New Method for Posthermetisation of Transformers

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New methods for subsequent hermetic sealing of transformers

By Dipl.-Ing. K. Olbricht

Transformers are often the most expensive equipment for power supply companies, and they are products to be planned on a longterm basis.
Both the financial and organizational risks rise the longer the transformer has been in operation. Potential failures as well as the very long delivery times, sometimes several years, cause great problems for power supply companies and industrial customers.

Figure 1: Power transformer

In Europe alone 60% of the installed transformers have been in operation for more than 25 years now although the service life under normal service conditions is only 25 to 30 years. It is therefore essential that reliable operation of the installed equipment is ensured in future as well.

Due to varying service temperatures during operation an extra volume must be provided to allow the oil to expand. This function is normally provided by the transformer's conservator connected with the transformer tank via a pipe and with the atmosphere via a pipe.

The service life of transformers, in particular power transformers with oil-paper insulation, is determined by the service life of cellulose in paper and in pressboard particles. Ageing and decomposition of the transformer cellulose affect both its electrical and mechanical strength. An increased water content of solid insulation material causes significant disadvantages for transformer operation, in particular in components subject to high electric load. Moisture reduces the mechanic and electric strength of insulating materials and accelerates the ageing process and partial discharge intensity.

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Apart from moisture oxygen is another catalyst accelerating ageing of the active insulation.

The impact of oxygen on ageing of oil can be suppressed by inhibitors. Accelerated decomposition of cellulose begins with advanced thermal decomposition and, hence - depending on load - with increasing age. Therefore, subsequent hermetic sealing in open-type transformers can prolong the service life of even older units and, in addition, is an effective solution when a leaking hermetic sealing has to be replaced or repaired.

The state of the art offers a number of solutions preventing or significantly slowing down the penetration of atmospheric oxygen and water in the transformer, thus slowing down its ageing process caused by oxidation.

Hermetically sealed transformer

The hermetically sealed transformer was developed to prevent oil from getting into contact with oxygen and water. The transformer tank that does neither have a conservator nor an air cushion is sealed. This design has been used for distribution transformers only and more recently also for medium-power transformers. The tank and the radiators must be able to accommodate thermal expansion of oil as an expandable medium. Hermetically sealed transformers require low maintenance.

Figure 2: Hermetically sealed transformer

Nitrogen cushion

A nitrogen cushion preventing the penetration of atmospheric oxygen and water in the oil filling is formed in the conservator above the oil level.

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Hydro-type compensator

Another method to prevent the oil from getting into contact with water and oxygen is the use of a hydro-type compensator in the conservator. Although this technical concept performs the tasks of hermetic sealing, its practical implementation has caused technical problems including higher costs, regular inspection of the rubber sack for tightness, longterm reliability of the membrane, difficult determination of oil level and inconveniencies with oil handling.

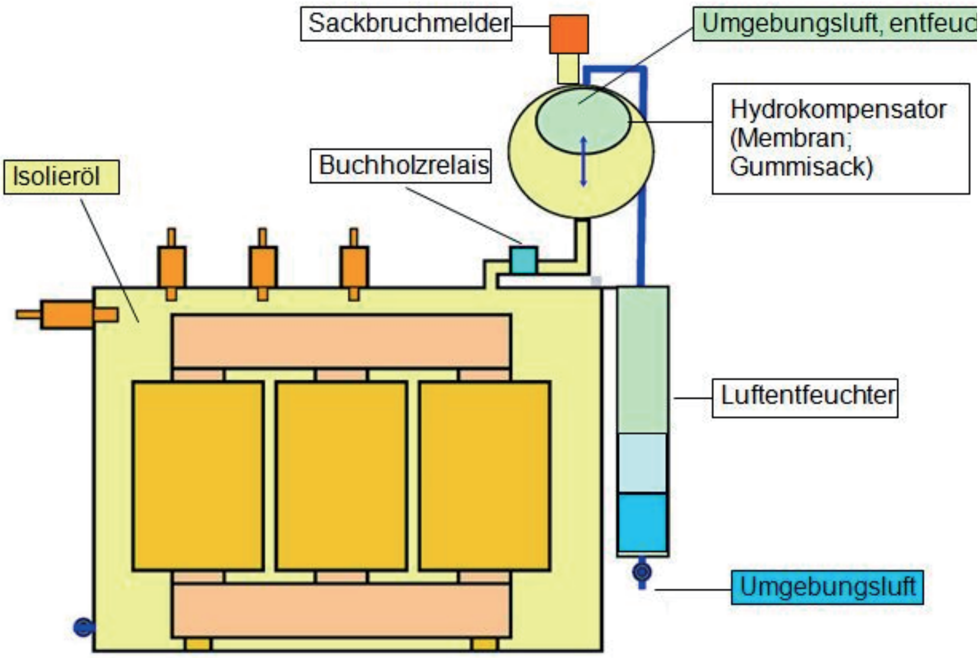

Figure 3: Transformer with hydro-type compensator

Sackbruchmelder	Air cell failure relay
Isolieröl	Insulating oil
Buchholzrelais	Buchholz relay
Umgebungsluft, entfeuchtet	Ambient air, dehumidified
Hydrokompensator (Membrane; Gummisack)	Hydro-type compensator (membrane; rubber sack)
Luftentfeuchter	Air dehumidifier
Umgebungsluft	Ambient air

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There exists another option for hermetically sealing a transformer or subsequent hermetic sealing.
This is a universal solution suitable for all transformers and eliminating the disadvantages of the other methods.

