

 Eskom	Standard	Technology
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Title: **SAFE OPERATING PRACTICE
FOR GIS SUBSTATIONS**

Unique Identifier: **240-67449796**

Alternative Reference Number: **<n/a>**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

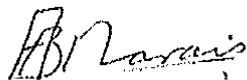
Revision: **2**

Total Pages: **8**

Next Review Date: **December 2023**

Disclosure Classification: **Controlled
Disclosure**

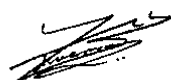
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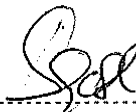
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1. Introduction

This document addresses two aspects regarding safe operating practice namely trapped charges and de-gassing of SF6 compartments. It provides instructions when switching is carried out at GIS Substations to prevent trapped charges and also to prevent insulation related failures in GIS due to gas compartment SF6 evacuation.

1.1 Trapped Charges

Operational Switching on GIS substations can lead to an electrical charge being trapped within the isolated sections. A trapped charge stresses the GIS with a DC voltage, which can lead to charge accumulation on the support insulators, compromising their insulating performance.

1.2 De-gassing of SF6 Compartments

Flash overs could occur in compartments if SF6 gas is evacuated before the compartment is completely disconnected and earthed via the general mass of earth.

2. Supporting clauses

2.1 Scope

This document will provide a safe practice to make sure that trap charges are drained and also that GIS equipment is isolated and earthed before compartments are de-gassed

2.1.1 Purpose

The purpose of this document is to entrench good operational practices for switching procedures to prevent trapped charge over-voltages and degassing of live comparts in GIS, causing serious electrical earth faults when preparing circuits for maintenance or repair work. The application of this practice must not violate any other procedures / standards.

2.1.2 Applicability

This document is applicable to all GIS substations and shall apply throughout Eskom Holdings Limited Divisions.

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] IEC 62271-303, High voltage switchgear and control gear – Part 303: Use and handling of sulphur hexafluoride (SF₆).
- [3] CIGRE guide for the preparation of customised practical SF₆ handling instructions
- [4] SANS62271-303 Part 303: Use and handling of Sulphur Hexafluoride (SF6)
- [5] NRS087 Guidelines for the management of SF6 (Sulphur Hexafluoride) for use in electrical equipment
- [6] 32-9: Definition of Eskom documents.
- [7] 32-644: Eskom documentation management standard.
- [8] 474-65: Operating Manual of the Steering Committee of Wires Technologies (SCOWT).

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[9] 32-846: Operating regulations for high voltage systems

[10] The South African Grid Code

[11] OEM Manuals

2.2.2 Informative

[12] TGN(E) 92. Switching procedures to limit trapped charge over-voltages in 132 kV, 275 kV and 400 kV gas-insulated switchgear (GIS) substations

[13] Occupational Health and Safety Act (no 85 of 1993)

2.3 Definitions

2.3.1 General

Definition	Description
De-energised	Disconnected from the power source but not necessary at zero potential
Isolate or Isolated or Isolation or Isolating	Refers to the disconnecting of the apparatus to form a visible air gap from all possible sources of electrical potential. In cases where a visible air gap cannot be created, equipment specific isolation procedures will apply. In the above context, isolation may be obtained by: <ul style="list-style-type: none"> the opening and removal of fuses/solids the opening of isolators the removal of jumpers/droppers the opening of air break switches the racking out of truck-type switchgear the immobilisation of breakers having visible contact separation, and not fitted with grading capacitors.
Live side	Means the part of the electrical circuit that is not de-energised
Trapped charge	It is a DC surface charge (Space charge) on or near an isolated high voltage conductor or electrode that was subject to AC voltage prior to isolation.

2.3.2 Disclosure classification

Public domain: published in any public forum without constraints (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AIS	Air insulated substation
GIS	Gas Insulated Switchgear
GIL	Gas Insulated Line
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety (OHS) Act No 85 Of 1993, as amended, of the Republic of South Africa
SF₆	Sulphur Hexafluoride
SOG	Safe Operating Procedure

2.5 Roles and responsibilities

National Control, Regional Control, Transmission Grid Managers and the Operating Unit Managers in Distribution, are responsible to implement this standard at all GIS installations. Where applicable a SOG per GIS substation must be compiled to address the switching practices as describe in this document.

2.6 Process for monitoring

National Control and Regional Control centres must ensure that the content of this document is monitored and flagged on their control system as per the South African Grid Code.

