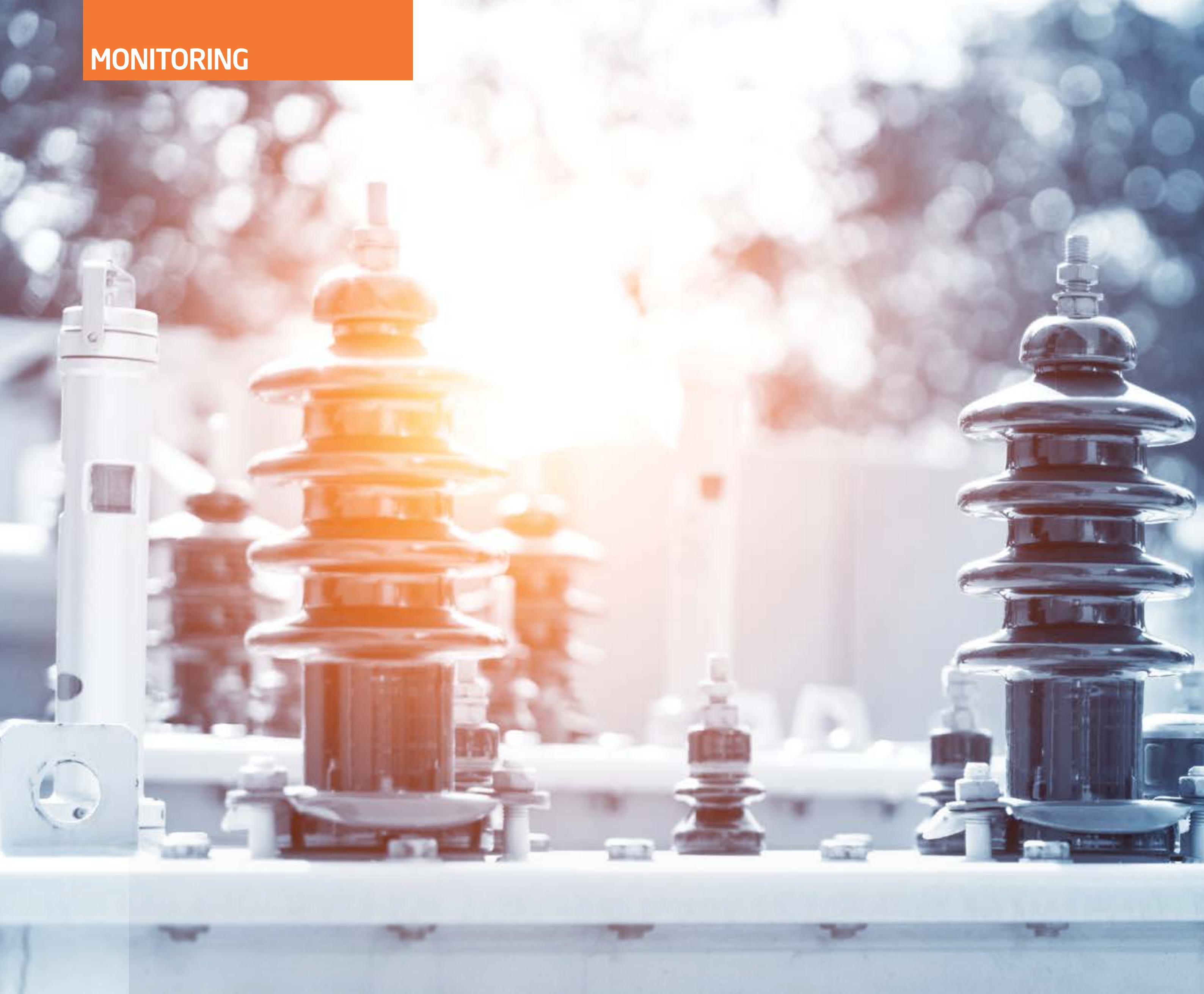

Sealed transformer monitoring

ABSTRACT

Interest in sealed distribution transformers, with and without gas cushions, increased in the 1950s. However, the tank of hermetically sealed transformers must tolerate a higher pressure, and this can lead to mechanical sealing problems. Contrarily, a lower pressure in the tank can put the internal dielectric seal at risk. Therefore, the pressure and temperature monitoring in hermetically sealed transformers are crucial to keep the pressure behaviour under control and to have the ability to perform proactive prevention.

KEYWORDS:

hermetically sealed transformers, monitoring, pressure, prevention, temperature

Introduction

Interest in sealed distribution transformers, with and without gas cushions [1], increased in the 1950s.

We will talk more about the latter ones, usually used in smaller sizes.

This equipment has found a large market request due to the following reasons:

- The insulating liquid is protected against the effects of the atmosphere. This allows for keeping the quality of the insulating materials with little or no maintenance.

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Oil is under pressure in hermetically sealed transformers, except in situations when the oil is under low pressure - contrary to transformers with a conservator

- Since a conservator is not required for a hermetically sealed design, this type of transformer has additional advantages arising from the reduced overall height if installed at the wind turbine or application where dimensions are a critical point.
- Suitable to be filled with natural ester oil (environmentally friendly) with flash point higher than 300 °C.

