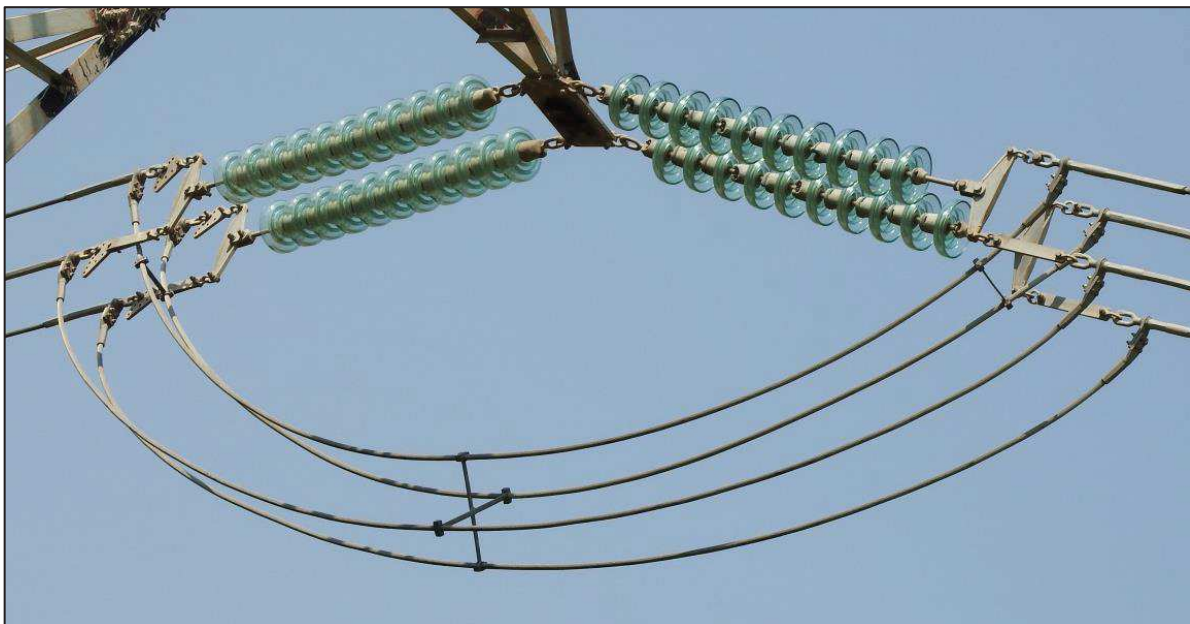
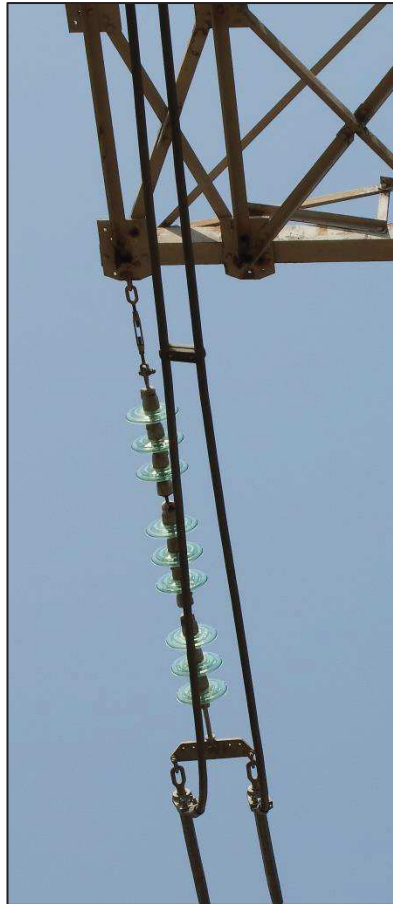


Figure 6: Tower 2, 3 & 4 Strain Assembly



**Figure 7: Single Insulator Assembly at Tower 4**



**Figure 8: Strain Assembly at Gantry**

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**Figure 9: Insulated Earthwire Assembly**

