Eskom	Standard	Distribution, Transmission & Generation

Title: **STANDARD FOR YARDSTONE IN ESKOM HV SUBSTATIONS**

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		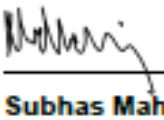
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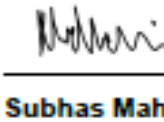

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PCM Reference: **240-108982466**

SCOT Study Committee Number/Name: **Standard and Design Procedures - Civil (Tx)**

Content

1. Introduction

This document prescribes the minimum requirements for substation HV yard stone to be used in Eskom substations. Every substation HV yard terrace should have a high resistive covering to increase the resistance of the current path through the body for personnel safety, reduce weed growth and help the ground to retain moisture

2. Supporting clauses

2.1 Scope

This specification covers the requirements for the stone surfacing of substation yards

2.1.1 Purpose

The purpose of this document is to provide a detail specification of the yard stone to be used within Eskom 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] SANS 1083:2014, Aggregates from natural sources

[3] SANS 3001:2012, Aggregate crushing value of coarse aggregates

[4] TJ Marais, Investigation into the electrical properties of crusher stone used in substation earthing systems (Cigré IEC International Symposium – South Africa 2015)

2.2.2 Informative

[5] 240-134369472, Substation Earth Grid Design Standard

[6] Buyers' Guide "D-DT-6366, STONE CRUSHED

2.3 Definitions

2.3.1 General

Definition	Description
Crusher run (road construction material)	Ungraded mixture of rock fragments and sand
Mod AASHTO	Modification of the laboratory test of finding the optimum moisture content (OMC) and maximum density under a standard compaction energy input as stipulated by the American Association of State Highway and Transportation Officials.
Operating Unit	In this document the term refers to either a Distribution Operating Unit or a Transmission Grid

Definition	Description
Resistivity	Intrinsic property of a material that is measured as its resistance to current per unit length for a uniform cross section. This quantity is generally specified in Ohms metre (Ωm).
Sieve Analysis	The determination of the proportions of particles within certain size ranges in a granular material by separation on sieves of different size openings.
X-ray Diffraction	An X-ray diffraction instrument can be used to determine the various types of clay minerals.
Durability Mill Index test	Provides a measure of the relative resistance of an aggregate to producing clay- sized fines when subjected to prescribed methods of interparticle abrasion in the presence of water
Glycol test	Test used to identify rock durability issues associated with smectite clay minerals
ACV (Aggregate Crushing Value) test	The Aggregate Crushing Value (ACV) Test Set measures how resistant an aggregate is, when being crushed under a gradually applied compressive load
10% FACT (Fines Aggregate Crushing Value) test	The 10 per cent Fines Aggregate Crushing Value is the force in kN reuired to crush a sample of -13,2+9,5mm aggregate so that 10 per cent of the total test sample will pass a 2,36 mm sieve.
AIV (Aggregate Impact Value) test	Provides a relative measure of the resistance of an aggregate to sudden shock or impact.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
ACV	Aggregate Crushing Value
AGG	Aggregates
AIV	Aggregate Impact Value
DMI	Durability Mill index
FACT	Fines Aggregate Crushing value Test
HT	High Tensile
HV	High Voltage
Kn	kilo Newton
M	Metre
Mm	Millimetre
OU	Operating Unit
PI	Plasticity Index
SANS	South African National Standard
XRD	X-ray Diffraction

2.5 Roles and responsibilities

Designers & the Asset Owner (respective OUs) should ensure that this specification is adhered to for all Eskom Substations. This applies to both new and existing substations.

The contractor shall be responsible for the provision of all services associated with the concept and implementation of the quality assurance control.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Not applicable.

3. REQUIREMENTS

3.1 Stone

Crushed stone shall be clean, hard, durable, and sound crushed (preferably granite) stone of aggregate size between 28mm and 37,5mm nominal size as stipulated in [2] and should have a wet resistivity value of at least 3000Ωm. Aggregates with a size below 28mm shall not be accepted.

At the beginning of the project (to allow for sufficient time to analyse and choose suitable subcontractor) the contractor is to identify three yardstone quarries near the proposed development. Samples are to be obtained from these quarries and subjected to tests outlined in this document, to determine suitability of aggregates.

Prior to acceptance of any crushed stone the ***aggregate report*** shall be submitted to the Substation Design Engineer for approval. The aggregate report shall include the results from an XRD analysis of the stone, Glycol test, ACV/10% FACT test, AIV or Modified AIV test (refer to 3.1.1 to 3.1.5), wet resistivity values (refer to [4]) and the grading results from a sieve analysis

The crushed stone should have a wet resistivity value of at least 3000Ωm and must be verified by to measuring the wet resistivity according to the methodology prescribed in [4].

