Eskom	Standard	Technology

Title: **GLASS CAP AND PIN INSULATORS FOR ESKOM TRANSMISSION HVAC**

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Compiled by	Approved by	Authorized by
Sifiso Zikhali	**Sanjay Narain**	**Riaz Vajeth**
Design Engineer	**Chief Engineer**	**Line Engineering Services Manager**
Date: 15/09/2020	Date: 15/09/2020	Date: 16 Sep 2020

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Supported by SCOT/SC

Bheki Ntshangase

Plant SC Chairperson

Date: 16/09/2020

PCM Reference: **240-59882346**

SCOT Study Committee Number/Name: **Lines SC – Insulator Care Group**

Content

1. Introduction

This is a standard to be used on all new and refurbishment projects which require glass insulators on all ESKOM Transmission voltages. This specification can be used as a basis for evaluating new suppliers for ESKOM related projects.

2. Supporting clauses

2.1 Scope

This document covers the technical requirements for glass cap and pin insulator units for use on Eskom Transmission's high voltage AC network.

2.1.1 Purpose

This document details the specific requirements for all ESKOM glass cap and pin insulators to be used on Transmission voltages. The document gives clear and precise manufacturing, assembling, packaging, transporting, handling and storing of glass cap and pin insulators. The document sets out the detail for evaluating of tenders and also new supplier base for ESKOM glass insulator usage.

2.1.2 Applicability

This specification shall be applicable to all Transmission overhead transmission lines and substations. It is for the construction of all new and refurbished, as well as for the maintenance of existing overhead transmission lines.

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. All South African National Standard (SANS) standards are exactly the same as International Electrotechnical Commission (IEC) ones.

2.2.1 Normative

The insulators shall further be designed, manufactured and tested in accordance with the latest revisions and amendments of:

[1] ISO 9001 Quality Management Systems.

[2] SANS / IEC 6060-1: High-voltage test techniques – Part 1: General definitions and test requirements

[3] SANS / IEC 60120: Dimensions of ball and socket couplings of string insulator units

[4] SANS / IEC 60305: Characteristics of string insulator units of the cap and pin type

[5] SANS / IEC 60372 – 1, 2: Locking devices for ball and socket couplings of string insulator units: Dimensions and tests

[6] SANS / IEC 60383 – 1, 2: Ceramic or glass insulator units for a.c. systems – Definitions, test methods and acceptance criteria

[7] IEC 60437: Radio interference on high voltage insulators

[8] SANS / IEC61467: AC Power arc tests on insulator sets

[9] SANS / IEC 60471: Dimensions of clevis and tongue couplings of string insulator units

[10] IEC 60575: Thermal-mechanical performance test and mechanical performance test on string insulator units

[11] IEC 60672 Parts 1, 2, & 3: Specification for ceramic and glass insulating materials

[12] SANS / IEC 61211: Insulators of ceramic material or glass for overhead line with a nominal voltage greater than 1000V – Puncture testing

[13] IEC 60797: Residual strength of string insulator units

[14] SANS 6892 (ISO 6892): Metallic materials- testing at ambient temperature

[15] SANS 121 (SANS ISO 1461): Hot-dip (galvanized) zinc coatings (other than on continuously zinc- coated sheet and wire)

[16] SANS 936: Spheroidal graphite iron castings

[17] SANS 1190: Malleable iron castings

[18] ISO/IEC 17025, General requirements for the competence of testing and calibration laboratories

2.2.2 Informative

[19] SANS / IEC 60815: Guide for the selection of insulators in respect of polluted conditions

[20] IEC 60507: Artificial Pollution Tests on high voltage insulators to be used on A.C. system

[21] IEC 6050 (471): International Electro-technical Vocabulary (IEV) – Chapter 471: Insulators

[22] Eskom Procedure, E 32-846, Operating regulations for high voltage systems

[23] 240-86601391: Technical Evaluation Standard For Line Insulators

2.3 Definitions

2.3.1 General

None

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
HVAC	High Voltage Alternating Current
kV	kilo Volts
m	metre
MN	Mega Newton
MPa	Mega Pascal
QITP	Quality Inspection Test Plan
VHN	Vickers Hardness number

2.5 Roles and responsibilities

Engineer – development and updating the document, approval of tenders and approval of suppliers

Buyer – to distribute this document to relevant supplier of glass cap and pin insulators

Project Manager – to verify the delivered of insulators meet the specification

2.6 Process for monitoring

Document number	Document title
DPC_34-04	Procedure For Management Of Technical Documents For SCOT.