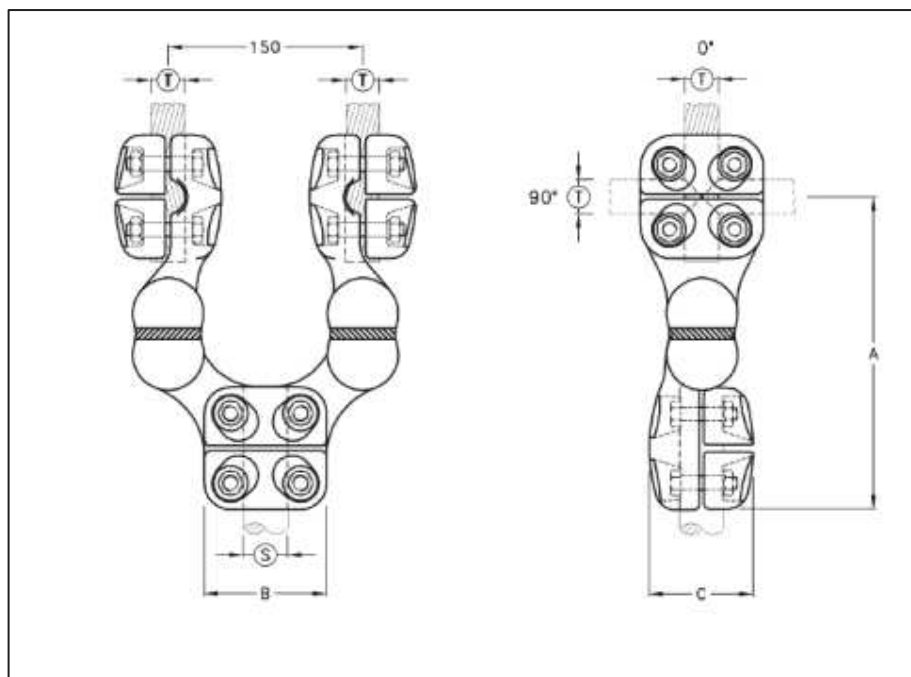
### 3.1.2.1 Miscellaneous Hardware

**Table 4: Miscellaneous Hardware Specifications**

Item Number	Description	Quantity	Comments
1	2 Tern to 2 Tern Dropper Clamps – Clamps to connect Athene Hillside Lines to Bypass	24	Modified Y-7/8 Clamps
2	Spacer Damper Quad Tern 450mm	60	None
3	Jumper Rigid Spacers – Twin	30	None
4	Jumper Rigid Spacers – Quad	12	None
5	Twin Bull Rigid Spacer	12	None
6	Junction Plates : Quad Tern to Twin Bull	6	To be manufactured
7	Jumper Flags, Bolts and Nuts	M12 for Tern Flags,	Jumper Flags and Junction Plates require new bolts and nuts since they will be opened.

### 3.1.3 Droppers

The droppers and dropper clamps for both lines need to be replaced. The current conductor being used for the droppers is Bull. Modified clamps will be used for the droppers. The clamps will be modified to accommodate the conductor spacing of 450mm.



Y-7/8	C21443	26	38.3	1600	0°+90°	253	95	82	4.90kg
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The length of bull conductor required for the droppers is approximately 100m. Bull is easily available and can be sourced easily.

### 3.1.4 Insulators

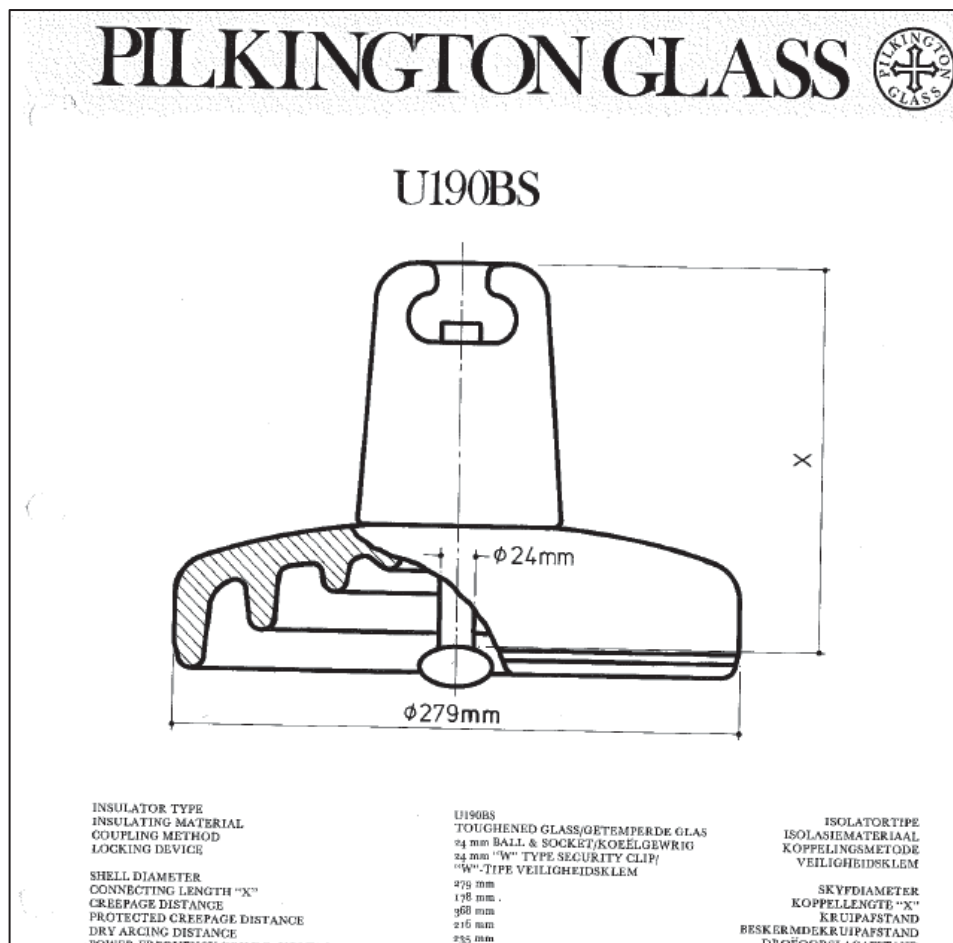
Based on information from East Grid the current glass insulators are the old type U190s i.e. 210kN.