In hermetically sealed transformers, the oil pressure is usually higher than the atmospheric pressure, and despite conservator-type transformers, the tank of these transformers acts as a pressurized vessel. The tank of hermetically sealed transformers must tolerate a higher pressure. Due to the elimination of the conservator, the oil temperature variations lead to expansion and contraction of the transformer tank. It affects transformer tank design, behaviour, and aging. Transformer tanks are manufactured in corrugated form for efficient heat transfer and oil cooling. The ribs of the corrugated tank have the essential rule in cooling and tolerating pressure variations [2], [3].

Critical aspects

Case 1: Transformer overloading

When the transformer is overloaded beyond the nameplate rating, there is an increase in temperature due to increased load losses.

Excessive temperatures prematurely age the insulations.

Solution: Monitoring of the temperature rise with a thermostat

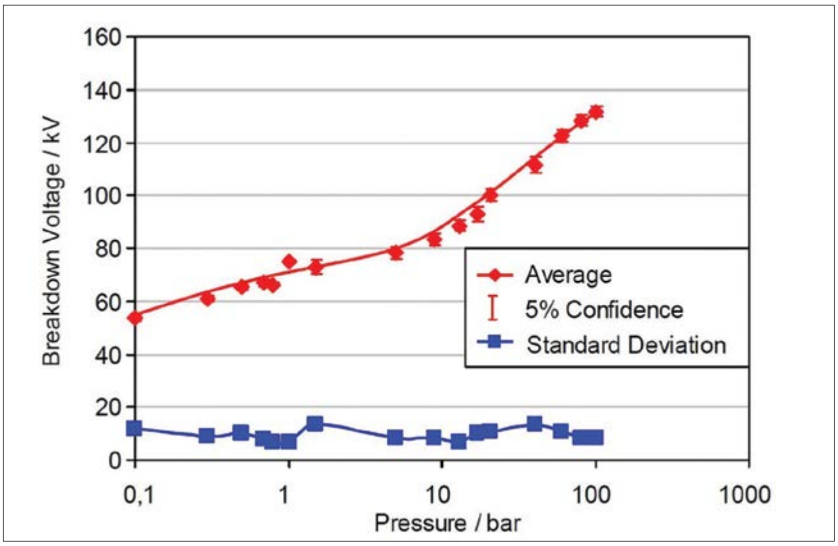
The thermostat provides a system for controlling the temperature and operates only when a prefixed temperature value is exceeded.

Case 2: Overpressure inside the tank

An accentuated overpressure could cause permanent deformation of the corrugated fins with consequent lowering of the oil level and internal discharge.

There are several methods that can be used to ensure that the internal pressure in the transformer tank is kept within an acceptable safe range.

Pressure and temperature monitoring in hermetically sealed transformers are crucial to keep the pressure behaviour under control and to have the ability to perform proactive prevention



Graph 1: Breakdown voltage of insulation oil as a function of pressure (logarithmic scale)

For example:
Use of gas cushion (typically nitrogen) where a pressure relief valve is used to reliving over-pressure, and an externally mounted regulated nitrogen supply to tops up the pressure if it falls below the design permitted lower pressure level.

Another solution: Monitoring of the pressure and oil level with an integrated safety device

The maximum pressure is kept under control with an overpressure valve or relay set, typically in the range 0.3–0.5 bars, the minimum level of oil is kept under control with an oil level indicator.

Case 3: Negative pressure inside the tank

In environments with huge ambient temperature fluctuations and strong load variations, the transformer oil temperature can reach values below the equilibrium temperature point "zero". The equilibrium point "zero" is set in the factory during the oil filling of the

transformer. If the temperature reaches point zero, negative pressure occurs inside the transformer tank. This specific condition can generate the following considerations:

a. Even under ideal conditions, oil has a discharge voltage that depends on the pressure, and it decreases in case of negative pressure (see Graph 1). What can explain this phenomenon? In areas with an intense electric field, gas bubbles are formed in oil before the discharge. Bubbles are less easily absorbed at a low pressure, where the solubility of the gas in oil decreases [4].
b. The experience of operation with these types of transformers teaches that this is a relevant aspect with a significant number of transformers that develop partial discharges and consequent generation of hydrogen with the relative risks of reliability.
c. Possible development of gas inside the transformer; this creates an internal variation of the equilibrium among oil and gas with the possibility to reach the saturation conditions of the gases at low pressure with a further negative impact on the discharge voltage.

Conclusion

Continuous monitoring of pressure and temperature in hermetically sealed transformers became crucial to:

- keep the pressure behaviour under control also in the negative range, where the breakdown voltage reduction could be dangerous,
- map the correlation between temperature and pressure to have proactive prevention of abnormal behaviour.

Bibliography

[1] E. B. Franklin, *Sealed transformers*, Proceedings of the IEE, June 1955

[2] S. Lee et al., *Development of thermal and structural design technology for a hermetically sealed oil transformer*, Transactions on The Built Environment, vol 126 -2012

[3] D. Herfati et al., *Calculation of mechanical stresses in hermetically sealed transformers*, CIRED 2007

[4] M. Koch et al., *The breakdown voltage of insulation oil under the influences of humidity, particles and pressure*, Int. Conference APTADM, ept. 2007, Wroclaw, Poland

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