2.7 Related/supporting documents

This document supersedes the following documents:

- TRMSCAAA3 rev4: Ceramic and Glass Cap and Pin Insulators
- TSP41-452: Glass Cap and Pin Insulators for ESKOM Transmission HVAC.

3. Requirements

The requirements for glass cap and pin insulators are detailed below.

3.1 General

Nothing in this specification shall lessen the obligations of the supplier detailed in any other documents forming part of the contract. The insulators shall be designed, manufactured and tested as specified herein.

3.2 Materials

Only toughened glass units of the cap and pin type is acceptable. The entire surface of the glass shall be free from any imperfections. The insulator metal parts shall not show any surface discontinuities, fissures, exfoliation, overlapping of material layers, blowholes or cracks. The materials selected for the glass, cap and pin shall be subject to Eskom's approval. The approval procedure will consider the material's strength characteristics, ductility and fracture toughness.

3.3 Glass

The composition of the toughened glass, as well as the relevant tests, will comply with IEC 60672 Parts 1-3.

3.4 Caps

The caps shall be made of malleable cast iron or spheroidal graphite iron. Metal parts shall not be made by jointing, welding, shrink fitting or any other processes from more than one piece of material. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona.

Metallurgical tests shall vary according to the type of ferrous material making up the cap of the insulator. The corresponding grain size, inclusion rating, chemical composition and microstructure shall provide the required structural and mechanical properties detailed in the appropriate standard, specifically:

a) SANS 1190, or equivalent for malleable cast iron,

b) SG 38 and SG 42 according to SANS 936, or equivalent, of ductile, spheroidal graphite cast iron.

Mechanical properties shall be in accordance with Table 1 of SANS 936. In addition to any other design requirements that Eskom may specify, the design load shall meet the following requirements:

a) 0.40 Minimum Failing Load (MN) < $0{,}60.f_y.F/F_{ult}$

b) 0.90 Minimum Failing Load (MN) < $1{,}1.f_y.F/F_{ult}$

Where:

'f_y' = 0.2 percent proof stress as per SANS 936 (MPa).

'F_{ult}' = Average ultimate tensile stress (MPa) of a representative sample of at least 30 insulator caps.

'F' = Average ultimate tensile load (MN) of a representative sample of at least 30 insulator caps.

3.5 Pins

The pins shall be made of drop forged steel.

The yield strength of the chosen materials shall exceed 200MPa for the material and final treatment condition involved. The flow stress of the chosen materials shall be less than 1 000MPa.

Tensile testing of all ferrous material shall be conducted in accordance with SANS (ISO) 6892. Unless otherwise approved by Eskom, the gauge length of tensile specimens shall be determined by the following relationship:

Gauge length = 5.66.(So), where So is the cross-sectional area of the gauge length.

3.6 End fittings

The sizes of end fittings (ball, socket) will be in accordance with SANS / IEC 60120.

3.7 Locking Devices

The locking device for ball and socket couplings shall be a stainless steel humpback split pin or W-clip complying with SANS / IEC 60372.

3.8 Cement

Cement will be of the Portland or aluminous type. Six samples of neat cement will be tested in the autoclave. The test conditions will be:

- Pressure: 20.4kg/cm^2
- Temperature: 216 °C
- Duration: 3 hours

The cement shall have an autoclave expansion limit of less than 0.12%.

3.9 Galvanizing

Both caps and pins will be hot dip galvanised in compliance with ISO 1461.

4. Manufacturing

The insulator units and the insulator sets will be submitted to type, sample and routine tests according to Table 3 of SANS / IEC 60383 and the referenced standards therein.

4.1 Type Tests

Before the closing date for tendering, all tenders shall satisfactorily perform the type tests, where applicable, to qualify their cap and pin insulators as acceptable for Eskom Transmission.

Each type test, if successfully completed, shall be performed once. If a component fails a type test the component cannot be retested until Eskom has approved the design modifications.

Type tests will be repeated according to the criteria outlined in SANS / IEC 60383 and additionally if the site of manufacture changes.

Each tenderer shall submit copies of each test certificate with the tender, showing the results of the type tests. Test certificates shall be issued by an approved, internationally acknowledged, reputable, and independent laboratory.