The total number of U300 insulator strings required is for the refurbishment is 72 and the number of U210 insulator strings required is 12.

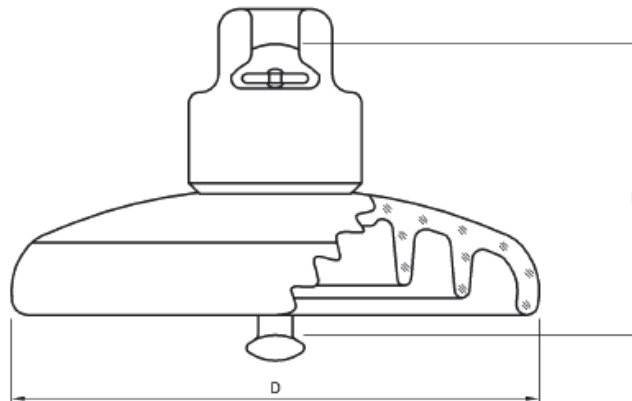
**NB. U190 insulators have been discontinued and will be replaced with U300. The number of discs per insulator string will be 10 to cater for the difference in the length the discs of the U190.**

**11 Discs of U190 = 1958mm**

**10 Discs of U300 = 1950mm**







**Toughened Glass Insulator**  
**Socket/Ball Type**

Type No	Catalogue Number	Nominal Diameter D	Nominal Spacing H	Nominal Creepage Distance	Standard Coupling I.E.C.	U.T.S. (kN)	Impulse Withstand Voltage Positive	Impulse Withstand Voltage Negative	Power Frequency Withstand Voltage Wet	Power Frequency Puncture Voltage	Unit Weight
U70BL	B940013	255	146	305	16	70	100kV	103kV	43kV	110kV	3.70kg
U120BS	B940023	255	146	305	16	120	100kV	103kV	43kV	110kV	4.00kg
U210B	B940033	280	170	380	20	210	110kV	110kV	45kV	130kV	7.00kg
U300BS	B940143	320	195	485	24	300	130kV	130kV	50kV	130kV	10.9kg

### 3.1.5 Corrosion

#### Towers:

All tower steel and hardware shall be protected by hot dip galvanizing to a minimum of 105  $\mu\text{m}$  (see SANS 121:2000). As an additional protection for designated parts of the tower on Section B of the line, paint will be required to cover gusset plates and bolts on all structures. Details of the paint system and options will be made available later. In addition to galvanizing, foundation stubs and anchor links will be coated with two coats of bitumastic paint.

#### Bolts:

As an alternative to galvanized bolts and nuts – corrosion protection in the form of specialized thermal diffusion zinc coating should be used for Section B and should comply with the requirements of SANS 9001:2008 and SANS 53811:2006 with a coating thickness of minimum 70 microns.

### 3.1.6 Foundations

Contractor to submit a design to cater for the refurbishment as per 240-47172520 – The Standard for the Construction of Overhead Powerlines (TRMSCAAC 5.2-1)

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### 3.1.7 Earthing

Other than complying to TRMSCAAC 5.2 rev 1 Annexure D, the contractor will need to provide a document detailing how one will mitigate the risks involved. Since both lines have no earthwire, the droppers from both lines will be disconnected during the refurbishment to mitigate against the risk of the voltage gradient increasing in the immediate area if a fault occurs on the line that is connected to the system.

