| Eskom | Scope of Work | Generation |
|---|---|---|

Title: **Kusile Power Station Copper Earthing Cables Replacement with Alternative Cables Scope of Work**

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## Content

# 1. Introduction

In electrical engineering, effective earthing is critical to ensure safety, minimize equipment damage, and maintain system reliability. Traditionally, copper has been the preferred material for earthing due to its high conductivity, durability, and resistance to corrosion. However, escalating costs, environmental concerns, and the increasing incidence of copper theft have prompted the industry to consider alternative materials and methods for earthing.

The earthing and lightning protection standard applicable to Kusile Power Station, has earthing cabling installed complying to the approved Eskom Standard. The current installed copper earthing is prone to theft, and there had been several theft cases of copper theft reported at Kusile Power Station. This scope of work is for the replacement of the copper earthing with alternative conductors to solve the copper theft problem and to improve Earthing and Lightning Project System reliability.

# 2. Supporting Clauses

## 2.1 Scope

The scope of work will be for the supply and replacement of all copper earthing conductors with an alternative earthing conductors at Kusile Power Station.

### 2.1.1 Purpose

The purpose of this document is to formally outline the requirements for the project to replace the copper earthing conductors with alternative conductors.

### 2.1.2 Applicability

This document shall be applicable to Kusile Power Station.

### 2.1.3 Effective date

This document will be effective from the date when the document is authorized.

## 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] ISO 9001 Quality Management Systems

[2] SANS 10200:2015 Neutral earthing in medium voltage industrial power systems

[3] SANS 10201:2024 Medium voltage earthing devices incorporating NECRTs, NECRs and NERs.

[4] SANS 62271-102:2023 Alternating current disconnectors and earthing switches

[5] SANS 725:2021 IEEE guide for safety in AC substation grounding

[6] SANS 1063:2020 Earth rods, couplers, and connections

### 2.2.2 Informative

[2] 203-334 Kusile Power Station Earthing & Lightning Protection Standard

[3] 240-56356396 Eskom Earthing & Lightning Protection Standard

## 2.3 Definitions

| Definition | Explanation |
|---|---|
| Copper conductor | Conductor used in electrical wiring. |
| Aluminium conductor | Is a type of high capacity, high strength stranded conductor. |
| Earthing | A process in which the instantaneous discharge of electrical energy takes place by transferring charges directly to the earth through low resistance wire. Low resistance earthing wire is chosen to provide the least resistance path for leakage of fault currents. |
| Earth mat | A mash formed with bare metallic conductors and buried in shallow soil to provide safety from touch and step potential. Earth mats are part of the grounding methods implemented in substations. |

## 2.4 Abbreviations

| Abbreviation | Explanation |
|---|---|
| AC | Alternating Current |
| CoC | Certificate of Compliance |
| C&I | Control and Instrumentation |
| DC | Direct Current |
| EMI | Electro-Magnetic Interference |
| ISO | International Organization for Standards |
| ITP | Inspection and Test Plan |
| m | Meters |
| mm | Mili-meters |
| N/A | Not Application |
| OEM | Original Equipment Manufacturer |
| QC | Quality Checks |
| QCP | Quality Control Plant |

## 2.5 Roles and Responsibilities

### 2.5.1.1 Supplier

a) Provide a quotation as part of tender deliverable.
b) Supply, delivery, and installation of Alternative Earthing conductors as detailed by this Scope of Work.
c) Provide technical support services as requested by the Employer.
d) Provide conductors technical information in accordance with the scope of work.
e) Responsible to ensure quality deliverables as required.
f) Responsible to ensure that every effort is made to keep to the agreed program and plan to execute the scope.
g) Conform to all the other requirements stipulated in this document.
h) Supply all the necessary type test sheets/results.
i) Invite the Employer or representative three (3) working days in advance for witness/hold points, if applicable, as agreed.
j) All Contractor employees entering site shall comply with Eskom's policies and site regulations, adherence to Eskom's Life Saving Rules, adherence to Generation Occurrence Management Procedure, Smoking Policy, zero tolerance on alcohol usage, etc. These requirements will be detailed during the induction training process.
k) Ensure that all staff brought onto site to work should be able to fluently speak, understand and write in English language.
l) The Contractor ensures that all staff brought to Kusile Power Station site have a valid fitness certificate based on the specified plant man-job specification.

