

 Eskom	Standard	Technology
---	----------	------------

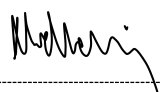
Title: **STANDARD FOR POWER FREQUENCY ELECTRIC AND MAGNETIC ANALYSIS IN SUBSTATIONS** Unique Identifier: **240-68971854**

Alternative Reference Number: **N/A**

Area of Applicability: **Engineering**

Next Review Date: **STABILISED**

COE Acceptance



Subhas Maharaj

Senior Manager: Substation Engineering

Date: 22/2/2021

DBOUS Acceptance



Amelia Mtshali

Senior Manager: Design Base & Operating Unit Support

Date: 25/02/2021

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

This letter is for multiple documents:

PCM Reference: **Design Substations**

SCOT Study Committee Number/Name: **Substations**

	Standard	Technology
---	-----------------	-------------------

Title: **STANDARD FOR POWER
FREQUENCY ELECTRIC AND
MAGNETIC ANALYSIS IN
SUBSTATIONS**

Unique Identifier: **240-68971854**

Alternative Reference Number: **N/A**

Area of Applicability: **Engineering**

Documentation Type: **Standard**

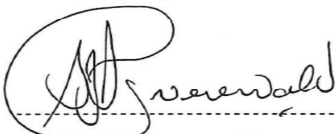
Revision: **1**

Total Pages: **12**

Next Review Date: **October 2020**

Disclosure Classification: **Controlled
Disclosure**

Compiled by



Braam Groenewald

**Corporate Specialist-
Substations**

Date: *12-10-2015*

Approved by




Braam Groenewald

**Corporate Specialist-
Substations**

Date: *12-10-2015*

Authorized by




Phineas Tlhatlhetji

**Senior Manager-Substation
Engineering**

Date: *13/10/2015*

Supported by SCOT/SC



Phineas Tlhatlhetji

SCOT/SC Chairperson

Date: *13/10/2015*

Content

	Page
1. Introduction.....	3
2. Supporting clauses.....	3
2.1 Scope.....	3
2.1.1 Purpose.....	3
2.1.2 Applicability.....	3
2.2 Normative/informative references.....	3
2.2.1 Normative.....	3
2.2.2 Informative.....	3
2.3 Definitions.....	3
2.3.1 General.....	3
2.3.2 Disclosure classification.....	4
2.4 Abbreviations.....	4
2.5 Roles and responsibilities.....	4
2.6 Process for monitoring.....	4
2.7 Related/supporting documents.....	4
3. Document content.....	4
3.1 Requirements.....	4
3.1.1 Electric Field.....	4
3.1.2 3.1.2 Magnetic Field.....	5
3.2 The Electric Field Strength.....	5
3.3 The Magnetic Flux Density.....	10
4. Authorization.....	12
5. Revisions.....	12
6. Development team.....	12
7. Acknowledgements.....	12

Figures

Figure 1: Allowable Electric Field Strength (E) in Designated Areas.....	5
Figure 2: Allowable Magnetic Flux Density (B) in Designated Areas.....	5
Figure 3: Flow Diagram to Determine the Electric Field levels where Human Exposure may occur comply with the ICNIRP Guide Lines.....	7
Figure 4: A Typical Result from a CDEGS Programme Simulation.....	8
Figure 5: A Typical Spot Plot from a CDEGS Programme Simulation.....	9
Figure 6: Flow Diagram to Determine the Magnetic Flux density in a Substation.....	11

1. Introduction

The document reflects on electric and magnetic field exposure levels that should be met where personnel may be exposed to these fields inside the substation as well as field levels that the public may be exposed to outside the substation. A clear distinction must be made from the above and field levels inside the servitude boundary of feeders to the station that may be higher.

2. Supporting clauses

2.1 Scope

A general description of the exposure zones is provided together with the classification of the different areas. This standard provides the calculation procedure to determine the likelihood of corona occurring for different conductor configurations.

2.1.1 Purpose

This standard provides information on the electric and magnetic field exposure levels that should be met within an AIS substation, as well as provide a guide to determine the electric and magnetic field levels.

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.
- [3] ICNIRP (2010).

2.2.2 Informative

None

2.3 Definitions

2.3.1 General

Definition	Description
Electric Field Strength	A measure of the strength of an electric field at a given point in space, equal to the force the field would induce on a unit electric charge at that point. Also called electric field intensity, electric intensity measured in kV/m.
Magnetic Flux Density	A vector quantity that is used as a quantitative measure of magnetic field; the force on a charged particle moving in the field is equal to the particle's charge times the cross product of the particle's velocity with the magnetic flux density (SI units). Also known as magnetic displacement; magnetic induction; magnetic vector measured in Tesla.

