Eskom	Engineering Instruction	Distribution

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Introduction

This Engineering Instruction (EI) outlines the ageing and pollution performance tests required in place of the Koeberg Insulation Pollution Test Station (KIPTS) type test. This is applicable to products that have not been previously tested at KIPTS. The interim measures detailed in this EI are to be used until the KIPTS test facility is reinstated and normal testing resumes. Therefore, until communicated otherwise, the KIPTS type test is not mandatory and is temporarily replaced by the interim requirements in this EI.

This EI defines the requirements for the approval of all medium voltage (MV) and high voltage (HV) insulator products for use on the Eskom Distribution network for applications, up to and including nominal system voltages of 132 kV. These requirements also apply to equipment insulation generally, e.g., bushings, or insulation housings, as well as insulator coating systems.

When the KIPTS test site is recommissioned, the testing of all MV and HV insulator products will resume and the KIPTS type test will be reinstated as the mandatory and primary requirement for pollution performance and aging of all insulation products to be used in the Eskom Distribution network.

Instruction

This instruction is issued to provide the requirements for the approval of MV and HV insulation in respect of ageing and pollution performance, throughout the Eskom Distribution Division.

Revision history

This Instruction is based on the technical approach proposed in a previous instruction that was compiled in December 2018 as ‘Revision 1’ of 240-142598739 [9]. ‘Revision 1’ was subsequently revised to generalise the requirements for both Transmission and Distribution applications and published as ‘Revision 3’ [10]. With the separation of Distribution and Transmission divisions, the original requirements are reinstated by this instruction. Therefore, this instruction supersedes ‘Revision 3’ and shall be implemented in Distribution for all products.

Date	Rev.	Compiled by	Remarks
Sep 2022	1.1	G Strelec & F Jooste on behalf of the Distribution Line Insulator Performance Care Group (Dx LIP CG)	First Issue

1. Normative and Informative references

Parties using this document shall apply the most recent edition of the documents listed in the normative references.

1.1 Normative

[1] SANS 61109, Insulators for overhead lines – Composite suspension and tension insulators for a.c. systems with a nominal voltage greater than 1 000 V – Definitions, test methods and acceptance criteria, Edition 2 (2008-05).

[2] SANS 62217, Polymeric HV insulators for indoor and outdoor use – General definitions, test methods and acceptance criteria, Edition 2 (2012-09).

[3] SANS TS 60507, Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems, Edition 3 (2013-12).

[4] SANS TS 60815-1, Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles, Edition 1 (2008-10).

[5] CIGRE TB 555, Artificial pollution test for polymer insulators, 2013.

[6] CIGRE TB 691, Pollution test of naturally and artificially contaminated insulators, 2017.

[7] 240-100495413, KIPTS natural aging and pollution performance test procedure for outdoor insulator products: section 0.

[8] SANS 17025, General requirements for the competence of testing and calibration laboratories.

1.2 Informative

[9] 240-142598739 Rev 1, Insulation pollution standards required in lieu of KIPTS, 2018 (withdrawn).

[10] 240-142598739 Rev 3, Rescinding of KIPTS testing as mandatory requirement and guidance on technical standards applicable for pollution related qualification of high voltage equipment, 2019.

[11] 240-75883896 Rev 1, Outdoor post and long rod insulators for new and refurbished powerlines for 66kV and 132kV standard, 2021.

2. Requirements for test facilities

All tests specified by this instruction are to be conducted at ISO 17025 [8] accredited, independent and registered laboratories.

3. KIPTS change of status as a mandatory criterion

The KIPTS type test requirement is temporarily waived as a gatekeeper and/or mandatory requirement in the approval of MV and HV equipment and products, until KIPTS is reinstated. References to KIPTS as a gatekeeper and/or mandatory requirement in Eskom standards, technical evaluation criteria and/or procurement documents shall be replaced by the alternative criteria stipulated in this instruction.

Note: The alternative tests outlined in this instruction are not applicable to products for which there is a valid KIPTS test certificate.