### 2.5.1.2 Employer: Technical Support & Engineering

a) Compile and submit scope of work with technical specifications.
b) Perform Quality Checks on the works and accompanying documentation.
c) Liaise with all relevant stakeholders for any input.
d) Ensure that this scope of work is in accordance with Eskom policies and procedures.
e) Provide all necessary information to assist in the conductor's procurement.
f) Participate in technical evaluations of the tender documents.
g) Assist with the preparation of all the reports to different tender committees, where applicable.

### 2.5.1.3 Employer: Procurement Department

a) Perform all procurement processes outlined on this scope of work.
b) Issue invitation to tender to the *Contractor for this scope of work.*
c) Set up clarification meetings between *Contractor* and the *Employer.*
d) Act as communication link between *Contractor* and the *Employer.*
e) Ensure all necessary payments are processed timeously and keep record thereof.

f) Arrange technical evaluation sessions.

g) Compile and present mandate to negotiate and arrange negotiation meetings when required and give feedback to relevant tender committee.

h) Keep record of all tender documentation.

#### 2.5.1.4 Management and Reporting

a) The Supplier is to be represented at any ad-hoc meetings that may arise to address any scope and safety related matters.

b) Liaise on meetings shall be held with the Employer's Representative or his/her delegate on as and when required basis to discuss any technical details, or concerns.

c) Meetings will be convened and chaired by the service manager, or an Eskom Senior employee as required, all meetings on shall be recorded using the Employer's attendance register and minutes taken.

#### 2.5.1.5 Communication and Correspondence

Correspondences shall be written formally on the letter head format of the organisation and addressed to the relevant person.

a) All correspondence includes but not limited to:

   i. Kusile Power Station

   ii. Employer's Contract number

   iii. Contract description

   iv. Correspondence subject matter

   v. Employer's name and contact details.

   vi. Contractors contact details.

   vii. Date

b) Where appropriate the correspondence includes the Employer's reference and is delivered as a single package or as per the agreed contract terms.

c) All communications from the Contractor are numbered sequentially with a prefix as advised by the Employer. The Employer responds in like manner. The prefix and numbering system are decided upon at the Inaugural meeting.

#### 2.5.1.6 Quality and Documentation Control

a) During the tender process a quality criterion will be defined that the Contractor must comply to.

b) The Contractor shall ensure that any witness, hold, and inspection points are strictly adhered to.

c) All Quality References and Standards as stipulated in this document will be adhered to.

d) The Contractor to comply with the Employer's quality documentation management system and processes.

### 2.6 Process for Monitoring

This document will be a once-off document to state the scope of work for the supply and delivery of electrical general consumables spares contract.

### 2.7 Related/Supporting Documents

Kusile Power Station Earthing System Health Report.

## 3. SCOPE OF WORK

### 3.1 Plant Description

Earthing installations in power plants are critical for ensuring safety and reliable operation, as they protect personnel, equipment, and instrumentation from electrical faults. The design and implementation of earthing systems can vary significantly depending on several key factors, including fault levels, soil resistivity, and the specific electrical and control requirements of various plant areas.

#### 3.1.1 Fault Level Considerations

The fault level, which is the maximum prospective current that can flow in a system during a fault condition, has a substantial impact on the earthing design. High fault levels require robust earthing systems to safely dissipate large fault currents without causing dangerous touch and step potentials around the installation. For example, in areas with high fault levels, like near generators or transformers, the earthing system needs to incorporate thicker conductors and deeper grounding rods or mats to handle the increased thermal and mechanical stresses.

#### 3.1.2 Area-Specific Earthing Requirements

Different plant areas have unique earthing requirements based on their specific functions and the nature of the equipment they house:

- **Power Generation Area:** This area, encompassing generators, transformers, and switchgear, usually requires a highly robust earthing grid because of high fault currents associated with power generation and distribution equipment. In this case, the earthing system often includes multiple interconnected ground rods or mats, creating a low-resistance path to ground and effectively distributing fault current across the grid to prevent localized heating and stress.

- **Process Control and Instrumentation (C&I) Room:** The Control and Instrumentation room, which houses sensitive control equipment, various measurement devices, has stringent earthing needs to protect against both electrical faults and electromagnetic interference (EMI). In the C&I room, the earthing system often incorporates a separate clean earth to provide a stable reference voltage for control signals. This system is carefully designed to avoid ground loops, which could induce noise in control signals and lead to erroneous readings or malfunction.
- **Substations and Switchgear Rooms:** Earthing in substations and switchgear rooms must account for high transient currents and lightning protection. The design often includes surge arrestors and low-resistance grounding mats or grids to divert both fault and lightning currents safely into the earth. The earthing conductors are typically sized to endure high short-circuit currents without degradation.