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 Substations
CDEGS	Current Density Electromagnetic Field and Grounding Software
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
ICNIRP	International Commission on Non-Ionising Radiation Protection
MTS	Main Transmission Substations

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 tables at the end of the document are to become part of the design documentation.

2.7 Related/supporting documents

Transmission Line Design

3. Document content

3.1 Requirements

Since Eskom has committed itself to be guided by the ICNIRP guidelines, the requirements set for Eskom MTS substations in terms of electric and magnetic field limits are given in Figures 1 and 2 respectively.

3.1.1 Electric Field

Areas where the public may be exposed outside the servitudes of feeders should be less or equal to 5kV/m within the substation, including the access road and the control building should be 10kV/m as these are occupational exposure areas.

It must be noted that electric field levels higher than 10kV/m (up to about 20 kV/m) may apply in the HV yard. The ICNIRP basic restriction will still be met. This is particularly relevant to 765 kV substations where unnecessary cost will be incurred to raise conductor height to meet a 10 kV/m level. Justification for the higher electric field is given by the surface coating (crusher stone) that limits the induced current and eventually the induced electric field inside the body.

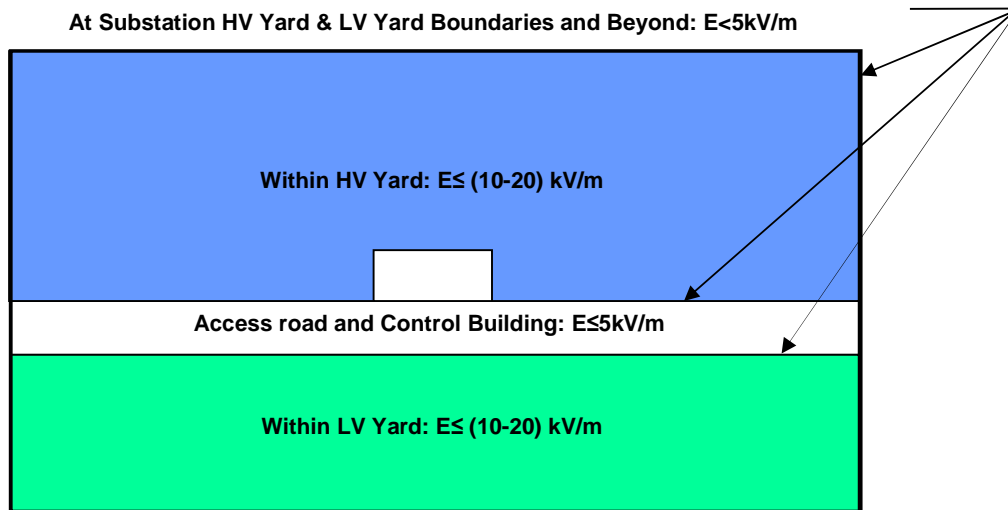


Figure 1: Allowable Electric Field Strength (E) in Designated Areas

3.1.2 3.1.2 Magnetic Field

The magnetic field requirement is in general relatively easy to meet. ICNIRP 2010 suggests $200 \mu\text{T}$ for public exposure. The access road and control building should comply with an occupational reference level.

It is important to note is that **air core reactors** in SVC stations may set up magnetic fields greater than $500 \mu\text{T}$.