4. Application conditions

This engineering instruction must be applied to all Distribution standards as follows:

1. If an existing standard contains the requirements specified in this instruction, it need not be revised.
2. If an existing standard does not contain the requirements specified in this instruction, it must be revised to refer to this instruction.
3. If there is insufficient time to revise an existing standard in case 2, a covering letter referring to this instruction can be attached to the enquiry.

When the new KIPTS site is operational, testing for natural pollution performance and aging will resume as a mandatory type test (i.e., ‘KIPTS type test’).

The requirements for product test certificates specified in this instruction, including pollution performance curves according to Section 6, will remain a requirement for submission with a tender for insulation products even after KIPTS testing is re-established.

Note: These pollution performance curves will be used in techniques for condition monitoring and life prediction of insulator products.

5. Ageing performance requirement

Test certificates stating compliance with SANS 61109 [1] shall be provided. These certificates shall include a successful 1000-hour salt-fog tracking and erosion test as per SANS 62217 [2].

6. Pollution performance requirement

Test certificates for pollution voltage withstand curves ($U_{50\%}$) developed from flashover tests at three pollution levels shall be provided for a test insulator. The test insulator shall have identical material and profile parameters to that of the insulator to be supplied.

The three required pollution levels are characteristic of pollution conditions for the networks installed across South Africa. These three pollution levels are represented by the following 'Salt Deposit Density' (SDD) levels: 0.06, 0.12 and 0.48 mg/cm^2; and with a 'Non-Soluble Deposit Density' (NSDD) of ≥ 0.1 mg/cm^2.The SDD levels for the three pollution levels are depicted by 'A', 'B' and 'C' in Figure 1. Further details are as follows:

- For *ceramic insulators*, the 'Solid Layer' test method according to SANS TS 60507 [3] shall be performed, using Procedure B. A spray gun is to be used for applying the Kaolin composition in accordance with Annex B.3.2. The recommendations given in Annex D and E of SANS TS 60507 [3] shall be followed to determine the degree of pollution on the test insulator by using the 'SDD' method.
- For *polymeric insulators* with 'Hydrophobicity Transfer Material' (HTM) properties, the test shall be performed according to the 'modified Solid Layer' test method, with the pre-conditioning procedure (i.e., with and without hydrophobicity recovery) according to CIGRE TB 555 [5] and CIGRE TB 691 [6].

The 50% probability withstand voltage ($U_{50\%}$) results for the three pollution flashover tests performed on the test insulator shall be converted to a 'flashover stress', in kV/m, along the standard test insulation length, 'H_T', as follows:

$$\textit{'Flashover stress'} = \frac{U_{50\%}}{H_T}$$

'H_T' is the linear insulation length between metal end fittings (Figure 2), that is used to determine the $U_{50\%}$, and is determined by the available voltage source used by the test facility, i.e., depending on the voltage source, an insulation length is selected to maintain the same ratio of 'flashover stress'. This stress shall be presented as a three-point approximated power law curve against the pollution level (SDD in mg/cm^2) as per Figure 1.