The above together with samples of the stone shall be submitted in good time to the design engineer for approval and no stone, other than the samples, shall be delivered to the site before the Site Supervisor's written approval has been obtained after consultation with the design engineer.

No crusher-run (road construction material or stone from mining activities (contaminated with chemicals)) will be accepted as yard stone.

3.2 Test requirements

3.2.1 X-Ray Diffraction (XRD) analysis

An XRD analysis is to be undertaken on aggregate samples to determine percentage smectite or secondary minerals present in the aggregate. Aggregates with a smectite or secondary minerals content of less than 10% are to be considered as likely to be durable. Those containing more than 10% smectite are to be subjected to the Durability Mill Index test and the 10% FACT/ACV test. The AIV or modified AIV tests should be used for crushed unweathered rock.

Aggregates that have less than 10% deleterious material content, should only undergo 10% FACT/ACV tests.

3.2.2 Durability Mill index (DMI) test

The durability mill index test should be undertaken as per SANS 3001:AG16. The maximum DMI value for sample passing either **0.425mm** sieve or **0.075mm** sieve (the 0.075 PI value should be used if sample has a zero PI value or is slightly plastic) should not exceed **125**. If the DMI is zero (will happen if PI value on 0.075 sieve is zero or is slightly plastic) the percentage passing the **0.425mm** sieve should not exceed **30**.

For repeatability of the tests, the grading of the material should be similar. Where the aggregates are obtained from crushed boulders or crushed cores, the sample is to comply to the below grading prior to testing.

3.2.3 Glycol test

The ethylene Glycol soaking test should be undertaken as per SANS 3001: AG14. The material should be soaked for a maximum of 20 days and inspected after 5, 10 and 20 days. For the sample to pass, there should be less than 10 pieces that have disintegrated (spilt into more than 3 pieces) after 20 days or less than 15 pieces that have disintegrated and fractured (split into not more than three pieces) after 20 days.

Excessive spalling (shedding of small fragments from their edges), fracture and disintegration within five days is an indication of low long-term durability.

3.2.4 ACV (Aggregate crushing value) / 10% FACT test

Aggregate crushing value test or 10% fines aggregates crushing test should be undertaken on a sample as per SANS 3001: AG10. Additionally, the test should also be undertaken using pieces that have been soaked in ethylene glycol for 4 days as per SANS 3001: AG15. Limits as shown in 1 should be used to determine suitability of material test results.

Table 1: Limits for 10% FACT and ACV tests

Test	Value
10% FACT (kN)	
Dry	210
Wet	160
4-day glycol soak	120
ACV (%)	
Dry	18.5
Wet	20.5
4-day glycol soak	22.2

3.2.5 AIV or Modified AIV test

The AIV test should be undertaken on crushed unweathered rock as per SANS 6239. Where the ethylene glycol test shows excessive deterioration the Modified AIV test can be used. Limits as shown in 2 should be used to determine suitability of material test results.