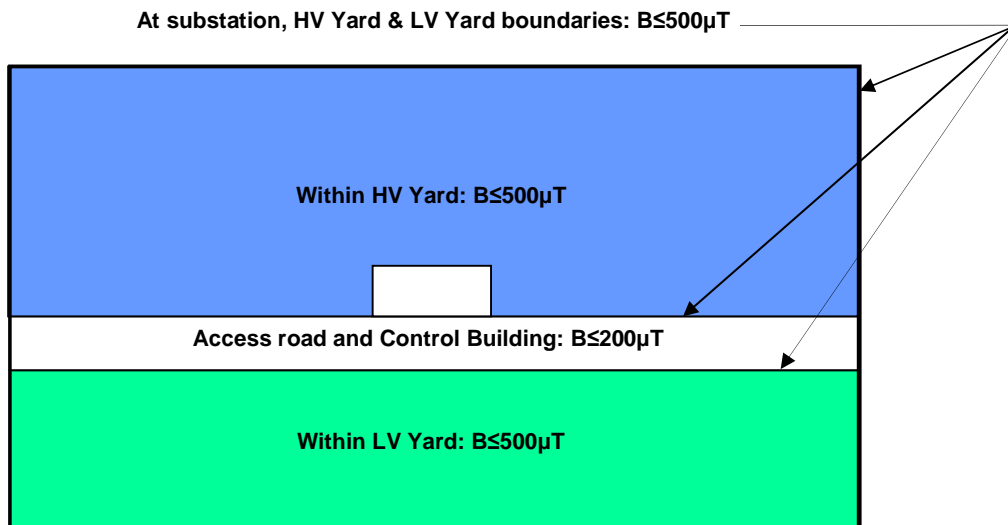


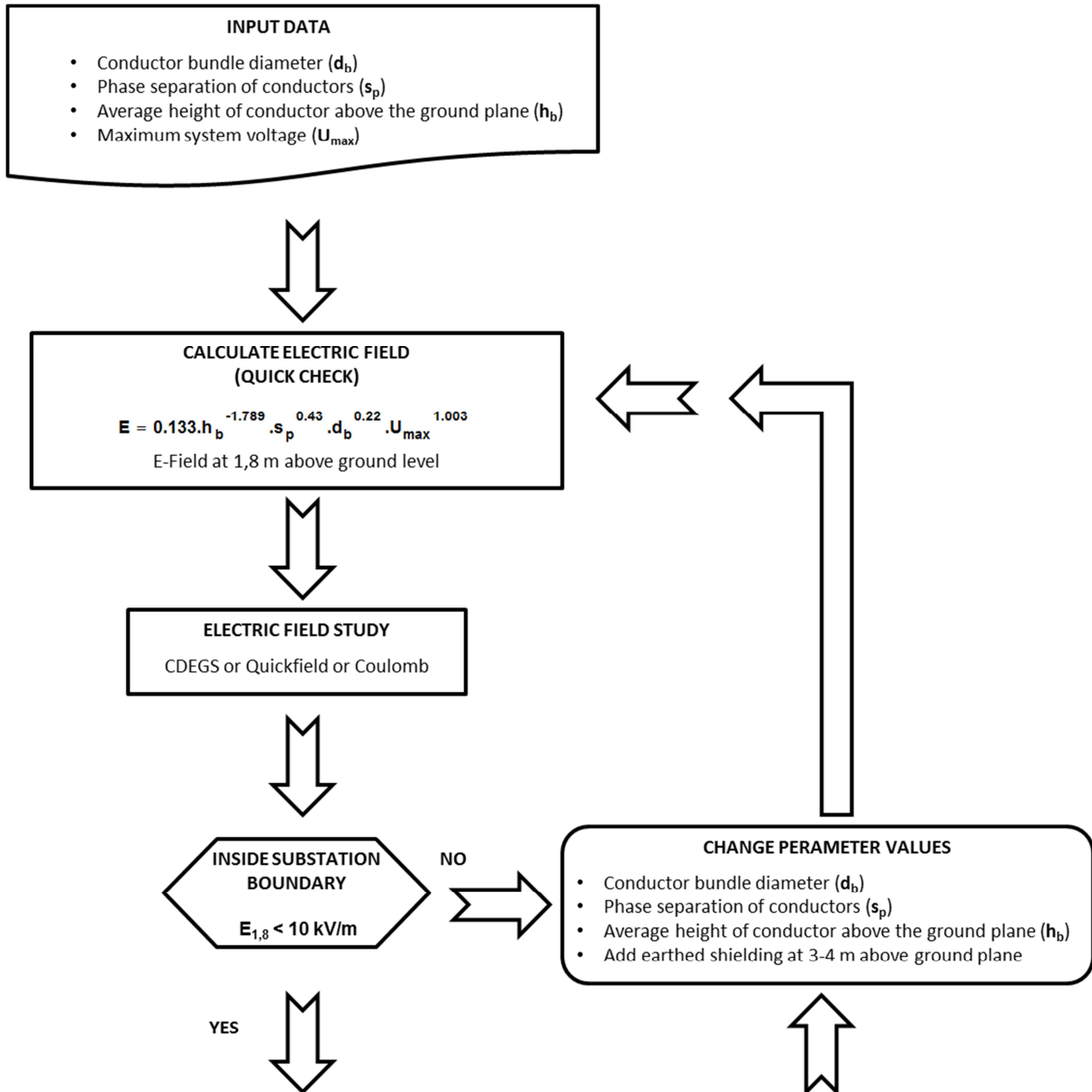
Figure 2: Allowable Magnetic Flux Density (B) in Designated Areas

3.2 The Electric Field Strength

Figure 3 provides flow diagram of the process of determining the electric field strength from measurable parameters. The formula for **E** given under Quick Check is purely for indicative purposes and does not negate the requirement of performing a complete CDEGS simulation study. Figures 4 and 5 are examples of the results obtained from such a study.

