Eskom	Standard	Technology

Title: **SPECIFICATION FOR PERMANENT ON-LINE OIL DRYING SYSTEM FOR USE ON TRANSFORMERS AND REACTORS**

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1. Introduction

Transformers and reactors (hereafter both being referred to as transformers) are designed with a life expectancy of 40 years. This life expectancy is greatly reduced if a transformer is operated with inadequate life management. The main three factors of transformer insulation ageing during service life are;

- Heat, which is generated when the transformer is in operation. This must be controlled to be within design limits through the proper maintenance of the cooling plant.
- Oxygen, which can be absorbed from the atmosphere and is a by-product of the ageing process. The ingress of oxygen is reduced by the use of air cells in the conservator tanks.
- Moisture, which is present in a transformer insulation as a remnant from factory processes, due to ageing processes, and can be absorbed from the atmosphere through leaks or other exposures. The effects of moisture are mitigated by drying the insulation, using various methods and techniques.

During normal operation, moisture in paper levels in transformers must be kept low (below 1% by weight) in order to slow down the ageing rate of the insulation. Online moisture removal systems are one such means of achieving this. However, this system is not intended to dry wet transformers but to keep dry transformers dry. A permanent online moisture removal system is considered by Eskom to be an economical and practical method for keeping a transformer dry. They are to be employed while moisture in paper is up to 2%, ideally while moisture levels are much lower.

When transformers are wet i.e. moisture in paper is > 2%, adequate methods of drying will be required and these include workshop drying, low frequency heating and vacuuming on site and drying using mobile filtration plant.

It is important that this equipment fulfil its duties without removing the dissolved gasses in the oil, which will be counterproductive for Eskom's condition monitoring and maintenance regimes.

2. Supporting clauses

2.1 Scope

This document specifies the minimum requirements for on-line moisture removal system to be fitted on transformers and reactors.

2.1.1 Purpose

The purpose of this document is to specify Eskom's requirements for permanent on-line oil moisture removal systems.

2.1.2 Applicability

This document shall apply throughout Eskom Holding Limited Divisions and to all bodies procuring transformers for Eskom.

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] 240-56062726: Standard for Intrusive Work and Oil Filling, Under Vacuum of Transformers and Reactors on Site

[2] 240-53902530 Data Concentrator specification

[3] 240-64038621 Remote Device Communication Standard for Data Retrieval and Remote Access

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[4] 240-68973110 Specification for power transformers rated for 1.25 MVA and 2.2kV and above

[5] 240-56030674 Corrosion Protection of new and in-service power & station auxiliary transformers.

[6] 240-56227443 Cable specification.

[7] IEEE 1613-2009, IEEE Standard for environmental and testing requirements for communications networking devices installed in electric power substations.

[8] IEC TS 61000-6-5:2001, Electromagnetic compatibility (EMC) Part 6-5: Generic standards. Immunity for power station and substation environments.

2.2.2 Informative

[9] 240-75661431: Mineral insulating oils (uninhibited and inhibited) Part 1: Purchasing, Management, Maintenance and Testing.

2.3 Definitions

2.3.1 General

Definition	Description
Permanent Online Moisture Removal System	A device designed to be permanently installed on transformers/reactors with the function of removing dissolved water as well as particulate contaminants from insulating oil in a controlled manner using filter technology whilst the transformer remains in service. The term permanent is used to distinguish this technology from that of mobile filtration plant but does not necessarily means the equipment cannot be moved from transformer to transformer.
Responsible Manager	This refers to: Electrical Engineering Manager, HV Plant Manager, or Plant Manager.

2.3.2 Disclosure classification

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

2.4 Abbreviations

Abbreviation	Description
CG	Care Group
DC	Direct Current
FTP	File Transfer Protocol
GPRS	General Packet Radio Service
HTTP	Hyper Text Transfer Protocol
IEC	International Electro-technical Commission
LC	A type of Fibre Connector
LCMP	Life Cycle Management Plan
LED	Light Emmitt Diode
N/O	Normally Open
OEM	Original Equipment Manufacturer
SCADA	Supervisory Control And Data Acquisition

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Abbreviation	Description
SCOT	Steer Committee Of Technology
SWA	Steel Wire Armoured
TCP/IP	Transmission Control protocol / Internet Protocol
UV	Ultra Violet

2.5 Roles and responsibilities

The responsible Manager shall ensure that the requirements of this document are complied with during the installation.