### 3.1.8 Fibre

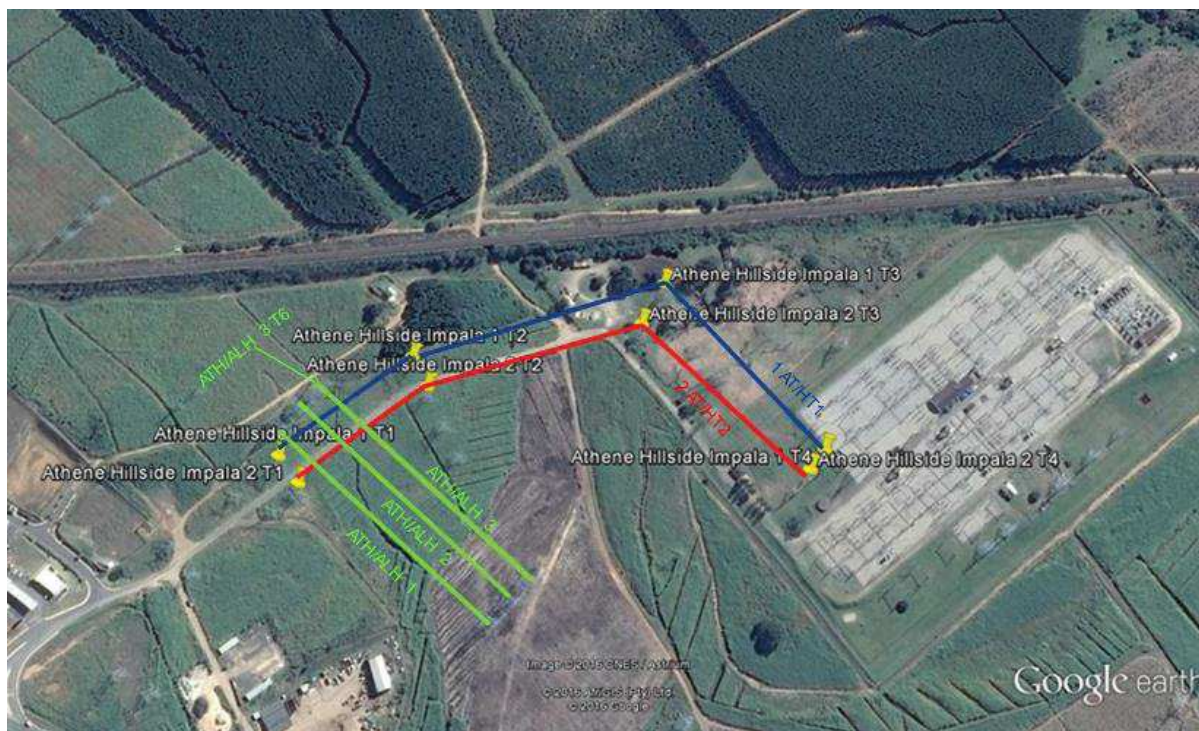
#### Current Situation:

- 48 core OPGW on Athene – Hillside 2.
- 48 core OPGW on Athene – Hillside 3.
- Athene – Hillside 3 T6 is connected to Athene-Hillside-Impala 1 T2 by means of 2 x 48 core ADSS. The connection then runs all the way to Impala via Athene – Hillside - Impala T3, T4 and the gantry.
- Athene – Hillside 3 T6 is connected to Athene – Hillside 2 T6 by means of duct cable.

In order to minimise the outage time for the fibre during the project, the following is recommended:

#### Sequence of Events during Construction:

1. Refurbish Line 2 first
2. After refurbishing line 2, trench from Athene-Hillside 3 T6 to Athene-Hillside-Impala 2 T2 and install 2 x 48 core duct cables.
3. Install 2 joint boxes on Athene-Hillside-Impala 2 T2 and string 2 x 48 core ADSS from Athene-Hillside-Impala 2 T2 until the gantry (install 2 new joint boxes on the gantry).
4. After the telecoms connection is in place, commence with refurbishment of Athene-Hillside-Impala 1.
5. After refurbishment of Athene-Hillside-Impala 1 is complete then string 2 x new 48 core ADSS from Athene-Hillside-Impala 1 T2 until gantry.



The current hardware configuration on Line 1 will suffice for the new 48-core ADSS fibre due to its light weight.

It should be noted that there is an agreement in place with the sugar cane owner, that the cane in this area is to be green harvested i.e. no burning of cane in this area.

### 3.1.6.1 Fibre Hardware

The hardware assembly for the ADSS Fibre is as follows:

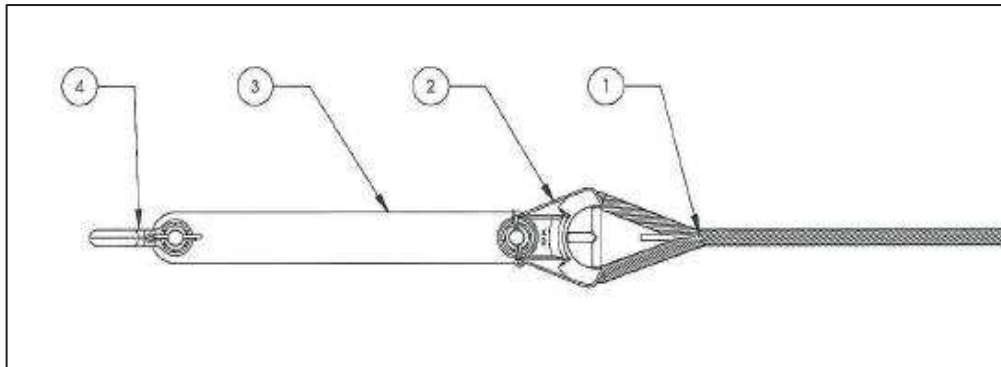
1. Fiberline Dead End Assembly
2. Thimble Clevis 120kN
3. Extension Link 350mm, 120kN
4. Shackle 120kN