ESKOM COPYRIGHT PROTECTED

The electric field strength is a function of the height of live conductors above ground (h_b -m), the inter-phase separation (s_p -m), the diameter of the phase conductor or conductor bundle (d_b -m) to a much lesser extent, and the maximum system voltage (U_{max} -kV)



Flow Diagram Continued on next Page

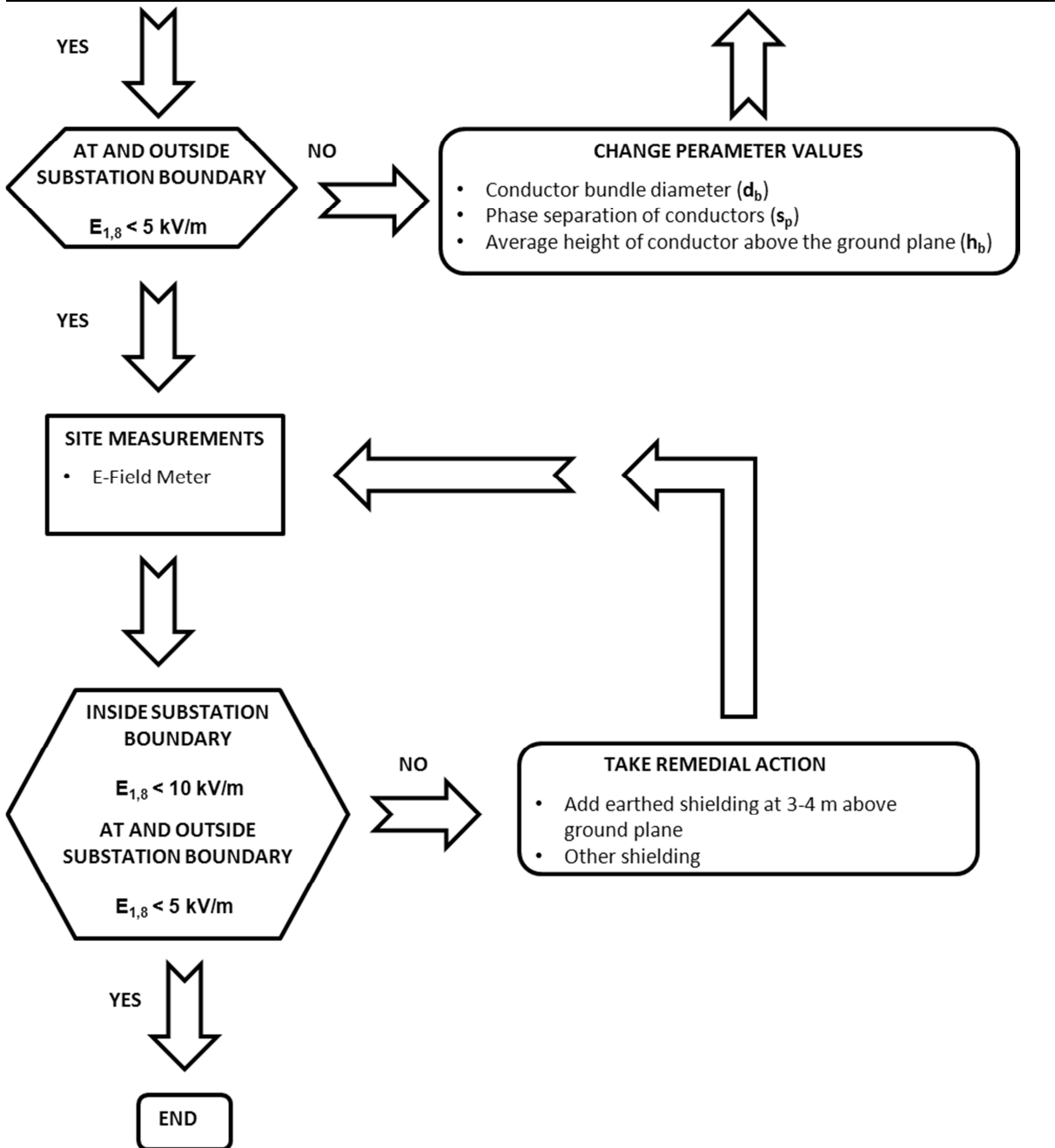
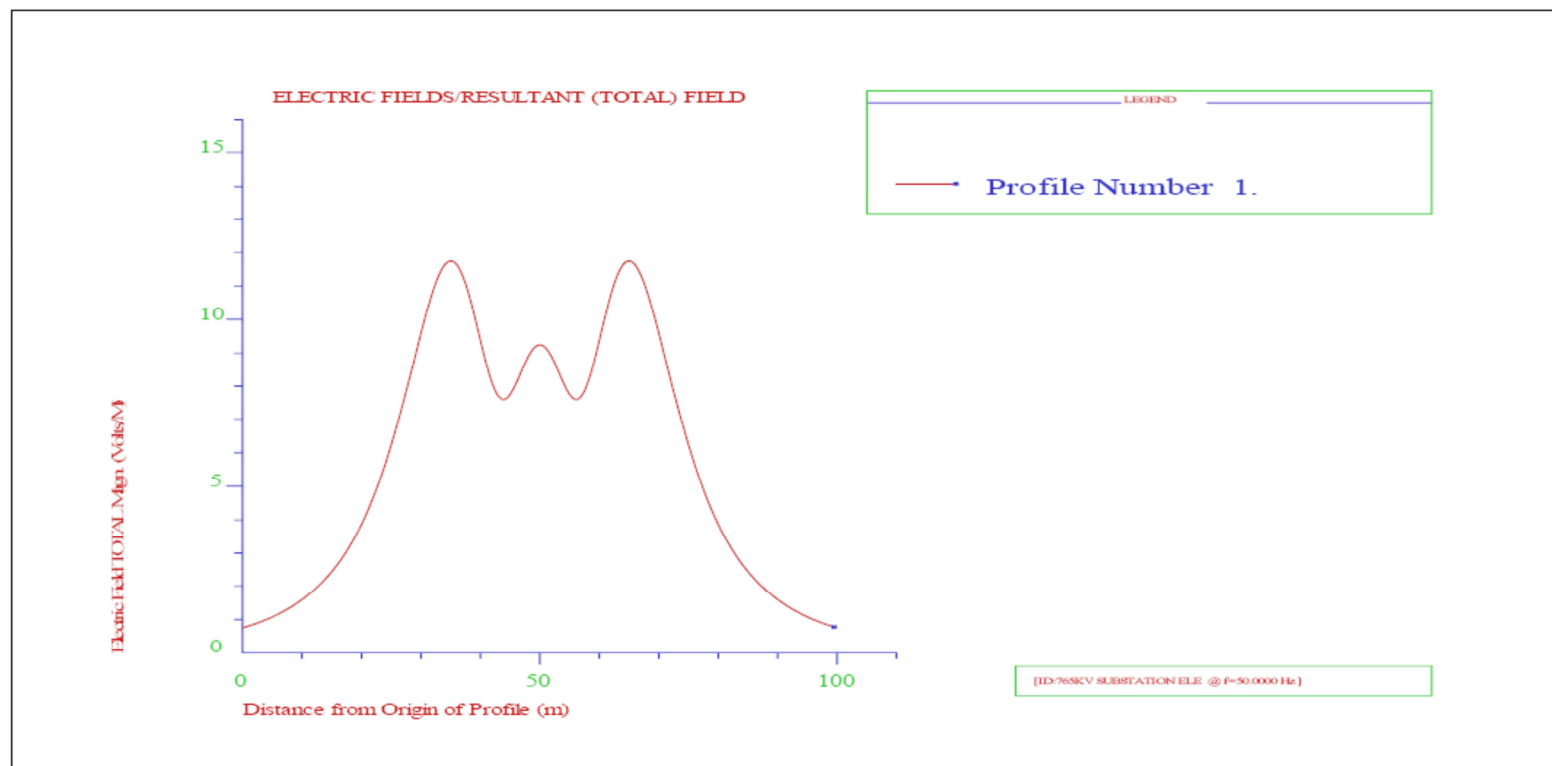