2.6 Process for monitoring

The SCOT transformers CG shall evaluate the need for revision of this document at their discretion.

2.7 Related/supporting documents

See References above.

3. Requirements

3.1 General

The system shall be able to operate without limitations over the oil temperature range from 0°C to + 115°C. It shall withstand the internal pressure of at least 100 kPa and full vacuum at sea level without damage. Expected design life of the moisture removal system shall reasonable match the expected life of a transformer of at least 40 years, when maintained as per OEM manual. All components shall be housed in a corrosion resistant enclosure with an IP 56 protection class. A thermostatically controlled anti-condensation heater shall be provided. Enclosure shall be manufactured from 1.6 mm or thicker 3CR12 or 304 stainless steel sheeting. The 304 stainless steel can be left bare and 3CR12 shall be epoxy powder coated with a minimum dry film coating thickness of 100 µm. Colour shall be SABS F48 Cloud Grey. Enclosure shall be provided with hinged access doors to perform general maintenance, cleaning, filter replacements and defect repairs such as replacement of defective components and oil leak repairs, and it shall make it possible to view the LEDs (see section 3.4.4 of this standard) without opening the doors.

3.2 Environmental Conditions

Outdoor installation.

Altitude above sea level – 1800 m.

Ambient temperatures

- Maximum + 40°C
- Monthly average + 28°C
- Yearly average + 25°C
- Minimum – 10°C

Average relative humidity 90%.

Solar radiation 2500 kWh/m².

Atmospheric UV radiation – High.

Seismic conditions at a minimum of 0.3g.

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Pollution Level- High marine and industrial (C5)

3.3 Functional Requirements

a) The system shall be designed for continuous operation and shall not impose any risk to the safe operation of the transformer.

b) The flow rate of the system shall ideally be around 400 litres/hour, however any selected speed shall provide a balance between effective drying and avoiding dangerous condition in a transformer. The speed of the oil leaving and returning into the transformer shall not exceed 500 mm/s.

c) The moisture removal rate per single pass through the filter system shall be a minimum of 1 ppm with the oil at a temperature of 40°C at the designed speed.

d) The filter system shall have the capacity to hold at least 6 litres of dissolved water before saturated.

e) The system shall be able to shut down (stop circulating) on its own when the moisture in paper level has dropped to a set value, which shall be between 0.5%-3% (programmable) .

f) The system shall be fitted with non-resettable digital counter for the oil litres that have passed through it.

g) The system shall remove both dissolved moisture in insulating oil as well as particulate contaminants up to 5 micron.

h) The system shall be dedicated for moisture removal and not degassing of the oil, i.e. ideally it must not remove gasses or the changes must not impede the fault diagnostics.

i) The system shall be provided with a compartment that will trap any bubbles before the oil returns to the transformer.

j) A gauge glass shall be provided to monitor the volume of collected air in the compartment.

k) The monitor shall be fitted with a float switch that will cut electrical supply to the oil pump of the drying system if gas collects in the air trap but before any bubbles are pumped into the transformer.

l) A warning light visible in direct sunlight and alarm signalling (see alarm and communication section 4.3) shall be provided to indicate gas collection trip.

m) Particle filter saturation shall be indicated by a daylight visible light and alarm signalling (see alarm and communication section 4.3).

n) The system shall be provided with shut-off valves on the oil inlet and outlet pipes. These valves shall be accessible from ground level.

o) Replacement of filter cartridges shall be possible with the transformer in service. Bleeding of the system after cartridge replacement shall be possible with the transformer in service.

p) The system shall be provided with moisture in oil sensor to enable the user to measure the moisture content in the oil before and after the filter elements. Display shall be in ppm.

q) Provision shall be made for connecting the system to the substation earth mat.