The type tests will be performed on units that have passed the routine and sample tests. The following tests shall be mandatory and included in the type test report:

4.1.1 Type test on insulator units

	Type Test	Relevant Standard	Clause
1	Verification of dimensions	SANS / IEC 60383-1	17
2	Dry Lightning Impulse withstand test (in accordance with SANS / IEC 6060-1)	SANS / IEC 60383-1	13
3	Wet Power Frequency withstand voltage test	SANS / IEC 60383-1	14
4	Electromechanical failing load test	SANS / IEC 60383-1	18
5	Mechanical failing load test	SANS / IEC 60383-1	19
6	Thermal-mechanical performance test(in accordance with IEC 60575)	SANS / IEC 60383-1	20
7	Impulse Puncture withstand test (SANS / IEC 61211)	SANS / IEC 60383-1	15
8	Residual Strength test	IEC 60797	
9	Power arc test	SANS / IEC 61467	7 & 8

For the mechanical failing load test, at least thirty (30) insulator units will be subjected to the test. The acceptance constant, k, shall be > 3. That is,

$$k = \frac{\overline{X} - R_s}{S} > 3$$

Where:

$\overline{X}$ is the mean value of the tested samples

R_s is the mechanical rated value

S is the standard deviation

Additionally, each measured value shall not be less than the specified mechanical strength.

For the thermal mechanical test, at least ten (10) insulator units shall be tested in accordance with IEC 60575. The acceptance criteria of the test are specified below:

a) The result of this performance test shall match the result of the ordinary mechanical and electrical failing load test. Therefore, the mean value, standard deviation and fracture pattern shall not significantly change between both tests.

b) Acceptance constant k, as for the mechanical failing load test, shall be equal or greater than 3.

c) Each value measured shall not be lower than the specified mechanical and electrical strength.

d) Electrical puncture shall not occur before the ultimate fracture.

4.1.2 Type test on insulator sets

	Type Test	Relevant Standard	Clause
1	Dry Lightning Impulse withstand test (in accordance with SANS / IEC 6060-1)	SANS / IEC 60383-1	13
2	Dry Power Frequency withstand voltage test	SANS / IEC 60383-1	14
3	Wet Power Frequency withstand voltage test	SANS / IEC 60383-2	10
4	Wet Switching Impulse withstand voltage test	SANS / IEC 60383-2	11
5	Radio Interference test	IEC 60437	
6	Corona Test (Visual)	SANS / IEC 60383-1	

Corona and radio interference tests shall be conducted on complete insulator sets, representing the service conditions as close as possible.

Test results for the insulator sets will also be included in the type test report for insulator units.

4.2 Sample tests

The sample sizes, test prescription and acceptance criteria will be in accordance with IEC383. Unlike the type tests which are performed once for a particular design, the sample tests will be repeated with each tender. Sample test report must be provided prior to dispatch of the insulators from the site of manufacture. The following tests are required:

	Type Test	Relevant Standard	Clause
1	Impulse Puncture withstand test (SANS / IEC 61211)	SANS / IEC 60383	15
2	Verification of dimensions	SANS / IEC 60383	17
3	Mechanical failing load test	SANS / IEC 60383	19
4	Verification of axial, radial and angular displacements	SANS / IEC 60383	21
5	Verification of the locking system (SANS / IEC 60372)	SANS / IEC 60383	22
6	Thermal shock test	SANS / IEC 60383	24
7	Galvanising test	SANS / IEC 60383	26

4.3 Routine tests

Routine tests will be in accordance with SANS / IEC 60383 and must include the following tests:

- Routine visual inspection
- Routine mechanical test
- Routine electrical test

A routine test report must accompany each insulator batch supplied to site.

ESKOM reserves the right to conduct full scale tests on final representative assemblies. Should the string not conform to the specified values, the costs of re-testing will be for the supplier's account.

5. Drawings

The enquiry to include one copy of a detailed assembly drawing for each insulator offered.

The selected supplier to submit two copies of the final detail and assembly drawings of the insulator. The drawings shall include the mechanical and dimensional insulator characteristics according to SANS / IEC 60305, and additional information listed:

a) Mechanical failing load

b) Routine test load

c) Maximum nominal diameter of the insulating part

d) Nominal spacing

e) Arcing distance

f) Total creepage distance

g) Protected creepage distance

h) Standard coupling

i) Dimension tolerances

j) Material description, mass and fabrication details

k) Suppliers catalogue numbers

l) Location of identification marking required in the specification

6. Markings

The markings requested by SANS / IEC 60383 will appear on each insulator unit. Each insulator unit shall bear the symbol identifying the manufacturer, and giving the year of manufacture and the specified mechanical load in kilo Newtons (kN). The markings shall be clearly visible, legible and durable for fifty years.