A total of 20 assemblies will be required for the refurbishment.

A total of 8 Joint Boxes will be required for the refurbishment.

A total of 120 Downlead clamps will be required for the refurbishment.

A total of 40 Spiral Vibration Dampers for the ADSS will be required for the refurbishment.



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**Table 5: Consolidated Hardware List**

Item	Rating (kN)	Part Number	Quantity
Tower shackle	210	975137-00	72
Ball Oval Eye	300	971007-00	72
Live Line Socket Tongue	300	971902-00	72
Double Extension Link-REUSE	REUSE		
Triangular Yoke Plate	REUSE		
Shackle	210	975137-00	324
Twisted Shackle	210	975075-00	144
Sag Adjuster	210	979127-00	72
Cranked Extension Link	REUSE		
Turnbuckle - Clevis Oval Eye	210	977487-00	12
Trapezoidal Yoke Plate	300	976054-00	6
Ball Oval Eye IEC 20mm	210	971004-00	12
Socket Clevis	210	972384-00	12
Shackle	120	975131-00	60
Composite Earthwire Insulator	120		8
Strain Clamp (11.5mm-13.5mm)	N/A	841514-00	8
Wire Rope Clamp for 19/2.7 -CROSBY CLAMP	N/A		16
2 Tern to 2 Tern Dropper Clamps	N/A	Modified Y-7/8 Clamps	24
Spacer Damper Quad Tern 450mm	N/A	856889-00	60
Jumper Rigid Spacers – Twin	N/A	856785-00	45
Jumper Rigid Spacers – Quad	N/A	856831-00	12
Junction Plates : Quad Tern to Twin Bull	N/A	Babcock to manufacture	6
M12 Bolts, nuts washers and Nodlock washers-junction plates. Bolts to be min 65mm long. Assuming that only one side of the jumper will be removed per tower.			450
U300 Glass Insulator Discs	300		720
U210 Glass Insulator Discs- CLOSING SPANS	210		132
Fiberlign Dead End strain Assembly-ADLASH			40
Joint Boxes	N/A		8
Downlead Clamps	N/A		120
Spiral Vibration Dampers	N/A		80
Tern Conductor - 1 drum			3000m
Bull Conductor- 1 drum			500m
ADLASH CABLE- 48 CORE- LONG SPAN			5000m

	<p align="center"><b>Detailed Design Report</b></p> <p align="center"><b>Athene Hillside Impala 1 &amp; 2 132kV</b></p> <p align="center"><b>Bypass Refurbishment</b></p>	<p align="center"><b>Technology</b></p>
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### 3.1.9 Obstacles, Risks & Mitigations

**Table 6: Obstacles, Risks and Mitigations**

Obstacles	Risks	Mitigations
<p>1. Substation Equipment below closing span, Substation Road, HV Yard Fence, Cattle Farm, Sugar Cane, Roads, Buildings.</p>	<p>1. Damage to substation equipment, Blockage of substation road, Damage to HV Yard Fence.</p> <p>2. Failure of hardware/ conductor/ tower while performing construction activities.</p> <p>3. Outages and outages on fibre network.</p> <p>4. Access to towers and spans.</p> <p>5. Contractor capabilities to perform work.</p> <p>6. Fault on energised line will increase voltage gradient in immediate area</p> <p>7. Weather</p>	<p>1. Construction of suitable structures to prevent conductor from touching ground.</p> <p>2. Development of suitable safe work procedure to perform construction activities.</p> <p>3. Planning of outages on both the lines and the fibre network to prevent delays.</p> <p>4. Planning of work during periods when servitude is clear and no planting and harvesting is being done.</p> <p>5. Use of competent prequalified contractors.</p> <p>6. Disconnect both lines from network.</p> <p>7. Incorporate weather delays into schedule.</p>



	<p align="center"><b>Detailed Design Report</b></p> <p align="center"><b>Athene Hillside Impala 1 &amp; 2 132kV</b></p> <p align="center"><b>Bypass Refurbishment</b></p>	<p align="center"><b>Technology</b></p>
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### 3.1.10 Basic Construction Activities

Below are listed the basic construction activities to complete the scope of work. During the tender stage and award stage discussions will be held with the contractor finalise the activities.