2.7 Related/supporting documents

Not applicable.

3. Discussion

3.1 Trapped Charges

During switching within GIS, trapped charge voltages will remain on the de-energised sections of a bus bar. On open terminal air insulated equipment this trapped charges decays very quickly to zero (typically less than one minute) due to moisture and small levels of pollution. In contrast within GIS equipment the insulation surface conductivity is very much lower and these trapped charges can remain for many hours following de-energisation if no discharge path exists

In general, trapped charges stress the affected equipment with a DC voltage. In addition, the system voltage can couple through the grading capacitors of an open circuit breaker, producing a superimposed AC voltage. For example, in a 400 kV system, the resultant voltage for a short length of bus bar can reach a peak of approximately 900 kV.

Trapped charges will rapidly be dissipated if a de-energised section of GIS is connected to any of the following:

- Power transformer/ shunt reactor star winding
- Electromagnetic VT on all three phases
- External air insulated equipment (bushing etc.)

Where none of the above is available, trapped charge may be dissipated by application of an earth switch on the isolated section.

The stored energy levels associated with a trapped charge are sufficiently low and if a flashover occurs upon an isolated section of GIS, the damage is expected to be minimal. Although undesirable, a single occurrence should not harm the continued normal AC performance. The operating personnel would be unaware of a low energy trapped charge flashover event as this is not detected by conventional protection,

The risk of a power system fault exists where a section of GIS is re-energised following prolonged exposure to the trapped charge conditions. Since accumulation of the charge on insulator surfaces takes place over a period of time, the risk of flashover increases with time of exposure.

This trapped charge over-voltage phenomena is common to all GIS equipment during switching and the objective is to minimise both the magnitude of the over-voltage and exposure duration of the equipment to these voltages, the latter being of particular importance.

Trap charges are likely to be occur on isolated sections of bus bar, without any electronic voltage transformers on all 3 phases and isolated feeders connected to a GIL or cable system.

3.1.1 Operating Objectives

The objectives of the switching practice must be to:

- Avoid leaving trapped charges on isolated sections of GIS, in all circumstances

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- Minimise the length of time GIS is exposed to trapped charge
- Remove superimposed AC voltage as soon as possible by opening the circuit breaker “live side” isolators.

3.1.2 Switching Practice

A trapped charge will be avoided if the switching practice is such that the de-energised section of GIS is connected to any of the items listed in section 3.1 the 3rd paragraph

Where no other means is available, the trapped charge must be dissipated by closing an earth switch in accordance with the ORHVS regulations.

To limit the risk of a power system fault on re-energisation, where a section of GIS has been exposed to trapped charge for a period of more than 60 minutes, the trapped charge should be dissipated before the section is re-energised.

3.2 De-gassing of SF6 gas compartments

Earth faults (flash overs) may occur when degassing SF6 gas compartments below alarm pressure. Prior to degassing of SF6 compartments, it must be ensured that the relevant sections of the compartment are de-energised, isolated and earthed.

The operators must consult both the gas and the electrical schematic diagrams of an installation before degassing the compartment for maintenance or repair purposes. It is essential that no electrical circuits remain alive in the gas compartment, which extends the total distance between consecutive gas-tight barriers, whilst gas evacuation takes place.

3.2.1 Safety testing

Safety testing of GIS equipment is not possible as with AIS equipment due to the enclosed nature of the plant (metal clad switchgear), therefore safety testing will be replaced by the visual inspection of the isolators and earth switches.

The equipment to be worked on shall be open and isolated as per the ORHVS.

Isolation shall be confirmed by the visual inspection of the isolator / earth switch status through the provided inspection windows.

Note: “Safety testing” must not be written on the operating sheet but “verify the isolator to be open”.

4. Authorization

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5. Revisions

Date	Rev	Compiler	Remarks
Dec 2018	2	AB Marais	Revision Update due to Expiring date
Oct 2013	1	AB Marais	Cap identified and to reduce the number of documents
Nov 1994	0	JP Boshoff	Latest Version of ESKASAAJ9
Oct 1982	0		Original issue of document as OPS 6208/24-4.

6. Development team

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7. Acknowledgements

The following document from National Grid UK was used as a reference.

TGN(E) 92. Switching procedures to limit trapped charge over-voltages in 132 kV, 275 kV and 400 kV gas-insulated switchgear (GIS) substations