Figure 3: Flow Diagram to Determine the Electric Field levels where Human Exposure may occur comply with the ICNIRP Guide Lines

HIFREQ (Job Id: 765KV SUBSTATION ELECTRIC FIELD EFFECTS 12 METRES 08 JUNE 2005)

Electric Fields/Resultant (Total) Field

09-June-2005 09:53:08 AM



Working Directory: D:\ESKOM\CDEGS\TRANSMISSION STUDIES\SUBSTATIONS\braam 765kv tony

Figure 4: A Typical Result from a CDEGS Programme Simulation

ESKOM COPYRIGHT PROTECTED

When downloaded from the WEB, this document is uncontrolled and the responsibility rests with the user to ensure it is in line with the authorized version on the WEB.

Appendix 1: CDEGS Spot Plot for 765kV Mercury Substation.

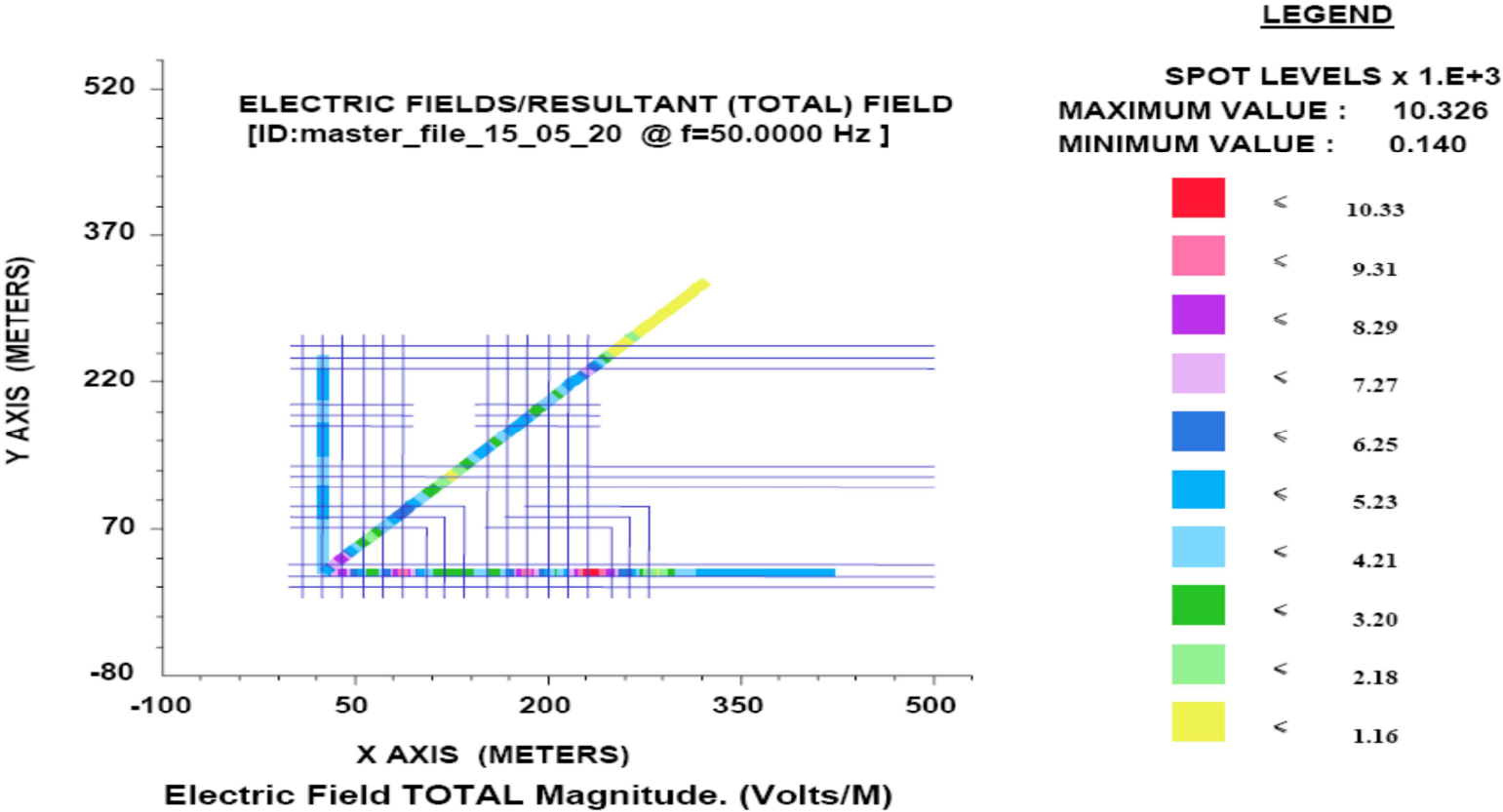


Figure 5: A Typical Spot Plot from a CDEGS Programme Simulation