Table 2: Limits for AIV test

AIV (%)	
Dry	20
Wet	31
4-day glycol minus wet	< 2

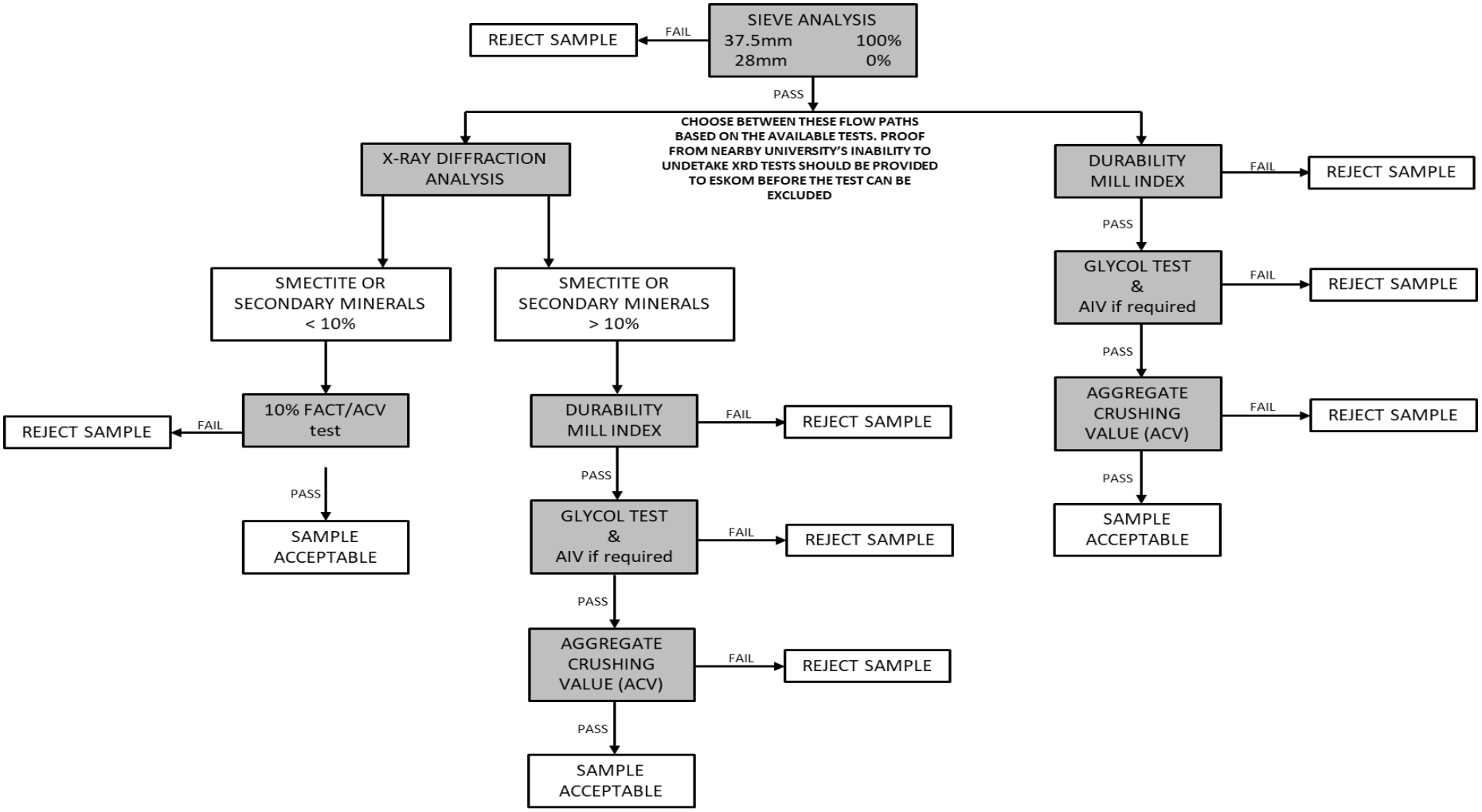

Figure 1: Flow chart to determine test to be undertaken on samples

3.3 Construction

3.3.1 Surface Preparation

After the completion of the earthworks and just before the application of the stone surfacing, the Contractor shall clear the area of all vegetation growth and ensure that the underlying wearing course layer is levelled to match required terrace levels and slopes, then re-compaction to a density as specified by the engineer or site drawing.

3.3.2 Laying of Stone

The stone shall be spread over the compacted surface of the yard, levelled, and lightly rolled to a finished thickness of at least 100 mm or as otherwise specified in the design drawings and/or document.

3.3.3 Tolerances

The average finished thickness of the stone layer shall be at least 100 mm or as otherwise specified in the design and nowhere shall the finished thickness be less than 10 mm less than the specified finished thickness.

The below table shows grading that will be accepted from laboratory test. Tests shall be undertaken for each batch of stone delivered on site.

Table 3: Grading requirements of aggregate

Property	**Nominal size of aggregate 37mm**
Specific Grading requirements, mass percentage of material that passes sieves of nominal aperture size, mm	
50	100%
37,5	100%
28	0%
20	-
14	-
10	-
7,1	-
5	-
2	-
1	-
0,075	0%

Crusher plants are to sieve the aggregates twice, to ensure uniform required grading of stone

3.3.4 Contractor's Equipment

The Contractor shall ensure the provision of suitable construction equipment for the spreading of the stone in compliance with the requirements of the specification.

3.4 Measurement and Payment

The rates as scheduled in the Bill of Quantities shall cover the cost of all activities, labour, materials, and testing required for the provision of the relative item in accordance with the design/drawings and specifications.

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Subhas Maharaj	Senior Manager – Substation Engineering Department
Andile Maneli	Middle Manager – Substation Engineering Department
Phenyo Mvuyana	Civil Engineer – Substation Engineering Department

5. Revisions

Date	Rev.	Compiler	Remarks
Aug 2022	2	P.N. Mvuyana	Additional tests added which should be part of the stone aggregate report.
Feb 2017	1	Z.I Mkhize	New document required

6. Development team

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

- Phenyo Mvuyana
- Zinhle Mkhize
- Nicolaas Mostert
- Theunus Marais

7. Acknowledgements

Not applicable.