Below is the table showing various conductor sizes per plant area.

| REF. CLAUSE | DESCRIPTION OF PLANT | DESCRIPTION OF EARTHING | RATED AREA OF COPPER ($mm^2$) | NUMBER OF CONNECTIONS | CONDUCTORS PER CONNECTION | ALTERNATIVE CONDUCTOR SIZES (mm) |
|---|---|---|---|---|---|---|
| | Generator and Unit Transformers | - Connection straps<br>- Earth rods | 600 | 2 | 2 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | Generator, 22 kV Phase Isolated Busbars (IPB), Earth Switch and Circuit Breaker | - Connecting straps<br>- Earth rods | 600 | 2 | 2 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | Generator VT or CT cores, surge arrestors and earthing transformers | - Connection straps<br>- Earth rods | 150 | 1 each | 1 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | Transformers | - Connecting straps<br>- Round earth conductor<br>- Insulated earth conductor | 600<br>70 | 2 | 2 | - 50 x 3 mm<br>- 2 x 10 mm ø<br>- Cable |
| | Trefoil cable bonds | - Connecting straps<br>- Earth rods | 75 | 1 | 1 | - 25 x 3 mm<br>- 1 x 10 mm ø |
| | Lead sheaths of MV cables | - Connection straps<br>- Round earth conductor | 75 | 1 | 1 | - 25 x 3 mm<br>- 1 x 10 mm ø |
| | Cable Junction Boxes | - Connecting straps<br>- Earth rods | 75 | 1 | 1 | - 25 x 3 mm<br>- 1 x 10 mm ø |
| | MV switchgear | - Connecting straps<br>- Round earth conductor | 600 | 2 | 2 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | 690 V & 400 V switchgear (unfused supply) | - Connection straps<br>- Round earth conductor | 600 | 2 | 2 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | 690 V & 400 V switchgear (fused supply) | - Connection straps<br>- Round earth conductor | 150 | 2 | 1 | - 50 x 3 mm<br>- 1 x 10 mm ø |
| | Control stations starters etc. | - Connecting straps<br>- Round earth conductor | 75 | 1 | 1 | - 50 x 3 mm<br>- 1 x 10 mm ø |

| REF. CLAUSE | DESCRIPTION OF PLANT | DESCRIPTION OF EARTHING | RATED AREA OF COPPER ($mm^2$) | NUMBER OF CONNECTIONS | CONDUCTORS PER CONNECTION | ALTERNATIVE CONDUCTOR SIZES (mm) |
|---|---|---|---|---|---|---|
| | MV motors | - Connection straps<br>- Round earth conductor | 150 | 1 | 1 | - 50 x 3 mm<br>- 2 x 10 mm ø |
| | LV motors: 400 V, 690 V and 220 V DC (above 30 kW) | - Connection straps<br>- Round earth conductor<br>- Insulated earth conductor | 75<br>70 or 16 | 1 | 1 | - 25 x 3 mm<br>- 1 x 10 mm ø<br>- Cable |
| | LV motors: 400 V, 690 V and 220 V DC (below 30 kW) | Earth continuity conductor in supply cable | 1.5 to 16 | 1 | 1 | Cable |
| | Air Cooled Condensers | - Earth mat<br>- Earth bar<br>- Steelwork/earth mat connection | - 75<br>- 150<br>- 600 | --<br>1<br>2 | --<br>1<br>2 | - 10 mm ø<br>- 50 x 3 mm<br>- 2 x 10 mm ø<br>- 50 x 3 mm<br>- 2 x 10 mm ø |
| | Computer and Computer Room Earthing | Floor grid/earth mat connecting straps | 75 | 1 | 1 | - 25 x 3 mm |
| | Water treatment plant | - Earth mat<br>- Earth bar<br>- Earth bar/earth mat connection | - 75<br>- 150<br>- 75 | --<br>- 1<br>- 1 (min) | --<br>- 1<br>- 1 | - 10 mm ø<br>- 50 x 3 mm<br>- 2 x 10 mm ø<br>- 25 x 3 mm<br>- 1 x 10 mm ø |
| | Workshops and stores | - Earth mat<br>- Earth bar | - 75<br>- 300 | --<br>- 2 | --<br>- 2 | - 10 mm ø<br>- 50 x 3 mm<br>- 2 x 10 mm ø |
| | Fuel oil plant | Earth bar/earth mat connection | 150 | 2 (min) | 1 | - 25 x 3 mm<br>- 1 x 10 mm ø |