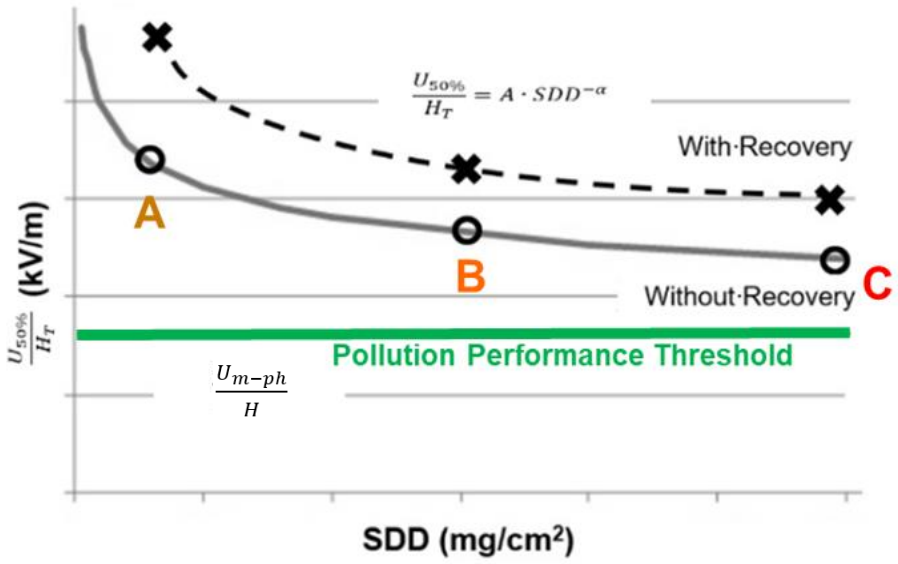

Figure 1: Pollution performance curve with SDD levels

The green line in Figure 1 represents the 'Pollution Performance Threshold', i.e., the acceptable flashover stress across the insulator under test and signifies the minimum acceptance criterion for pollution performance.

This threshold is calculated as follows:

$$\textit{'Pollution performance threshold'} = \frac{U_{m-ph}}{H} \text{ (in kV/m)}$$

'H' (Figure 2) is the insulation length and '$U_{m\text{-}ph}$' is the highest system phase-to-earth r.m.s. voltage that the insulator is subjected to. Section 7 shows an example of how this is applied.

In place of the natural pollution performance test performed at KIPTS, an insulator shall be accepted if:

$\frac{U_{50\%}}{H_T} > \frac{U_{m-ph}}{H}$ in the following SDD ranges. For HTM insulators, the performance 'without recovery' must be considered as it is the worst case:

1. 0.06 to 0.12 mg/cm^2 for use in 'Light' to 'Medium' pollution environments (Figure 1, from 'A' to 'B' on the pollution performance curve).
2. 0.12 to 0.48 mg/cm^2 for use in 'Heavy' to 'Very Heavy' environments (Figure 1, parts 'B' to 'C' on the curve).

The two acceptance criteria above correspond with the two tests that are performed at KIPTS for 'Light-Medium' and 'Heavy-Very Heavy' conditions [7].

The $U_{50\%}$ determined at the following three pollution levels: 0.06, 0.12 and 0.48 mg/cm^2, constitutes the three points that define the 'pollution performance curve' for a particular insulator.

For HTM insulators, the curves for both 'with recovery' and 'without recovery' shall be provided in the supplied test certificate.

The insulator pollution flashover performance curve constants, A (in kV/m) and α (dimensionless) are to be determined by curve fitting according to the equation:

$$\frac{U_{50\%}}{H_T} = A \cdot SDD^{-\alpha}$$

Note: This pollution performance data may be used by Eskom along with 'Site Pollution Severity' (SPS) in the 'statistical approach' for insulator selection as per Annex G in SANS TS 60815-1 [4] to optimise insulator selection for special applications.

7. Example of pollution performance evaluation

The insulator shown in Figure 2 is to be installed on a 132 kV overhead line. The maximum system phase-earth voltage is calculated as follows:

$$U_{m-ph} = \frac{U_m}{\sqrt{3}} = \frac{145\ kV}{\sqrt{3}} = 83.8\ kV$$

The minimum insulation length (H) is 1.2 m (Figure 2, minimum distance between end-fittings). This gives the following 'insulation stress':

$$\frac{U_{m-ph}}{H} = 70\ kV/m$$

If the insulator 'strength' at the three points 'A', 'B' and 'C' of the pollution performance curve (Figure 1) is below this threshold (green line in Figure 1), the insulator performance is not acceptable. If points 'A' and 'B' are above the threshold line, then the insulator may be used in 'Light' to 'Medium' pollution environments. If 'B' and 'C' are above the threshold line, then the insulator may be used in 'Heavy' to 'Very Heavy' pollution environments.