**Table 7: Basic Construction Activities**

Item no	Basic description of steps to follow (not limited to these).
1	Site establishment by contractor
2	Development of Technical Documentation by Contractor – Method Statements, ITPS, etc.
3	Development and implementation of suitable structures for mitigation purposes – fences, road, houses, etc.
4	Supply, assemble new towers in sections
5	Implement Earthing Practices as accepted by Eskom.
6	Disconnect T-off lines from Athene Hillside Lines.
7	Drop phase and fibre connections from tower to ground(disconnection of droppers from Athene Hillside Lines also)
8	Remove old towers and replace with new
9	Reconnect phase and fibre connections with new insulators and hardware
10	Reconnect dropper to the Athene Hillside Lines
11	Redo foundation caps

	<p align="center"><b>Detailed Design Report</b></p> <p align="center"><b>Athene Hillside Impala 1 &amp; 2 132kV Bypass Refurbishment</b></p>	<p align="center"><b>Technology</b></p>
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#### **4. Conclusion**

This report outlines the detail design for the Athene Hillside Impala 1 & 2 132kV Bypass refurbishment. For the eight towers complete replacement of six will be done whilst two will be refurbished. Replacement of hardware and insulators will also be done.

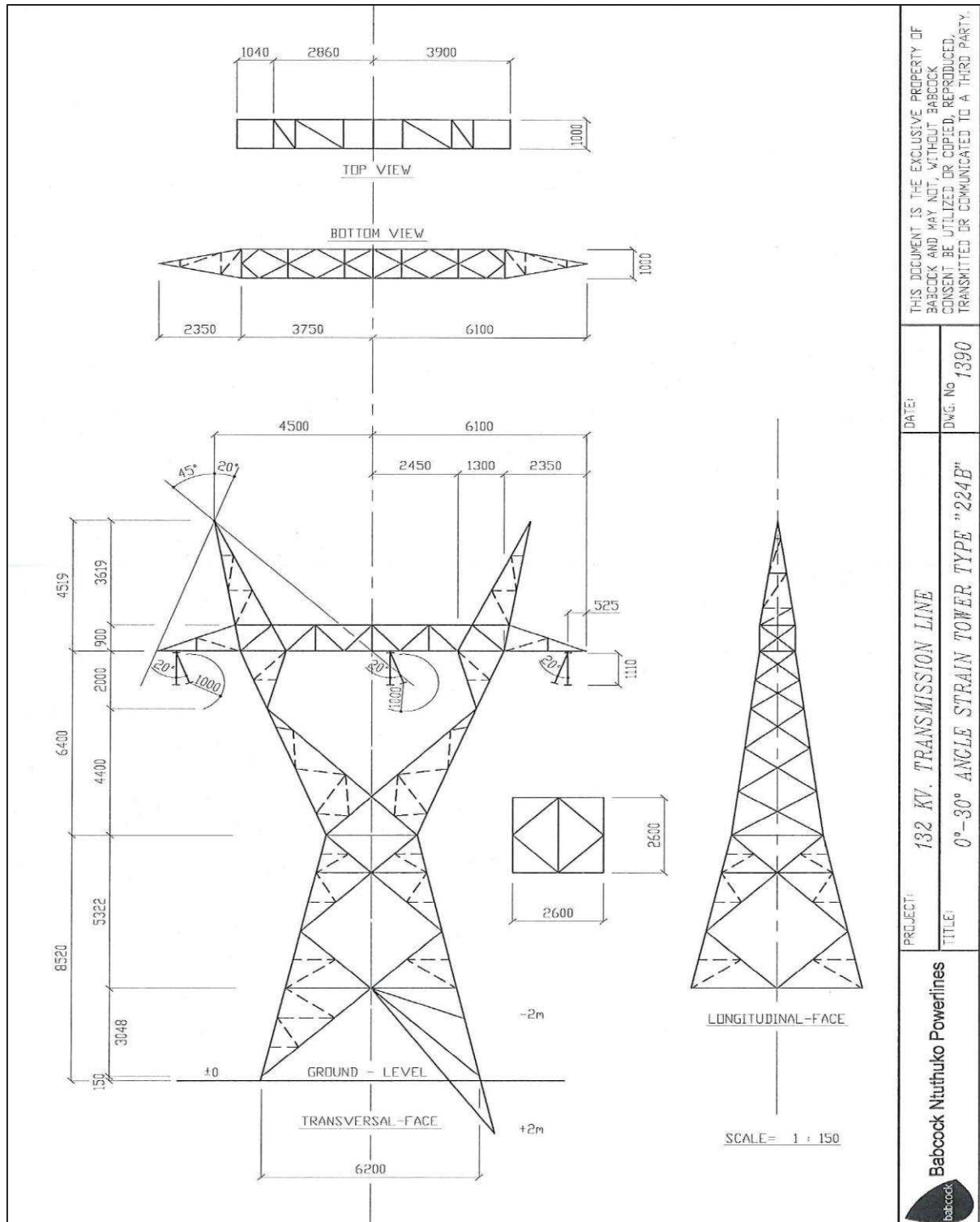
In order to minimise the outage time for the fibre during the project, it is recommended that Line 2 is to be refurbished first and the 2 x 24 core ADSS fibre will be spliced onto a 48 core fibre in the joint box on Athene Hillside Impala 2 T2. The 48 core will then be strung on line 2 for the duration of the refurbishment on line 1. Once the refurbishment on line 1 is completed 2 x 48 core ADSS fibre will be strung on line 1.

