Eskom	Report	Technology

Title: **PHILIPPI TRF3 TO GIS 132KV CABLE SYSTEM PROJECT SPECIFICATION**

Unique Identifier:	**240-171000243**
Alternative Reference Number:	**n/a**
Area of Applicability:	**Engineering**
Documentation Type:	**Report**
Revision:	**1**
Total Pages:	**15**
Next Review Date:	**n/a**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	Functional Responsibility	Authorized by
Fernando Witbooi	**Fernando Witbooi**	**Bheki Ntshangase**
Chief Technologist:	**Asset Management: SED**	**Senior Manager: Asset Management SED**
Date: 29/09/2023	Date: 29/09/2023	Date: 29/09/2023

PCM Reference: Choose an item.

SCOT Study Committee Number/Name: **Cable Systems and Metal Enclosed Switchgear**

Content

Figures

1. Introduction

This document provides the design and minimum technical requirements for the implementation of a 132kV cable system for the connection of the new 500 MVA 400 / 132 kV transformer (TFR3) to the existing indoor 132kV GIS at Philippi substation.

2. Supporting clauses

2.1 Scope

The scope of the document contains the minimum technical requirements for the design, manufacture, supply and installation of a 132kV cable system to interconnect the new 500MVA 400/132kV transformer to the existing indoor GIS at Philippi substation.

2.1.1 Purpose

The purpose of the document is to specify the minimum technical requirements for the design, manufacture, supply and installation of a 132kV cable system to interconnect the new 500MVA 400/132kV transformer to the existing indoor GIS at Philippi substation.

2.1.2 Applicability

This document shall apply for Eskom Holdings Limited, Transmission division wherein Eskom has a controlling interest.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] SANS/IEC 60840: Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) — Test methods and requirements

[2] IEC 6227-209 High-voltage switchgear and controlgear - Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables - Fluid-filled and dry-type cable-terminations

[3] IEC 60229: Test on cable over sheaths which have a special protective function and are applied by extrusion

[4] IEC 61914 Cable cleats for electrical installations

[5] IEC 60287: Calculation of the continuous rating of cables (100% load factor)

[6] IEC 60811: Common test methods for insulation and sheathing materials of electric cables

[7] IEC 61443: Short circuit temperature limits of electric cables with rated voltages above 30 kV (Um 36 kV)

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Cable system	Cable with installed accessories (i.e. joints if applicable, terminations, earthing and bonding system)

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
Al	Aluminium
CAS	Corrugated Aluminium Sheath
CV	Curriculum Vitae
ECC	Earth Continuity Conductor
GIS	Gas Insulated Switchgear
HV	High Voltage
SVL	Sheath Voltage Limiter
XLPE	Cross-Linked Polyethylene

2.5 Roles and responsibilities

The appointed Eskom Technical representatives are responsible for the compilation and review of this document.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Refer to clause/ section 2.2.

3. General background and layout

The new 132kV cable to be installed will interconnect the new 500MVA 400 / 132 kV transformer (TFR3), which will be installed in the outdoor high voltage yard to the existing indoor 132kV GIS at Philippi substation. The orientation of the existing GIS termination is vertical as highlighted in Figure 1. The 132kV cable will be directly buried in the ground over its entire route length of approximately 100m.