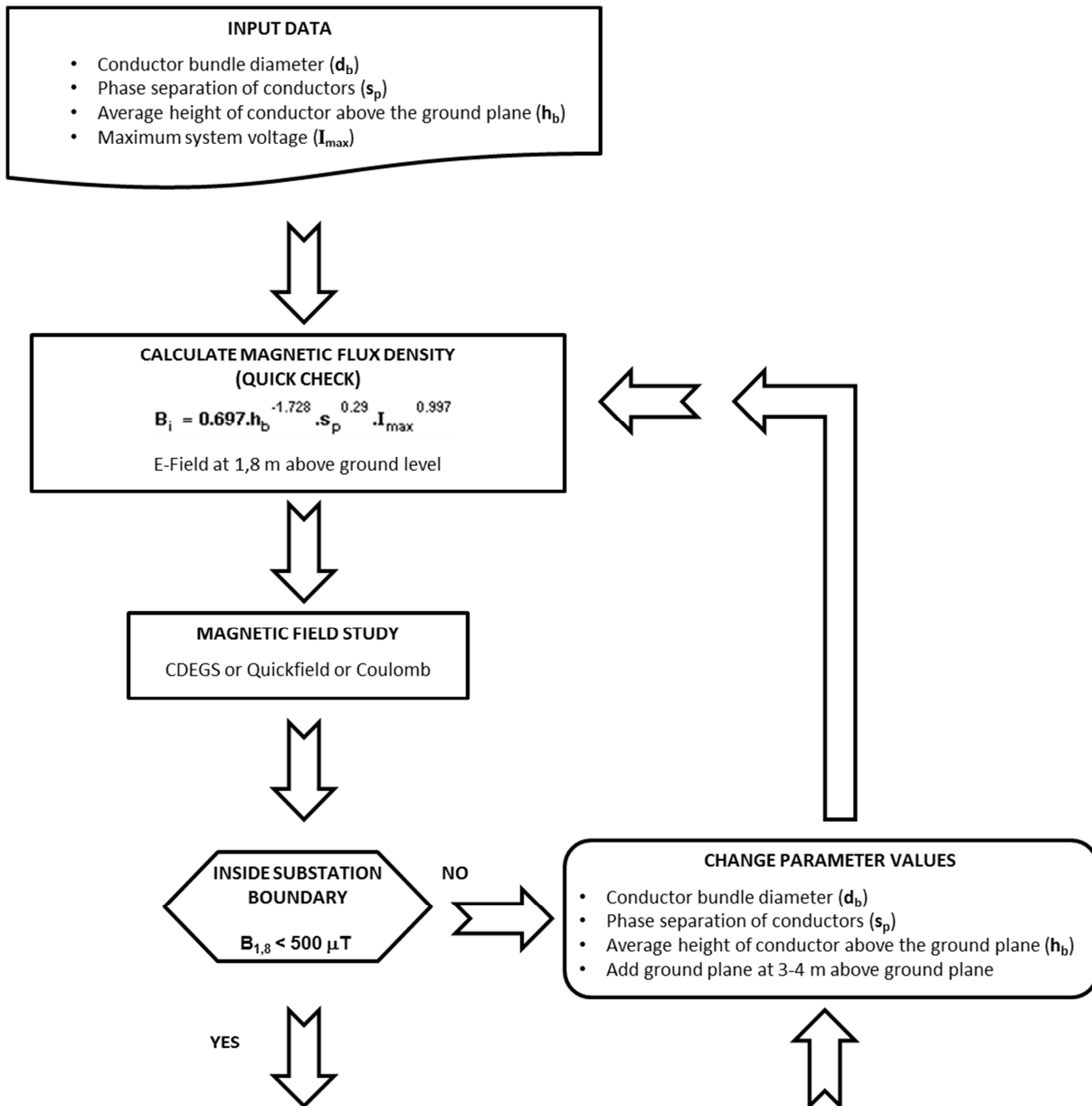
ESKOM COPYRIGHT PROTECTED

When downloaded from the WEB, this document is uncontrolled and the responsibility rests with the user
to ensure it is in line with the authorized version on the WEB.

3.3 The Magnetic Flux Density

Figure 6 provides a flow diagram of the process to determining the magnetic flux density from measurable parameters. The formula for **B** given under Quick Check is purely for indicative purposes and does not negate the requirement of performing a complete CDEGS simulation study.

The magnetic flux density is a function of the height of live conductors above ground (h_b -m), the inter-phase separation (s_p -m) and the maximum system current (I_{max} -A).