7. Packaging requirements

7.1 Packaging

a) Details of the proposed packaging method will be required and be subject to Eskom approval.

b) Insulators shall be packed for shipment in crates of sufficient strength to prevent damage to the contents during transit and handling.

c) Crates shall be of sufficient strength to withstand palletising and reset failure under dry or wet weather conditions, during transit, storage, and subsequent handling in the field and shall be rodent resistant.

d) Each crate shall consist of a string of five or six assembled and connected units.

e) Any special handling requirements shall be clearly stated.

f) The supplier shall notify ESKOM of any special methods recommended for storage.

g) The supplier shall, at his expense, and at Eskom's discretion, replace insulator units that are damaged due to unsuitable packaging.

h) The supplier shall, at his expense, and at Eskom's discretion, replace insulator units that are damaged during transit up to Eskom's delivery point.

i) All boxes, pallets or containers shall be numbered and marked in accordance with the following example:

Project Name:		Suppliers Name:
Project Number:	Delivery Address:	
	Order Number:	
	Description of Material:	
	Gross Weight:	

7.2 Pallets

The crated insulator units shall be suitably steel banded on pallets. The gross mass of the pallets shall not exceed 1 800 kg. Pallets shall be suitable for handling by fork lift trucks, capable of two-way entry and reversible.

8. Manufacturer Documentation (Hard-copy and Electronic)

It is imperative that the supplier provides the following requested documentation, preferably in the order of the listing indicated below. Accordingly, the following information must be provided:

a) Completed Technical Schedules for each insulator type being offered. The supplier must clearly indicate any deviations appropriately.

b) Drawings for each insulator type must be according to Section 5 in this standard.

c) Proof of ISO 9001 accreditation.

d) Proof of design, manufacture, supply and service experience for glass cap and pin insulators for the last ten years.

e) References to at least 5 projects/lines outside the country of manufacture where the offered insulator is being used. References to other insulator strength classes, not being offered for the specific project or tender, should be omitted. The references shall indicate the name of the transmission line and its operating voltage, month and year of delivery, completion and operation, quantity and strength class of operated insulators, and names of the utility representatives, their titles, addresses, and telephone and fax numbers for further communication.

f) Documentary evidence to satisfy the purchaser that the annual failure rate of insulators offered by the manufacturer is less than 1/10 000 pieces per year for Extra and Ultra High Voltage levels. The required evidence should be issued by at least 3 (three) different recognised utilities in the world which are located outside the country of manufacture.

g) Letter stating full compliance to the conditions specified in this standard.

h) Certificates of origin of the materials utilised.

i) Written guidelines concerning the transport, handling and storage of the insulators.

j) Letter of consent for the purchaser to carry out factory inspections and witnessing of sample and routine tests. As far as practicable, the manufacturing site, quality of materials, workmanship and testing of all insulators to be supplied shall be inspected if Eskom so desires. Every facility is to be provided by the supplier to carry out the necessary inspection of the manufacture and the costs of all tests during manufacture and preparation of test records are to be borne by the supplier.

k) Letter of acceptance to provide insulator samples upon the ESKOM request. The full cost of supply of samples will be borne by the supplier.

l) Design test reports pertinent to the product being offered. Design test reports not related to the products being offered will be considered irrelevant. According to IEC 60383, the mechanical design test certificates must not be older than ten years. Only design test reports issued by an approved, internationally acknowledged, reputable, independent laboratory will be considered valid. The design test reports must include the tests listed in Section 4.1.

m) Letter of agreement to provide sample and routine test reports during the delivery of insulator batches to site. The letter must also acknowledge that a batch of insulators delivered to site can be rejected if the mentioned test reports are not submitted.

n) Letter stating compliance to delivery schedules specified in the enquiry document.

o) Letter indicating an adequate production capacity for the offered insulators.

p) QITP for the routine testing

q) Any further supporting documentation not included in the above.

9. Technical Evaluation Criteria

The evaluation of the manufacture and glass insulator(s) offered shall be done according to the Technical Evaluation Standard 240-86601391.

10. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Nishal Mahatho	Senior Specialist (Insulators) – Research, Test and Development
Riaz Vajeth	Senior Manager – Line Engineering Services
Gavin Strelec	Chief Engineer High Voltage Engineering – Research, Test and Development
Dr Wallace L Vosloo	Corporate Specialist High Voltage Engineering – Distribution Solutions Centre of Expertise
Sanjay Narain	Chief Engineer (Insulator) – Line Engineering Services
Kevin Kleinhans	Chief Engineer – Insulation Coordination PDE HV Plant
Eric Marshall	Chief Engineer – Live Work Group Technology
Raphael Swinny	Middle Manager – Research, Test and Development (KIPTS)
Thavenesen Govender	Chief Engineer – HVDC and FACTS
Fernando Witbooi	Chief Technologist – Insulation Coordination

11. Revisions

Date	Rev	Compiler	Remarks
September 2020	3	S Zikhali	Sect. 2.2.2 Renaming of the evaluation standard 240-86601391
May 2016	2	S Zikhali	Inclusion of the SANS / IEC 62217, 32-846 and ISO/IEC 17025 as part of the Normative references and criteria accepted by ESKOM. (Sect. 2.2) Included the request for QITPs instead of Quality Documents (Sect. 8(p)) Removed the evaluation criteria to the Evaluation Standard 240-86601391 Removed the Scoring on the Sample Schedules (Annex A)
Aug 2014	1	S Zikhali	New Technology Template and doc number changed. Sect 4.3, (Par 3) added. Sect 7.1 detailed packaging requirements added. Sect 8, (manufacturer documentation) added. Section 9, (Technical evaluation criteria) added Changed IEC standards adopted by SANS to SANS/IEC
Dec 2007	0	F Witbooi	New numbering format. Replaced BS EN 10002-1 with SANS (ISO) 6892. BS970 withdrawn. Reference to ASTM replaced with equivalent SANS standard. Omitted superfluous clauses already contained in IEC and SANS standards.

12. Development team

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

- Sanjay Narain (Chief Engineer – Tx Insulators CG)
- Sifiso Zikhali (Engineer – Tx Insulators CG)

13. Acknowledgement

Not applicable.

Annex A – Technical Schedules Sample

Procurement to ensure the insulator supplier fills in these details at the time of enquiry. Any deviations or alternatives should clearly be indicated on these schedules.

The supplier must complete the blank areas in the schedule.

Schedule A – SUPPLIER'S RESPONSIVENESS

No	Item	Comply (Y/N)	Comments
1	All Schedules A, B and C completed		
2	Drawings for all offered insulators according to 240-77125760		
3	Proof- IS09001		
4	Proof- 10yr manufacturing experience		
5	Reference list of supply to 5 projects outside country		
6	Proof of Failure rate 1/10000		
7	Letter of compliance to Eskom Standard 240-77125760		
8	Certificates of origin of raw materials		
9	Transport, Handling and Storage Guidelines provided		
10	Allowance- manufacturing inspection/witnessing tests		
11	Allowance to provide samples		
12	Agreement Letter for sample and routine tests provided		
13	Delivery schedules letter		
14	Production capacity letter		
15	QITP for the routine testing		
Deviations:			

Schedule B – TEST MATRIX

		Item Number as per Annex A convention :						
Test		**File name of electronic test report submitted**	**Applicable page number**	**Product code used in type test report**	**Full product code of item offered**	**Name of test facility and electronic file name of accreditation certificate/evidence**	**Comments**	**Outcome Passed/ Failed**
1	Relevant SANS / IEC 60383 DESIGN TEST Certificate provided							
1a	Dimension verification included							
1b	Dry Ll withstand included							
1c	Wet 50Hz withstand included							
1d	Mechanical Failing Load test included							
1e	Thermal-mechanical performance test included							
1f	Steep front of wave test included							
1g	Power arc test included							
1h	Residual strength test included							
GLASS STRING PARAMETERS								
2a	Dry Ll withstand value provided							
2b	Wet Sl withstand value provided							

Schedule C – INSULATOR REQUIREMENTS

INSULATOR TYPE	? KN INSULATORS		
Conceptual Design Drawing No.	Check conceptual drawing as per project/tender specification		
PARAMETER	CLIENT REQUIREMENTS	Comply (Y/N)	Comments
INDIVIDUAL GLASS CAP AND PIN UNITS			
Minimum mechanical failing load	? kN		
Maximum nominal diameter	? mm		
Nominal spacing	? mm		
Standard coupling (SANS/ IEC 60120)	? mm		
Maximum creepage distance	? mm		
Minimum dry 50Hz withstand voltage	? kV		
Minimum wet 50Hz withstand voltage	? kV		
Minimum dry, positive LI withstand voltage	? kV		
Minimum puncture withstand voltage	? kV		
STRING PARAMETERS			
Minimum Dry LI withstand value	? kV		
Minimum Wet SI withstand value	? kV		
Deviations:			