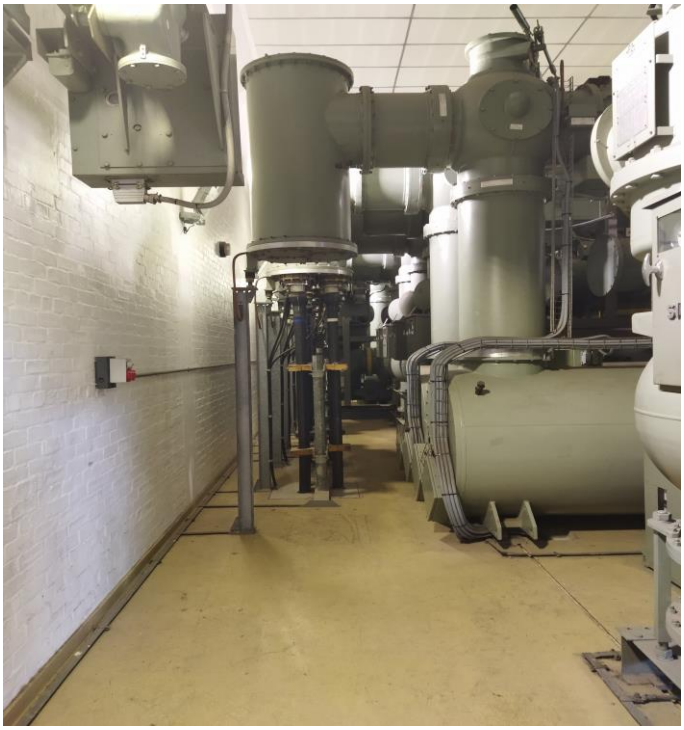

Figure 1: Vertical orientation of existing 132kV GIS termination

4. Minimum cable system design and installation requirements

In the request for proposal, the cable systems suppliers are required to sufficiently optimise the 132kV XLPE cable system design, manufacture and installation, for the prevailing conditions and constraints that may arise from on-site conditions or specified in this document. All cable and accessories details, raw material information, datasheets, drawings, preliminary routing and configurations, trench designs where applicable, racking designs, applicable calculations with assumptions and results, test plans, quality inspection test plans and any other requirements contained in this specification shall be included in the final cable systems suppliers design package.

The cable systems shall be designed to comply with the following minimum criteria:

a) Prequalified cable or that meeting the extension of prequalification in accordance with IEC60840 shall be accepted.

b) Only cable having been type tested as a system, that is with the associated accessories supplied as part of this tender, in accordance with IEC60840 be accepted.

c) No lead sheathed cables will be accepted. CAS, extruded, welded, lapped laminated sheaths with copper or aluminium wires are acceptable.

d) Water blocking methods shall be applied to the cable and water penetration test shall have been conducted on the cable offered either as part of the type test report or separately.

e) The XLPE cable system shall have a minimum design life of 40 years. When required, cable systems suppliers shall submit calculations and/or assumptions supporting the system design life criteria, considering thermal, electrical and mechanical ageing of the cable system, i.e. both the cable and accessories.

f) Each XLPE cable system shall meet the specified maximum continuous current rating at a daily load factor of 1 (100%) for the Eskom defined maximum conductor continuous current temperature limit of 90°C. A minimum continuous current rating of 2187 A is required for this installation. This is to coincide with a 500 MVA cable system continuous loading. The emergency current ratings at 105 °C shall be provided and also for a four hour, two hour and one hour rating. The minimum symmetrical three phase fault level requirement is 50kA for 1 second and the minimum single phase to earth fault level requirement is 40kA for 1 second.

Calculation of the cable system ampacity (rating) shall show all the rating factors that were considered. The applicable ambient temperature range as stated in schedule A. Cable system ampacity (rating) calculations are required for an ambient temperature of 40°C and soil temperature of 25˚C at laying depths of between 1 to 1.2 meters. Calculations with all relevant assumptions and conditions considered shall be submitted. The cable system design should be optimised to prevent using any cable joints and should be limited to a single core cable per phase circuit design arrangement.

g) Following is the primary material required for the combined 132kV cable systems for this project:

1) 3 ×100m single core 132kV cable

2) 3 ×outdoor cable terminations shall be supplied with composite / silicon bushings.

3) 3 ×dry-type SF6 cable terminations, inclusive of female bushing shall be supplied.

4) 3 ×Outdoor termination support structures.

5) Earth Continuity Conductors(ECC) and/or bonding leads of 110m length.

6) 3-way Link disconnecting box

7) 3-way SVL link disconnecting box

8) 3 ×SVL arresters

h) Single end point bonded methods shall be used to minimise sheath currents and maintain sheath voltages within acceptable limits. The open circuited sheath standing voltage should preferably not exceed 65 V.

i) The SVL shall be adequately rated to withstand temporary power frequency or transient over voltages induced during maximum fault current conditions, switching and lightning events. Detailed calculations shall be submitted for the sheath standing voltage for steady state and transient currents, and for the SVL rating selected.

j) The cable system supplier and installation contractor shall be responsible for surveying the final cable route in accordance with the preliminary routing information provided.

k) The cable length shall make provision for snaking, where applicable, of the cable along its route, bending, slack and passage of the cable through the termination support structures and at the termination ends.

l) The cable system design shall make provision for all trenching where applicable, steel support frames, termination support structures, termination foundations, termination clamps, cable racking and cable cleats in accordance with IEC61914 and in accordance with the expected thermal mechanical behaviour of the cable. All final drawings, appropriately referenced, related to these items shall be provided as part of the final design package.

