Managing OIP Transformer Bushings on Eskom & NTCSA's Transformers: Standardization and Replacement Challenges

Khayakazi Dioka, Eskom NTCSA

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Introduction to Bushings

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1

A bushing is a crucial component in transformers, allowing conductors to pass through grounded barriers while providing insulation between high-voltage windings and the transformer tank.

2

Bushings are critical for the safe operation of transformers, ensuring that the electrical connections do not pose a risk to the surrounding environment or personnel.

3

Bushings are designed to last 20–30 years, with transformers having a lifespan of around 40 years, meaning bushings typically require replacement at least once during the transformer's service life.

Eskom/NTCSA Bushing Journey

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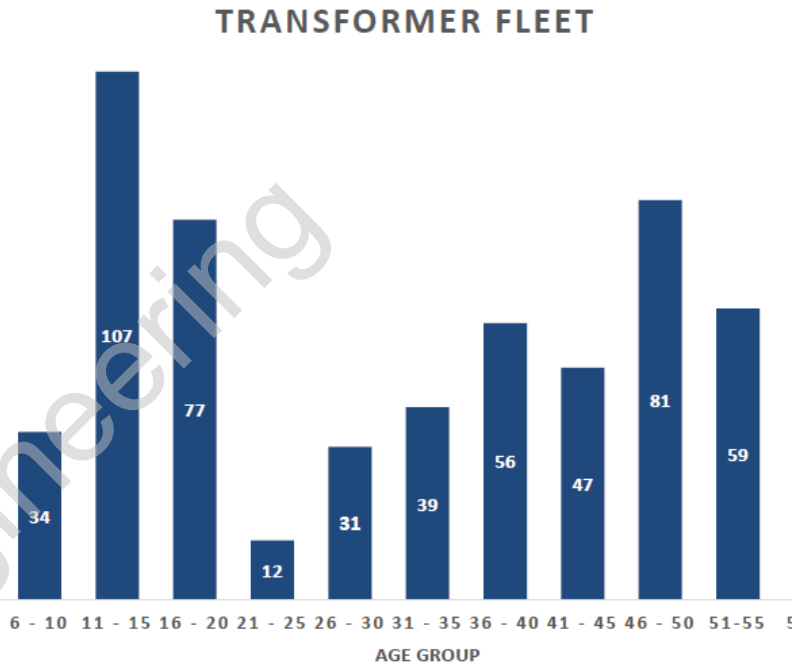
- **Oil-Impregnated Paper (OIP) Bushings**
  - Historically used in Eskom and NTCSA transformers.
  - Subject to performance issues and failures over time, leading to increased maintenance and replacement needs.
- **Introduction of Resin-Impregnated Paper (RIP) Bushings (2007)**
  - Transitioned to RIP technology for better reliability, safety, and reduced fire risk.
  - RIP bushings have superior fail-safe features, making them a more secure option for transformer networks.