| REF. CLAUSE | DESCRIPTION OF PLANT | DESCRIPTION OF EARTHING | RATED AREA OF COPPER ($mm^2$) | NUMBER OF CONNECTIONS | CONDUCTORS PER CONNECTION | ALTERNATIVE CONDUCTOR SIZES (mm) |
|---|---|---|---|---|---|---|
| | Boiler and turbine house steelwork | - Earth mat | - 75 | -- | -- | - 10 mm ø |
| | | - Main earth bar | - 300 | - 1 | - 1 | - 50 x 6 mm<br>- 2 x 2 x 10 mm ø |
| | | - Earth bar/earth mat connection | - 120 | - Every 2 columns | - 1 | - 40 x 3 mm<br>- 1 x 10 mm ø |
| | | - Subsidiary earth bars | - 230 | - 2 | - 1 | - 40 x 3 mm<br>- 1 x 10 mm ø |

## 3.2 WORK TO BE PERFORMED BY CONTRACTOR

The following are the Supplier's requirement:

a. Supply and deliver alternative earthing cables, lugs, and clamps.

b. Remove all earthing copper strategically to avoid compromising earthing in various areas.

c. Replace all removed copper with alternative earthing conductors.

d. Verify or re-issue CoC to confirm compliance of new earthing installations.

e. Conduct earth test and compare with test done with copper conductors.

The scope of the modification is to replace the current installed copper earthing as listed in table 2 below with recommended alternatives.

**Table 1: Scope of alternative earthing with quantities**

| Installed in the Plant | Alternative replacement earthing cables | Area of alternative earthing cables ($mm^2$) | Quantity |
|---|---|---|---|
| Insulated copper cable (6mm2) | Anti-theft (Kwena) Cable | 6 | 500m |
| Insulated copper cable (16mm2) | Anti-theft (Kwena) Cable | 16 | 500m |
| Insulated copper cable (25mm2) | Anti-theft (Kwena) Cable | 25 | 500m |
| Insulated copper cable (35mm2) | Anti-theft (Kwena) Cable | 35 | 500m |
| Insulated copper cable (70mm2) | Anti-theft (Kwena) Cable | 70 | 5000m |
| Copper Lugs (6mm2) | Copper Tin Plated lugs | 6 | 500 units |
| Copper Lugs (16mm2) | Copper Tin Plated lugs | 16 | 500 units |

| Installed in the Plant | Alternative replacement earthing cables | Area of alternative earthing cables ($mm^2$) | Quantity |
|---|---|---|---|
| Copper Lugs (25mm2) | Copper Tin Plated lugs | 25 | 500 units |
| Copper Lugs (35mm2) | Copper Tin Plated lugs | 35 | 500 units |
| Copper Lugs (70mm2) | Copper Tin Plated lugs | 70 | 800 units |
| 100 x 3 mm copper strip | Aluminium Strip | 100X3 | 500m |
| 50 x 6 mm Copper Bar | Aluminium Strip | 100X6 | 500m |
| Copper C-Clamps | Tin plated C-Clamps | N/A | 500 units |
| 10mm diameter black annealed copper | 13.5mm Aluminium | N/A | 500m |

### 3.3 CONSTRAINTS ON HOW THE CONTRACTOR PROVIDES THE GOODS.

#### 3.3.1 Quality Assurance Requirements

- All works to comply to quality standard ISO 9001:2015
- QCP and ITP to be submitted by the service provider for the employer to review, indicate intervention points and approve.

## 4. Acceptance

This document has been seen and accepted by:

| Full Name and Surname | Designation |
|---|---|
| Bongekile Makini | Electrical Maintenance Manager |
| Refilwe Mosadi | Manager Projects |
| Thulani Ngcamu | Electrical Senior Supervisor Units |
| Gugu Shozi | System Engineer (Switchgear) |

## 5. Revisions

| Date | Rev. | Compiler | Remarks |
|---|---|---|---|
| November 2024 | 1 | G Mbangula | New document created for the earthing replacement project. |
| October 2024 | 0.1 | G Mbangula | First edition of the copper earthing cables replacement with alterative earthing cables which are anti-theft. |

## 6. Development Team

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

- George Mbangula

## 7. Acknowledgements (if applicable)

- George Mbangula
- Refilwe Mosadi
- Dineo Mdhluli
- Collin Lepee