m) Detailed calculations/finite element simulation shall be submitted to show the calculated electromechanical force design considerations where applicable for cable racking/support and cleat designs. Detailed calculations of the forces employed and mitigated during the installation of the cable shall be submitted.

n) Where there is a need to modify the GIS termination enclosure, detailed finite element/multi-physics simulations shall be done to ascertain the effect on electrical field strength and any associated mitigation of excessive electrical field strengths.

o) Bonding and earthing of all support frames and structures, cleats and clamps, inclusive of semiconductive surfaces as required, shall be done, in order to limit any adverse induced voltages due to various operating conditions such as inrush, loading rejection or switching.

p) A 32mm fibre optic cable duct shall be installed adjacent and along the cable route.

5. 132kV Cable Scope method statement

A method statement and procedure for the execution of the cable and accessories design, manufacturing, installation, testing and measurements shall be provided covering the following minimum aspects:

a) Project Plan indicating time frames of all related activities including GIS works.

b) Project team and roles for project management, supervising, installation and jointing must be provided. Organograms for all relevant project teams, and roles to be submitted.

c) Final design, design review and engineering phase time allowance after contract award.

d) In process inspections at the cable and the accessories manufacturing plants.

e) Quality inspection test plans and factory acceptance tests for the cable and all cable accessories at the manufacturing plants.

f) Final site and route surveying, site preparation and/or establishment.

g) Erection of steel bracing and supporting structures and installation of foundations (civil works).

h) Trenching, racking and installation design and on-site quality inspection plans.

i) Jointing/splicing (if applicable) installation instructions and on-site quality inspection plans.

j) Cable pulling methods to be employed.

k) Sheath bonding arrangement, bonding lead, link disconnecting boxes, SVLs: Design, manufacturing, quality inspection test plan, installation, and on-site testing and commissioning.

l) Outdoor and SF6 Cable terminations inclusive of female bushing: installation methods and on-site quality inspection plans.

m) Quality assurance tests and measurements to be conducted during installation such as;

   1) Bonding lead current measurements

   2) Sheath-bonding verification

   3) Contact resistances for earth and bonding connections

   4) Positive and zero sequence impedance measurement.

n) After installation testing, and commissioning method.

6. GIS scope of works

All GIS related supply and works shall be done in accordance with IEC 62271-209 for the GIS cable terminations.

6.1 Preparation and Installation of GIS termination

- Preparatory works, to enable the cable installations.
- De-gassing of GIS.
- Modification of existing GIS compartment to accommodate new GIS termination/sealing end(where required).
- Installation or replacement of female GIS bushing.
- Installation of supporting structures/ frame for cable (where required).
- Re-gassing of GIS.

6.2 GIS related documentation

The following documentation pertaining to the GIS installation shall be provided as part of the final design package.

- Full set of drawings complete with labels and dimensions for all installed GIS components.
- All installation and maintenance manuals.
- All operating instructions.

7. Other requirements

a) Operation and maintenance manuals for the cable systems and accessories installed shall be provided as part of the final design package.

b) 10 year system guarantee will be required for the cable systems, supplied, installed and commissioned. This 10 year system guarantee will be required for the operating conditions as stipulated in this report and the normal scheduled maintenance prescribed and agreed to by Eskom for this project.

c) The cable system supplier and installation contractor shall be responsible for surveying the final cable route in accordance with the preliminary information provided and specify the final drum lengths required for installation.

d) The cable lengths shall make provision for the outdoor termination and SF6 terminations.

e) Additional parameters and submissions that will be required at time of project execution are contained in Appendix B.

8. Type tests and Pre-qualification tests

a) Type tests, including the water penetration tests, shall have been performed on the cable and accessories as a system, in accordance with clause 12 of IEC 60840. Range of approval covered by the type test shall be in accordance with clause 12.2 of IEC 60840 The type test reports shall clearly identify the cables and accessories according to clauses 6 and 7 of IEC 60840. The type test reports shall include fully detailed and dimensioned drawings of the cable and accessories tested. Including the raw materials used and the manufacturing line and manufacturing plant location used.

b) Outdoor terminations with composite insulators shall be designed and tested according to IEC 61462.

c) SF6/GIS dry-type terminations shall be designed and tested according to IEC 62271-209 for XLPE cables.

d) Pre-qualification tests, shall have been performed on cable and accessories tested as a system, in accordance with clause 13 of IEC 60840. Range of approval covered by the pre-qualification shall be in accordance with clause 13 of IEC 60840. The Pre-qualification reports shall clearly identify the cables and accessories according to clauses 6 and 7 of IEC 60840. Including the raw materials used and the manufacturing line and manufacturing plant location used. The Pre-qualification reports shall include fully detailed and dimensioned drawings of the cable and accessories tested.