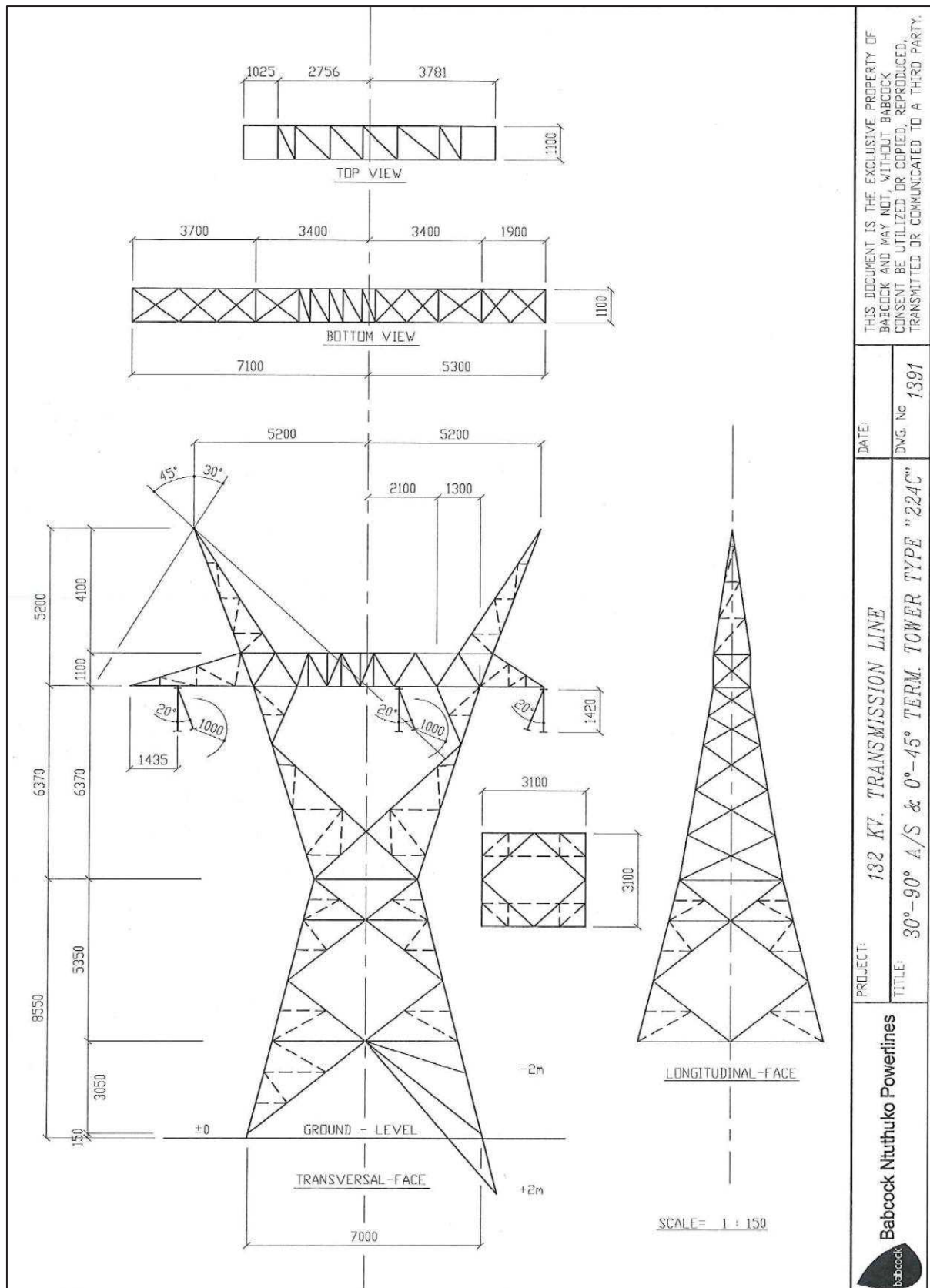
Based on the concept design the refurbishment of the eight towers can be executed easily if the risks highlighted in table 6 are mitigated against before execution begins.