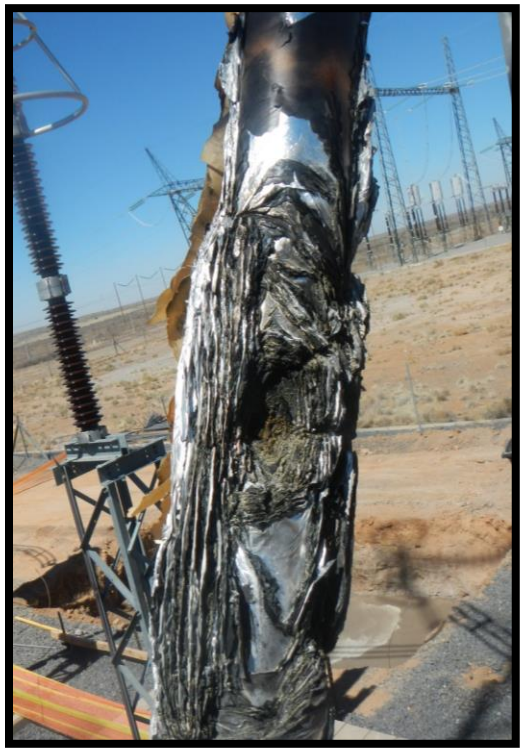


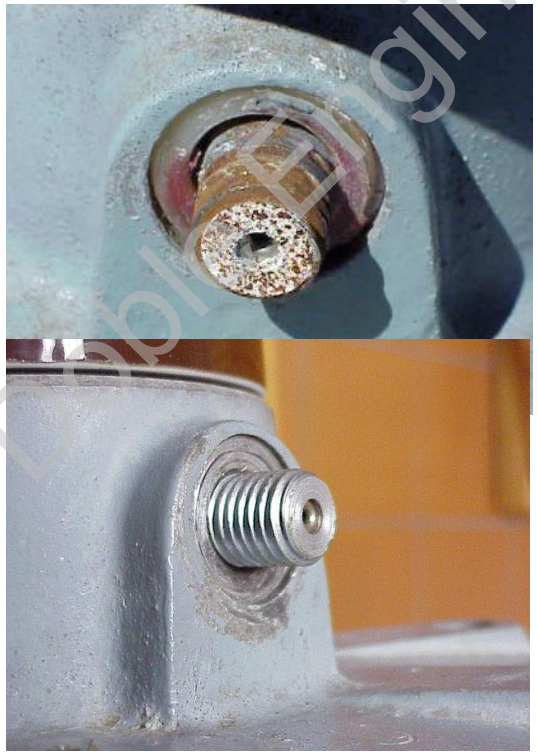
- **Standardization:**
  - Eskom standardized its transformer fleet, promoting compatibility and better management of spare parts, including bushings.

Managing OIP Bushing Fleet 2007-2016

Replacement of Defective OIP Bushings:

- Known defective OIP bushings were replaced through national projects, particularly for 400kV, and 275kV transformers.
- Other bushings, e.g.,132kV, 88kV, were modified to extend their service life.





Managed through different technical instructions – Specific bushing type

- Test point modifications – screw on cap seizes and cannot be removed – fitting lock-nut and dust cap
- Inspection and test

Managing OIP Bushing Fleet 2016 to Date

- All OIP type bushings >20 years in service, with no test records ≤36 months retest and analyse.
- Routine sampling every 3 years.
- Only use serviceable OIP bushings in stores under emergencies.
- No replenishment of stock by OIP bushings.

Test	Findings	Action
1) **Visual Inspection**	Discoloration of gauge glass ,no oil level and oil leak is evident from bushing compartment	Remove and scrap
1) **Tan Delta and Capacitance Test**	Tan delta < 0.5	Keep in service if no leaks or thermal issues.
	0.5 ≤ tan delta < 0.7	Keep in service, test yearly and plan for replacement
	Tan delta >0.7%	Immediately remove from service and scrap it
1) **Infrared scanning**	Overheating detected when comparing phases	Investigate, repair or replace.

Eskom/NTCSA Bushings Health Appraisal

Bushings Health Appraisal – 2020 Results

Bushing Condition Assessment:

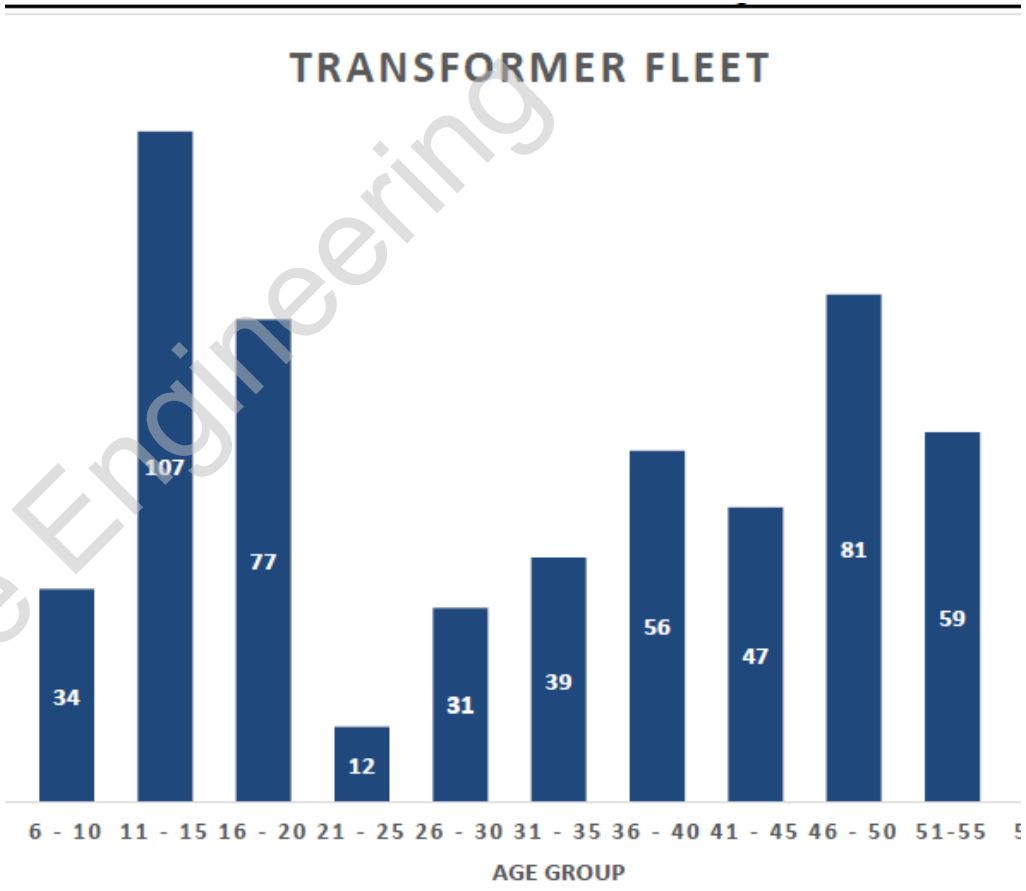
Tan delta Values	Condition	Recommended Action
<0.5%	Good	Normal Maintenance
0.5% - 0.7%	Deteriorating	Keep in service, test yearly and plan for replacement
≥0.7%	Deteriorated	Replace Immediately

Testing and Results Analysis:

Grid	Tested bushings (%)	Bushings for replace-ment (no.)	Bushings requiring increased monitoring frequency (no.)
Region 1	88%	1	2
Region 2	33%	7	27
Region 3	75%	0	24
Region 4	86%	0	22
Region 5	91%	0	55
Region 6	32%	1	9
Region 7	76%	6	57
Region 8	81%	4	33
Region 9	85%	4	42

Challenges – Data and Testing

- **Missing data** - 54% of the OIP bushings in service test results were available for analyses.
- **Unknown bushings** – nameplate information
- **No test tap** – no test results, bushings removed for testing.
- **Incorrect results** - Environmental Factors (Dust, dirt, atmospheric moisture)