3.4 Alarming and Communication

The device shall provide relay based alarming, LED based warnings as well as a digital communication interface. These are described in the following clauses.

3.4.1 Signals that must be available

The following minimum data registers/signals must be available for interrogation via the communication interface:

- Percentage saturation of the cartridges.
- Moisture in paper as percentage

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- Water ppm value in to the system- Moisture sample taken to be referenced with a temperature, date and time stamp.
- Water ppm value out from the system.
- Error code for a particular fault (intention is an error code would be provided to the supplier when reporting a fault).

3.4.2 Communication Interface

- The devices data and communication should meet all the major points of [3].
- The device should be able to provide data/statuses through the IEC 61850 protocol.
- Remote access and interrogation should also be possible using TCP/IP using HTTP(S) based web interface.
- It must be possible to fully configure, diagnose and interrogate the system using a web interface i.e. no software must be required to configure or interrogate the system.
- Downloading of files should be possible using FTP.
- The device may be connected to a data concentrator downstream which would be specified according to [2].
- The monitoring device shall have an on-board storage capability with the ability to download data using USB 2.0 or recent.

3.4.3 COMMUNICATION MEDIUM

Communication with the device must be possible via the following media:

- Multimode Fibre Ethernet port (100BaseFX) with Duplex LC connector.
- Copper Ethernet port (100BaseTX) with RJ45 Connector.
- USB 2.0 or recent.

3.4.4 LEDs

a) Daylight visible LED indicator lights shall be provided for the following:

- Normal operation and system powered (Green),
- Filter cartridges saturated (Orange- this should turn on when the cartridges are 70% saturated ,Red – this should turn on when the cartridges are 90% saturated),
- Problem detected with the system itself (Blue).

These LED indicator lights shall be visible without needing to open the enclosure doors.

3.4.5 Local Indication

On the system itself a display screen must be present which presents as a minimum the signals described in 3.4.1

3.4.6 Relay Outputs

2 potential free contacts (alarm relays) should be provided for:

1) Main Cartridges Saturated (N/O, and should close when the cartridges are 90% saturated).

2) System Fault (N/O, and should close when any fault is found in the dryer system).

These will interface to the SCADA system which shall have the 2 relays as above. The relays shall be specified as per **Table 1** below.

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Table 1: Requirements for relays used for alarms

Make and carry current	1 A @ 250 Vdc
Carry Continuously	1 A
Break (Inductive L/R=40ms)	10 W @ 250 V dc

3.5 Site Installation Requirements

a) No welding shall be performed on the transformer main tank to secure brackets or fittings.

b) The unit shall be free standing and self-supported.

c) Only stainless steel brackets, fittings, pipes and fasteners shall be used.

d) The system shall be effectively earthed to the substation earth-mat by means of one 3 mm x 50 mm flat copper strip.

e) In cases where the main drain and vacuum valves are used (for oil extraction and return) for this system, T-pieces with the same flange size as the valve shall be fitted. These shall be manufactured from 304 stainless steel or mild steel with a corrosion protection that complies with [5]. The flange to flange length of the T-piece shall be 120 mm. The oil shall leave transformer at drain valve and return on the vacuum valve.

f) Pipes shall be adequately secured and mechanically protected to prevent any damage during normal maintenance activities.

g) The device shall be mounted on a free standing frame positioned inside the oil bund area, but not in a position that will hinder replacement of the transformer or any maintenance activities.

3.6 Replacement filter elements

a) Replacement filter elements, maintenance and breakdown spare parts shall be freely available in

b) South Africa.

c) Replacement filter elements shall be supplied dry.

d) The saturated weight of individual filter elements shall be a maximum of 25kg per cartridge to facilitate easy replacement by any member of the staff.

e) When filters are saturated, the moisture shall not be released back into the oil. See 3.3 e).

f) Disposable element type filter cartridge systems are preferred and for non-disposable filter cartridge, the system must be such that one personnel can do the replacement, i.e. saturated weight must be up to 25kg.

g) Waste oil for bleeding purposes shall be limited to maximum of 5 litres per filter system.