9. Quality Assurance tests and measurements

The following quality assurance tests and measurements shall be conducted during or after installation as applicable;

a) Bonding lead current measurements

b) Sheath-bonding verification

c) Contact resistances for earth and bonding connections

d) Positive and Zero sequence impedance measurements

10. The cable system after installation tests

The Contractor shall conduct the following after installation tests. These tests shall comply with clause 16 of SANS 60840 respectively. These proposals, inclusive of method statement, shall be provided with the tender. All test and measurement data and results shall be provided to Eskom in a final report for Eskom review and compliance acceptance.

a) DC over sheath integrity test.

b) AC Voltage withstand test with test levels(s) within GIS withstand limits.

c) Partial discharge (PD) measurement. PD test methods, detection systems as well as pass/fail criteria to be provided.

11. Risks identified for the 132kV Cable system project:

Electrical clearances and safe working clearances need to be considered for the cable terminations to cater for the cable system installation and commissioning testing that will be performed on-site.

12. Tender Submissions

The following documents must be submitted as part of the tender submissions.;

1) Completed Schedule B in Appendix A

2) Method statement for the HV cable scope and GIS works.

3) Experience and qualifications of technical specialists and/or designers responsible for cable system design and technical support shall be provided. A one page CV for each specialist will be sufficient. A minimum of two Engineers or Engineering Technologists are required.

4) Experience and certification of jointers and installation teams demonstrating relevant HV cable installation experience shall be provided. A one page CV for each team member will be sufficient. A minimum of three team members consisting of one jointer/installation supervisor and two jointers is required

5) Preliminary outline drawings with dimensions and appropriately labelled of all key components

6) Successfully passed Prequalification certification/report

7) Successfully passed Type Test Report with water penetration test for cable and terminations

8) Cable construction drawing(s) with layer labels and dimensions

9) Ampacity calculations.

10) Preliminary cable supports and cleats drawings

11) Outdoor and GIS termination drawings with labels and dimensions

12) Accessory drawings: link boxes, bonding leads, SVL and ECC

13. Conclusion

This report is effective to recommend and specify cable system request for proposal requirements to connect the 132kV cable system to Transformer 3 and the internal GIS at Philippi substation. The cable systems supplier and installation company to complete Annex A technical schedule B as part of the tender deliverables.

14. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Bheki Ntshangase	Senior Manager: Asset Management: SED
Frik Schoeman	Senior Technologist: Asset Management: SED

15. Revisions

Date	Rev.	Compiler	Remarks
Sept 2023	1	F Witbooi	Revise technical requirements in line with new procurement strategy. Added GIS scopes. Revise evaluation criteria.

16. Development team

The following people were involved in the development of this document:

- Fernando Witbooi: Chief Technologist Engineering : Asset Management :SED

17. Acknowledgements

Not applicable.

Annex A – Schedules A and B for the Philippi 132 kV TRF3 XLPE cable system Schedule A: Purchaser's specific requirements

Schedule A: Purchaser's specific requirements

Schedule B: Guarantees and technical particulars of equipment offered - to be completed by tenderer

Item	Description		Schedule A	Schedule B
1	**Ambient and installation parameters**			
1.1	a) altitude	m	1800	xxxxxxxx
	b) ambient air temperature	°C	–5 °C to 40 °C	xxxxxxxx
	c) soil temperature	°C	-10 °C to 25 °C	xxxxxxxx
	d) soil thermal resistivity	K·m/W	1.2	xxxxxxxx
	e) depth of burial	m	1.2	xxxxxxxx
	f) configuration		Flat spaced	
	g) special bonding applied		single end point bonded	
	h) lightning ground flash density		severe (14 flashes/km^2/yr)	xxxxxxxx
	i) solar radiation	W/m^2	1 100	xxxxxxxx
	j) ultraviolet radiation		High	xxxxxxxx
	k) relative humidity		10 % to 95 %;	xxxxxxxx
	m) wind pressure and seismic		+-700 Pa (34 m/s) and 3g	xxxxxxxx
	n) pollution severity defined by IEC 60815:		Very heavy	xxxxxxxx
	o) specific creepage distance required for external insulation	mm/kV	31	
	o) maximum conductor operating temperature	°C	90°C (@ 500MVA)	
1.2	Load current (rating)	A	2187(500 MVA)	
1.3	Rated voltage cable and accessories (U as per IEC 60840)	kV	132	
1.4	**Estimated required cable length**	m	300	
2	**Cable specifications**			
2.1	Conductor cross-sectional area	mm^2	Specify	
2.2	Conductor material	Cu/Al	Specify	
2.3	Ampacity (at 90°C)			
	a) 100 % load factor	A	Provide	
	b) 110% for 4 hours	A	Specify	
	c) 120% for 2 hours	A	Specify	