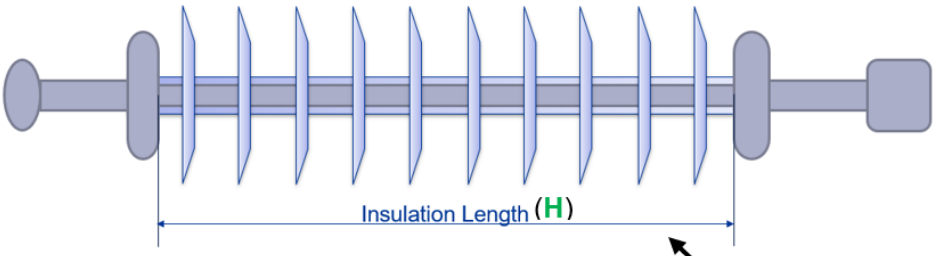

Table 1a: Longrod electrical and mechanical characteristics

1	2	3	4
Characteristic	Highest system voltage 72,5 kV	Highest system Voltage 100 kV	Highest system Voltage 145 kV
Rated lightning impulse withstand voltage kV, peak at STP.(BIL)	350	450	650
Rated short duration wet power frequency withstand voltage r.m.s. , kV	140	185	275
Minimum distance between end fittings (mm)	900 OR	730	1200
Connecting Length (mm)	880 ±20*	1000 ±20	1480 ±20
End fitting – Live end	IEC 60120 Ball 16	IEC 60120 Ball 16 Or	IEC 60120 Ball 16

H

Figure 2: Dimensional parameters of 132 kV long rod insulators [11]

8. Material fingerprinting

'Material fingerprints' for insulators (or insulator coatings) are to be supplied in accordance with KIPTS procedure [7].

9. Provision of sample

A single sample of the product and its drawing must be submitted for verification purposes. This sample will be stored as a reference sample.

10. Summary of requirements for submission for technical evaluation

Table 1 summarises the requirements of this Instruction and the items to be submitted for evaluation.

Table 1: Technical evaluation submission requirements

Item	Requirement	Standards	Clause in this instruction	Received (Yes/No)	Accepted (Yes/No)
1	Aging performance qualification which includes 1000 hr salt fog test: test certificate	SANS 61109 [1] SANS 62217 [2]	5		
2	Pollution performance curve	SANS 60815-1 [4] Cigre TB 555 [5] Cigre TB 691 [6]	6		
3	Material fingerprint analysis	240-100495413 [7]	0		
4	Sample	240-100495413 [7]	0		
5	Dimension drawing	240-100495413 [7]	0		

The end user shall use Table 1 to evaluate submissions in response to enquiries. The test certificates and samples must be submitted for technical evaluation to Research, Test and Development (RT&D) – Distribution Solutions COE. Distribution Solutions COE shall verify the information and shall issue a certificate for each product type indicating approval status. This is a similar process to the issuing of KIPTS certificates in the past and is to ensure consistency in the issuing of test certificates for insulator products. The issuing of KIPTS certificates by Distribution Solutions COE will resume when KIPTS is reinstated.

11. Future select KIPTS testing

When KIPTS is reinstated, Eskom reserves the right to subject selected insulators that have been approved in accordance with the interim KIPTS requirements, to natural aging and pollution performance tests at KIPTS. The cost for testing products that were accepted based on the criteria specified in this instruction at KIPTS will be borne by Eskom'. Should the insulator not perform adequately in accordance with the KIPTS acceptance criteria for aging and pollution performance, Eskom reserves the right to withhold further procurement until the defect is corrected by the manufacturer.

12. KIPTS certificate validity

Eskom shall accept existing valid KIPTS certificates issued previously, provided the product is identical in design and material, to the product for which the certificate was issued.

13. Technical support

Users requiring technical support on the implementation of this instruction should contact any of the following:

- David Mvayo.
- Gavin Strelec.
- Frans Jooste.
- Richardo Davey.
- Jason Blaauw.

14. Development team

- Gavin Strelec.
- Frans Jooste.
- Richardo Davey.
- Jason Blaauw.
- Andreas Beutel.
- Other members of the Dx LIP CG.