Eskom	**Standard**	**Technology**

Title: **APPLICATION OF AIS AND GIS SWITCHGEAR AT ESKOM MAIN TRANSMISSION SUBSTATIONS**

Unique Identifier: **240-75305807**

Alternative Reference Number: **n/a**

Area of Applicability: **Engineering**

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COE Acceptance

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Date: 19 March 2021

DBOUS Acceptance

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Date: 22/03/2021

This document is **STABILISED.** The technical content in this document is not expected to change because the document covers: *(Tick applicable motivation)*

1	A specific plant, project or solution	
2	A mature and stable technical area/technology	x
3	Established and accepted practices.	x

PCM Reference: **<xxxxxx>**
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Content

1. Introduction

Designers are often faced with a number of challenges in determining where to apply AIS and GIS technologies at substation sites. The document lists a number of criteria that need to be considered in the decision making process.

2. Supporting clauses

2.1 Scope

The document only covers AIS and GIS substations in a broad sense and does not prescribe any particular busbar configuration.

2.1.1 Purpose

This document is written to assist in the decision making process of the choice of technology to be applied in the design and construction of Main Transmission System substations.

2.1.2 Applicability

This document 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] Substation Layout Design Guide.

2.2.2 Informative

[3] User Guide for the Application of Gas-Insulated Switchgear (GIS) for Rated Voltages of 72.5 kV and above (125), CIGRE Working Group 23.10, Task Force 03, April 1998

[4] Evaluation of Different Switchgear Technologies (AIS, MTS, GIS) for Rated Voltages of 52 V and Above (390), Working Group B3.20, August 2009

2.3 Definitions

2.3.1 General

Definition	Description
Air insulated systems	An electric power system that has the busbars and equipment terminations generally open to air and utilizes insulation properties of ambient air for insulation to ground
Gas insulated systems	An electric power system that has enclosed busbars and equipment terminations that utilizes insulation properties of a gas, generally SF6, for phase-to-earth and phase-to-phase insulation

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
AIS	Air insulated systems
GIS	Gas insulated systems
MTS	Main Transmission System

2.5 Roles and responsibilities

Group lead engineers need to be fully briefed on the contents of this document. They will in turn be expected to instruct their direct reports in its use.

2.6 Process for monitoring

The document is to be updated from time to time as the technology develops.

2.7 Related/supporting documents

None

3. Document content

High voltage substations comprise high-voltage switchgear and devices with different insulating systems viz. air or gas (SF6). When planning high-voltage substations, some basic questions have to be answered in order to define the type of high-voltage switchgear that would be most appropriate in a particular application:

- What is the function of the substation
- What is its location within the power supply system
- What are the climatic and environmental conditions
- Are there specific geological requirements regarding locations
- Are there space/cost restrictions

Depending on the answers, either AIS or GIS would be the right choice.

3.1 Air-insulated Switchgear (AIS)

The preferred technology for implementation at all MTS substations is in the form of air insulated systems (AIS). The availability of land is generally not a constraint, particularly in the rural areas.

AIS are favourably priced high-voltage substations for rated voltages up to 800kV, and are popular wherever space restrictions and environmental circumstances are not severe. The individual electrical and mechanical components of an AIS installation are assembled on site. Air-insulated outdoor substations of open design are not completely safe to touch and are directly exposed to the effects of the climate and the environment.

AIS systems inherently allow more freedom of choice of individual components such as circuit breakers, isolators, current transformers etc. The life expectancy of AIS is 25-30 years.

When rated and short-circuit currents are high, aluminium tubes are increasingly used to replace flexible stranded conductors for busbars and feeders. They can handle currents as high as 8000 A and short-circuits up to 63 kA without difficulty. Other influences on the switchyard design are availability of land, the lie of the land, the accessibility and location of incoming and outgoing overhead-lines, the number of transformers and voltage levels.

3.2 Gas-insulated Switchgear (GIS)

The initial equipment cost of GIS is usually higher than that of AIS. As a consequence, many other criteria/advantages need to be considered to justify the higher initial cost. For certain applications, the advantage of GIS is the key factor which makes GIS the only possible solution.