Item	Description		Schedule A	Schedule B
	d) 130% for 1 hour	A	Specify	
	e) 105ºC rating	A	Specify	
2.4	a) Symmetrical short-circuit fault level	kA	50	
	b) Fault level duration	s	1	
2.5	Nominal thickness of XLPE insulation	mm	xxxxxxxx	
2.6	Conductor screen radial stress at U_0	kV/mm	Specify	
2.7	Core screen radial stress at U_0	kV/mm	Specify	
2.8	Type of Metallic sheath		Specify	
2.9	a) Earth fault level	kA	40	
	b) Fault level duration	s	1	
2.10	Detail of nominal thickness of Al or Cu sheath and/or nominal thickness of copper wire strands and number of copper wire strands		Provide drawing reference /description	
2.11	Details of water barriers/blocking applied		Provide drawing reference/description	
2.12	Type of outer sheath (PVC/PE/HDPE etc.)		Specify	
2.13	Outer sheath has flame retardance and low halogen		Yes	
2.14	Conductive coating applied		Graphite or alternative	
2.15	**Other Cable parameters**			
	a) mass of cable	kg/m		
	b) minimum installation bending radius	mm		
	c) d.c. resistance of conductor at 20 °C	Ω/ km		
	d) a.c. resistance of conductor at 90°C	Ω/ km		
	e) a.c. resistance of sheath with conductor at 90 °C	Ω/ km		
	f) reactance per phase	Ω/ km		
	g) capacitance per phase	nF/km		
	h) zero sequence impedance	Ω/ km		
	i) zero sequence capacitance	nF/km		
3	**Cable supporting structures, Cleats and Clamps**			
3.1	Details of cable support structures		Drawing(s)/ document reference	
3.2	Details of cleats		Drawing(s)/ document reference	

Item	Description		Schedule A	Schedule B
3.3	Details of intermittent clamps		Drawing(s)/ document reference	
4	**Terminations**			
4.1	Details of the SF6/GIS cable terminations		Drawing(s) reference	
4.2	Details of the Outdoor cable terminations		Drawing(s) reference	
4.3	Details of cable termination/ end support structure		Drawing(s) reference	
4.4	Pollution Severity		Very heavy	XXXXXXXXXX
4.5	Insulator material type		Silicone composite	
4.6	Required minimum specific creepage distance	mm/kV	31	
4.7	Measured creepage distance	mm	Provide	
5	**ECC/Bonding Leads**			
5.1	Type of ECC/bonding lead		Single core	
5.2	ECC/Bonding lead conductor material (Cu/Al)		Specify	
5.3	ECC/Bonding lead conductor cross-sectional area	mm^2	Specify	
5.4	Thickness of ECC/bonding lead insulation	mm	Specify	
5.5	Dimensional details of ECC/bonding lead		Drawing(s) reference	
5.6	Estimated length of ECC/bonding leads	m	110	
6	**Other Accessories**			
6.1	Details of Link disconnecting box		Drawing(s) reference	
6.2	Details of SVL link box		Drawing(s) reference	
6.3	Details of SVL		Drawing(s)/document reference	
6.4	Fibre optic cable duct (32mm) installed		Yes	

Annex B – Additional Information requirements

Item	Description
1	**Additional cable drum and installation information required:**
	a) Cable drum design and material
	b) Method of wood treatment (if applicable)
	c) Details of haulage/pulling equipment
	d) Maximum permissible pulling tensions (in kN)
2	**Miscellaneous requirements**
	a) SVL MCOV characteristic curves
	b) Installation instruction for outdoor and GIS terminations offered
	c) Specialized tools required for jointing and terminating
	d) Quality inspection test plans for all components (Outdoor terminations, GIS terminations, cable supports, cleats and clamps, other accessories, link disconnecting boxes) and installation processes