Challenges - Standardized Bushings Replacing Non-Standardized Bushings

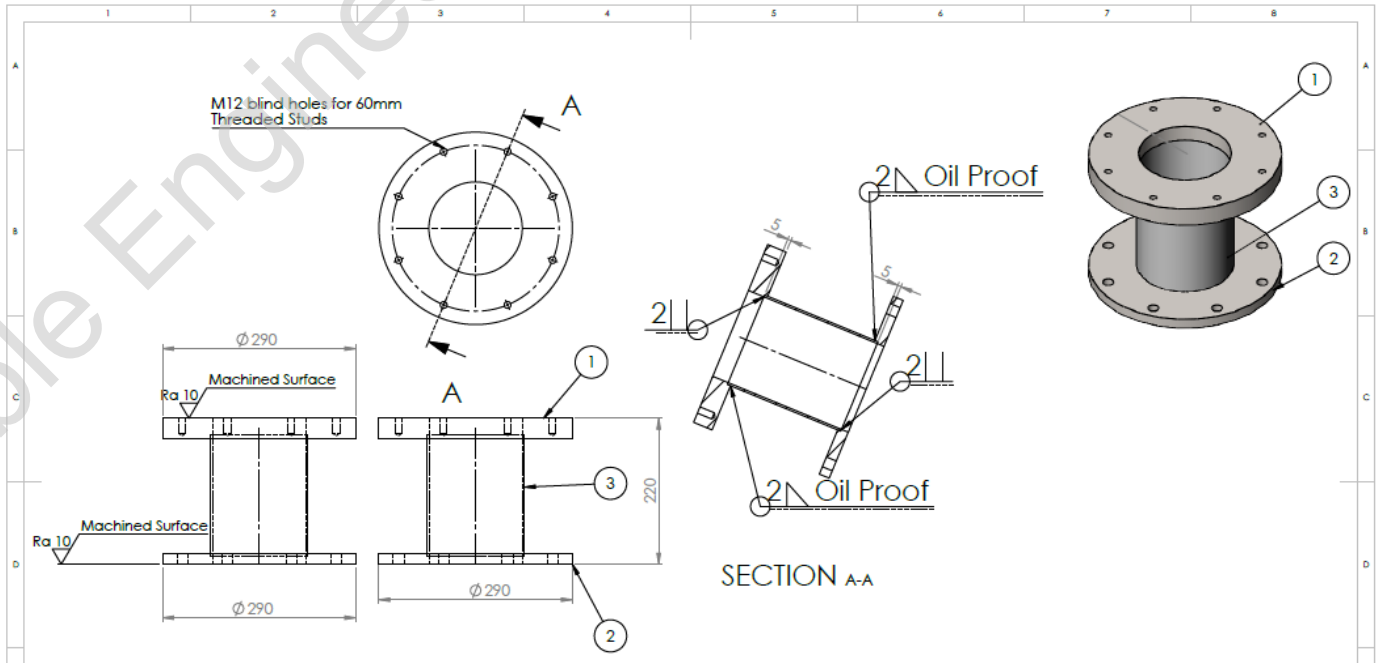
Standard network voltages with different bushing sizes, e.g.,132kV 1250A bushing

	Bushing A1	Bushing A2	Bushings A3	Bushing A4	Standardized Bushing
Oil Side Length (mm)	580	740	940	1130	660
Flange diameter(mm)	335	335	335	520	290
PCD (mm)	290	290	290	470	250
Fixing bolts (no. x mm)	12 x 16 (Ø)	12 x 16(Ø)	12 x 16(Ø)	12 x 20(Ø)	8 x 16(Ø)
CT extension length	150	300	480	600	300
CT Ext diameter	200	160	190	325	160

Challenges - Standardized Bushings Replacing Non-Standardized Bushings

Typical design modifications include;

- manufacturing of adaptor flanges to be rewelded on existing flanges
- manufacturing new solid rods (conductors), or machining replacement conductor to required lengths
- cutting of exit leads to be connected into shortened conductor
- manufacturing an adaptor turret where the replacement bushing is longer than an existing bushing



Ultimate Bushing Replacement Challenges to Transformer Fleet

- **Prolonged outages** – testing, modifications, and full commissioning (full drain/partial drain).
- **Intrusive work management** – quality issues, human error effect e.g., transformer severe incident
- **Quick depletion of inventory –** fail one, replace three, slow procurement process.
- **Skill availability** – testing and installation

Highlights/Learnings

- Data management - unavailability of records > retesting
- The importance of standardization on components for compatibility and strategic spares management
- Clearly defined maintenance scope of work/method statements, instruction documents, etc.
- Skills development (local Doble trainings and workshops)

Thank you.