Flow Diagram Continued on next Page

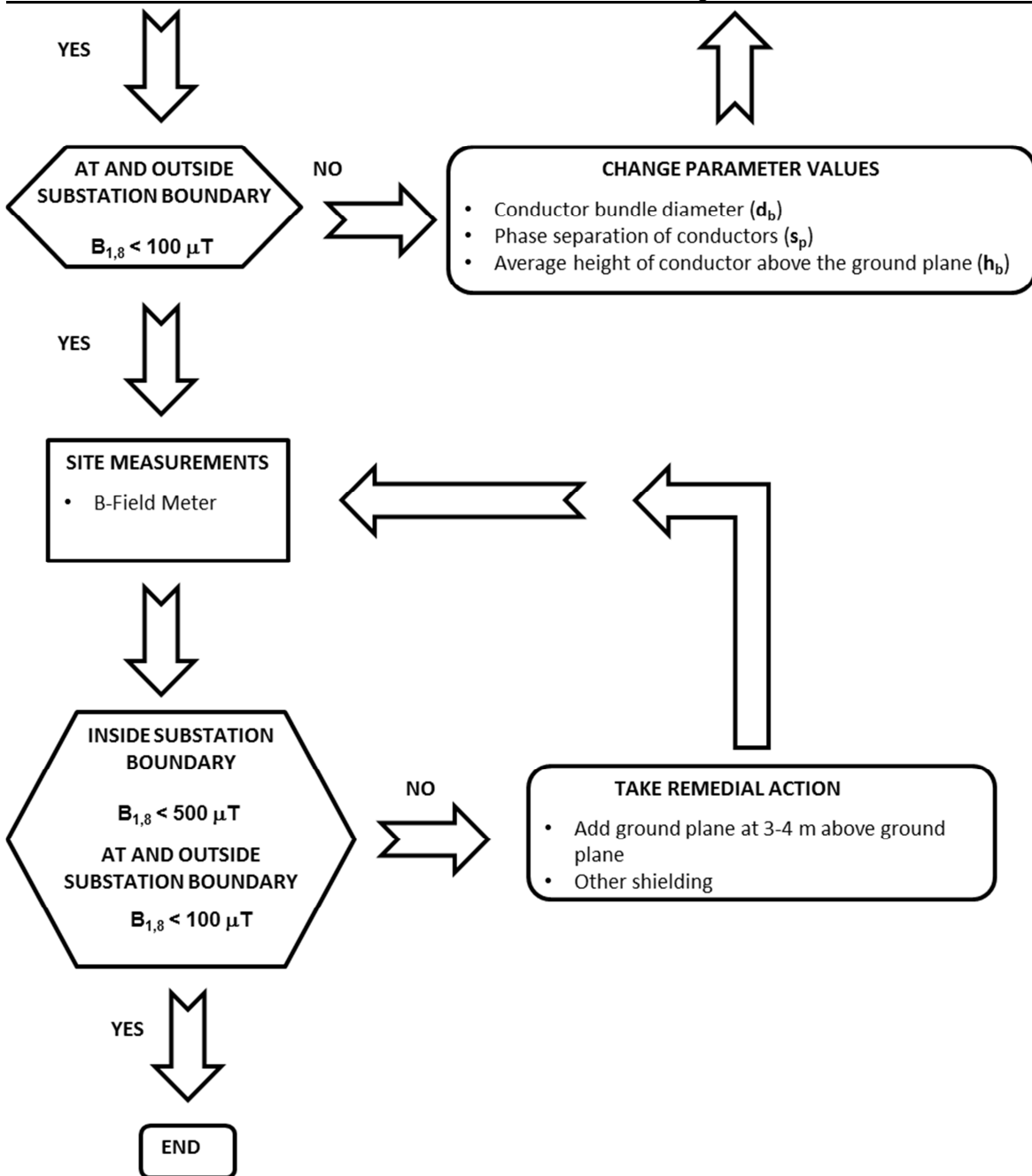


Figure 6: Flow Diagram to Determine the Magnetic Flux density in a Substation

Magnetic field shielding is usually more challenging to achieve and require special techniques. Specialised studies need to be done.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Abre le Roux	Chief Engineer –
Braam Groenewald	Corporate Specialist – Substation Engineering
Derrick Delly	Chief Engineer – Substation Engineering
Enderani Naicker	Chief Engineer – Substation Engineering
Ian Hill	Senior Technologist – Substation Engineering
Mark Pepper	Chief Engineer – Substation Engineering
Phineas Tlhatlhetji	Senior Manager - Substation Engineering
Rukesh Ramnarain	Chief Engineer – Substation Engineering
Sipho Zulu	Chief Engineer – Substation Engineering

5. Revisions

Date	Rev	Compiler	Remarks
Oct 2015	1	AJS Groenewald	First Issue.

6. Development team

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

- Abre le Roux Substation Engineering, Technology Group
- Braam Groenewald Substation Engineering, Technology Group
- Enderani Naicker Substation Engineering, Technology Group
- Phineas Tlhatlhetji Substation Engineering, Technology Group
- Dr Pieter Pretorius TAP

7. Acknowledgements

With thanks to the development team.