3.7 Corrosion protection

a) Corrosion shall be eliminated by the use of non-corrodible materials, and by avoiding the contact of dissimilar metals. Where cast components are used they shall be of high quality and nonporous castings. Bare metal or aluminium castings shall be epoxy powder coated (exterior grade) or anodised.

b) All fasteners shall be stainless steel. Electro galvanising or electro plating of parts and fasteners is not acceptable.

c) Adequate lubrication shall be applied to all threaded areas of bolts, studs and screws. Any good quality high temperature grease may be used.

d) In all other respects, it must be in accordance with [4].

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3.8 Electrical Connections

a) The systems electrical circuits shall withstand an applied voltage of 2 kV DC for 60 seconds, applied in turn, between each electrically independent circuit and the casing of the device, and between the separate independent electrical circuits.

b) Terminal boxes and terminal strips shall allow sufficient space for fitting and securing of 2.5 mm control wiring and cabling. Termination strips shall be numbered and basic wiring diagrams shall be provided inside the lid of the terminal box and in the installation instructions. All terminals shall be of spring loaded type.

c) The relay contacts shall be cabled to the Marshalling Kiosk by means of steel wired armoured cabling that is heat, oil and UV resistant.

d) A main isolator shall be provided at the point of supply. Two pole circuit breaker to be used.

e) Main isolator shall be properly labelled. Labels shall be white with black lettering and shall be permanently engraved. Labels shall be secured by means of high bonding double sided tape (1 mm thickness).

f) Only SWA cable that is oil, heat and UV resistant shall be used. These must comply with Eskom cable specification 240-56227443.

g) Cable glands shall be suitable for the type of cable used and shall be stainless steel or tinned brass. The cable glands shall effective earth the cable armouring of armoured cables.

h) Cables shall be permanently marked and numbered. Cable strands shall be marked and lugged according to application drawings. Cables with the correct number of strands shall be used.

3.9 Nameplate Information

The system shall be provided with a permanent engraved 316 stainless steel nameplate with the following information in a tabular format: Make, Type, Serial Number, Moisture Removal Capacity, Filter Element Type Re-order Information, Oil Flow Rate, oil flow schematic and Year of Manufacture. Labels shall be secured by means of high bonding double-sided tape (1 mm thickness).

3.10 Training

During installation training shall be provided to staff to maintain the system and replace the filter cartridges. Training shall include de-commissioning and re-commissioning of the system

Training must also be given for configuration and interrogation with all of the systems relays, and electronic systems.

This shall form part of the handover checks.

3.11 Documentation and Packaging

a) Original and fully detailed instructions for assembly, operation and maintenance of the system shall be included with each system. The system shall be securely packed and properly protected against damage and moisture ingress during shipping and storage.

b) A standard test card bearing the manufacturer's serial number of the system shall be included with each of the operating instruction manuals.

c) The pipe openings and shall be suitably sealed to prevent ingress of dirt and moisture duringv shipment and storage.

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3.12 Technical evaluation and final approval

The OEM / Supplier shall be responsible to supply a moisture removal system for technical evaluation. The equipment shall be supplied to Eskom and will be subjected to full technical and operational evaluation. The sample shall be supplied in accordance with this specification and it will remain the property of the supplier. This specification serves as a minimum requirement for manufacturers that supply moisture removal systems. Any deviation from this specification has to be approved by Eskom in writing before ordering or manufacturing of the system. Final written approval shall be provided once a technical evaluation has been completed and equipment found in compliance with this specification and Eskom requirements. Any changes to the approved product will be subjected to re-evaluation and approval.

4. Authorisation

This document has been seen and accepted by:

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5. Revisions

Date	Rev	Compiler	Remarks
July 2021	2	Mantsie Hlakudi	Revised the technical requirements in line with the research report RES/RR/20/1954059
July 2014	1	Michael Ngubane	New Standard

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7. Acknowledgements

The development team of the original document

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