The compact design and small dimensions of GIS make it possible to install substations up to 550kV right in the middle of load centres of urban or industrial areas. Each switchgear bay is factory-assembled and includes the full complement of isolators, earthing switches instrument transformers, control and protection equipment (although Eskom prefers to provide the secondary plant items themselves), and interlocking and monitoring facilities commonly used for this type of installation. The earthed metal enclosures of GIS assure not only insensitivity to contamination, but also safety from electric shock. Life expectancy of GIS is 40-50 years.

Installation time of GIS is generally faster than for AIS.

Gas insulated systems would only be applied under the following conditions:

3.2.1 Land Availability

Land availability is a constraint and an AIS substation of the specified number of bays simply cannot be accommodated (future Jupiter “B” 400/275kV Substation).

3.2.2 Topology

The land that is available is located on the side of a steep slope and the cost of earthworks is excessive even with the implementation of multiple terraces (Mbewu 765/400kV Substation)

3.2.3 Environmental Impact

There are severe constraints due to the impact of the substation on the environment (environmentally very sensitive areas, urban areas) where a small footprint of the substation is essential. GIS systems require 10-20% of the land area of a conventional AIS system when considering only the switchgear. The saving in overall land area depends very much on the specific voltage level and the connection to transformers, reactors and incoming/outgoing lines. Maximum saving is achieved by cable connections as well as GIL connections. If the substation is connected to overhead lines, the space will have to be allocated for towers and down-droppers which will in all likelihood reduce the total land saving.

3.2.4 Visual Impact

Where visual impact is of major concern, particularly when a high voltage substation is to be located in a residential area (Craighall 275/88kV Substation and future Kyalami 400/132kV Substation)

3.2.5 Pollution

Where it can be demonstrated through tests and investigations that environmental factors such as severe marine pollution and heavy industrial pollution are of such a nature that exposed insulation will be compromised even when equipment insulation of a higher voltage is insufficient This may occur on a coastal site where saline pollution deposits may be heavy, or similarly in industrial locations where other pollution deposits may be substantial. Cleaning of insulators may be required on a very regular basis (possibly annually). Similarly, corrosion of metallic components, flanges, electrical joints etc. may be severe. All these considerations may lead to very high maintenance costs for AIS whereas GIS, enclosed in a building, would be immune from these effects except for the SF6/air bushings. The application of GIS may often be justified on these grounds alone. (Koeberg 400/132kV substation and, Gromis and Oranjemond 400kV Switchyard due to severe marine pollution and fog).

3.2.6 Altitude

Where a substation is to be installed at high altitude and the effects of air pressure is of such a nature that exposed insulation will be compromised. The installation of GIS would only require the SF6/air bushings to be considered as opposed to all the equipment in an AIS installation, making the AIS option very costly due to the requirement of higher insulation levels.

3.2.7 Seismic Factors

Seismically active areas where the substation needs to move as a unit on a raft foundation (Koeberg 400/132kV Substation). Seismic considerations may dictate extensive mechanical support and bracing of an AIS in order to meet specified requirements. The physical design of GIS allows seismic criteria to be more readily achieved at a lower cost.

3.2.8 Noise Emission

Noise emission from a substation can be significant, particularly where the substation is situated close to areas of habitation. The operational noise emitted from a GIS substation, particularly if it is an indoor installation, is likely to be significantly less than that of an equivalent AIS installation. The emission of electro-magnetic fields can also be significantly lower than in the case of AIS, depending on the design of the GIS and the earthing system.

3.2.9 Faults

Where phase-to-phase faults are to be completely avoided, this can be achieved where phases are contained in separate compartments. This is generally applicable at EHV levels and above.

The disadvantage with GIS is that one is locked into the original supplier who may inflate prices. Switchgear vintages change and extensions and retrofits are not straightforward.

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev.	Compiler	Remarks
May 2014	1	AJS Groenewald	First Issue.

6. Development team

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

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7. Acknowledgements

N/A