Although replacing of conductor is not part of the scope of work, additional conductor will be ordered to cater for any damages that may occur during execution. Samples of hardware and insulators that will be replaced will be taken for testing to determine the remaining life. This will allow for better planning for maintenance for components in this area and in areas that generally have high corrosion rates.

After the towers have been refurbished, the towers will need to be assessed in terms of corrosion every year. This will ensure that the situation that we are currently facing will not surface again.

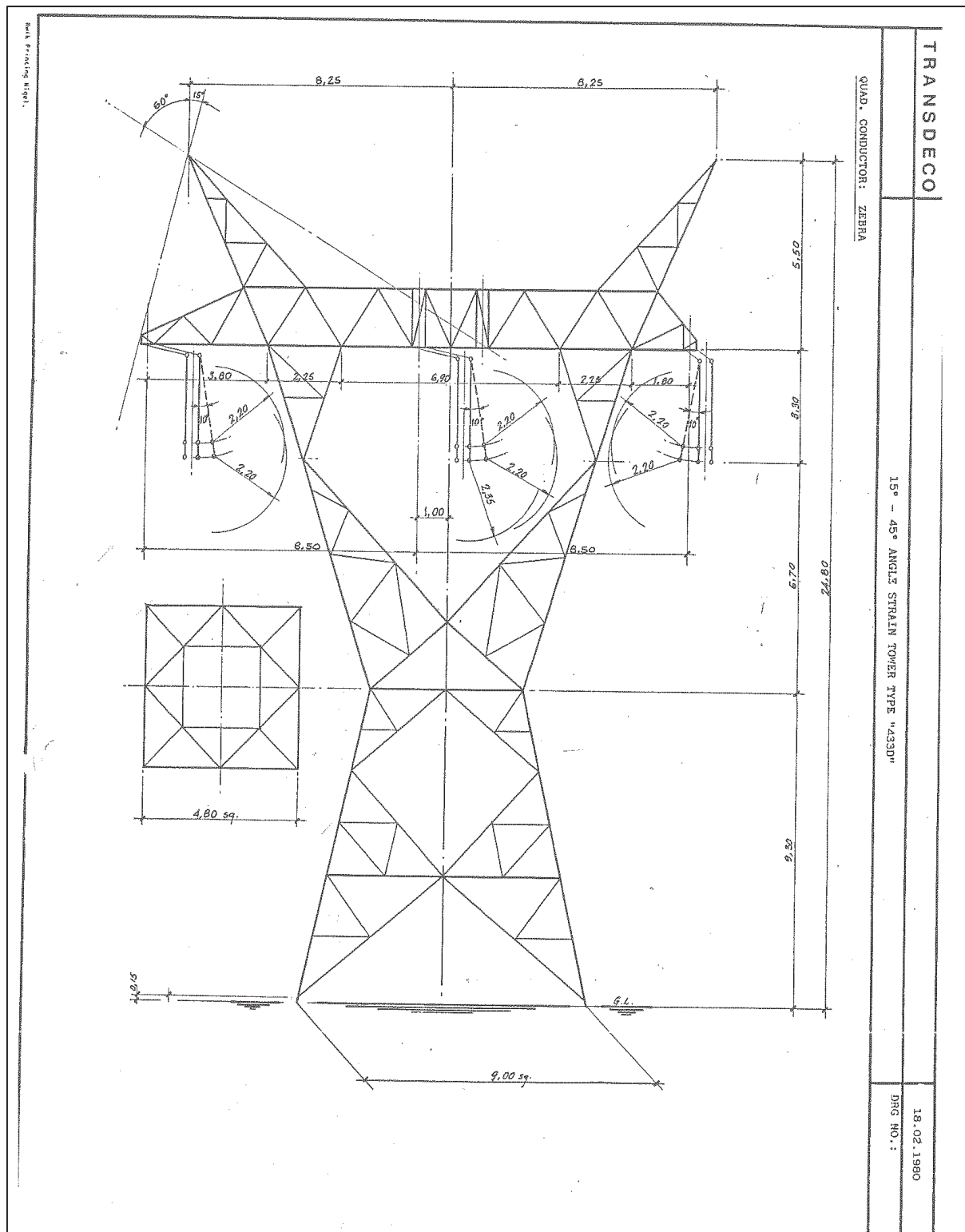
## 5. APPENDICES





	<b>Detailed Design Report</b> <b>Athene Hillside Impala 1 &amp; 2 132kV</b> <b>Bypass Refurbishment</b>	<b>Technology</b>
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Figure 11: 224C Outline Drawing



**Figure 12: 433D Outline Drawing**