This solution is the **breather buffer box G3B.**

Figure 4: Fermentation lock

The breather buffer box operates on the principle of the fermentation lock known from wine making.
The gas in the conservator that expands with increasing temperature pushes the oil level in the external cylinder of the box downwards and, in parallel, in the internal cylinder upwards.
During cooling down the atmospheric pressure pushes the oil into the opposite direction.

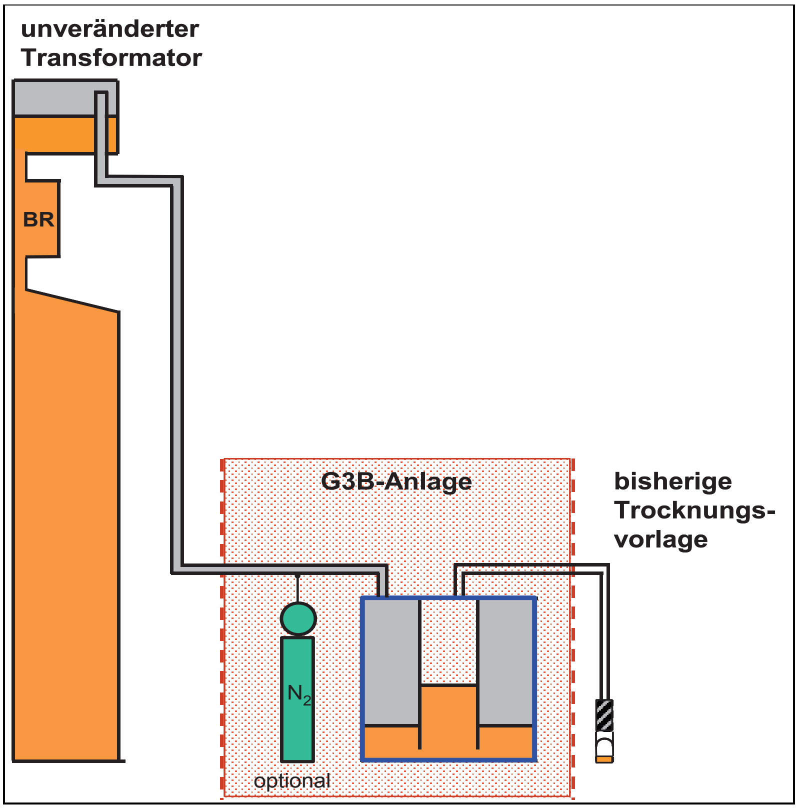

Figure 5: Principal scheme of the breather buffer box

unveränderter Transformator	Unchanged transformer
BR	Buchholz relay
G3B-Anlage	G3B unit
bisherige Trocknungsvorlage	Desiccant used until now
optional	optional

Construction of a breather buffer box unit

The G3B unit consists of a cylindrical box integrated in the breathing line of the transformer upstream of the moisture absorber. Optionally a nitrogen pressure gas bottle can be integrated.
The box is provided with a bottomless inner cylinder and is partly filled with oil as a service medium for pressure variation and diffusion barrier supported by a floating aluminium disk. The box cannot be locked and has two natural end positions for the oil level differences which serve to compensate the 30°C difference of the tank oil temperature. Under these conditions the oxygen-reduced air in the gas chamber of the conservator is separated in the cylinder box from the dry ambient air. If the atmospheric pressure in the conservator is exceeded by 40 mbar (maximum oil level in the internal cylinder), gas is released into the atmosphere. If pressure falls below the atmospheric pressure by 20 mbar (minimum oil level in the internal cylinder), either dry ambient air (subsequent natural hermetic sealing) or nitrogen from the pressure gas bottle is supplied (subsequent N2-aided hermetic sealing).

The boxes are available in different sizes:
G3B-1 for an oil weight in the transformer up to 1 t
G3B-2 for an oil weight in the transformer up to 2 t
G3B-5 for an oil weight in the transformer up to 5 t

Installation

G3B units are of modular construction including the oil sump of the transformer. Up to three cylindrical boxes can be placed one above the other, or the boxes can be arranged as twin columns connected in parallel and installed in the oil sump. The nitrogen pressure gas bottle is placed in a gas cabinet outside the oil sump. The unit is filled with a defined oil quantity. The subsequent hermetic sealing process can be accelerated by flushing the conservator with nitrogen during installation.

Figure 6: G3B unit with weatherproof lining

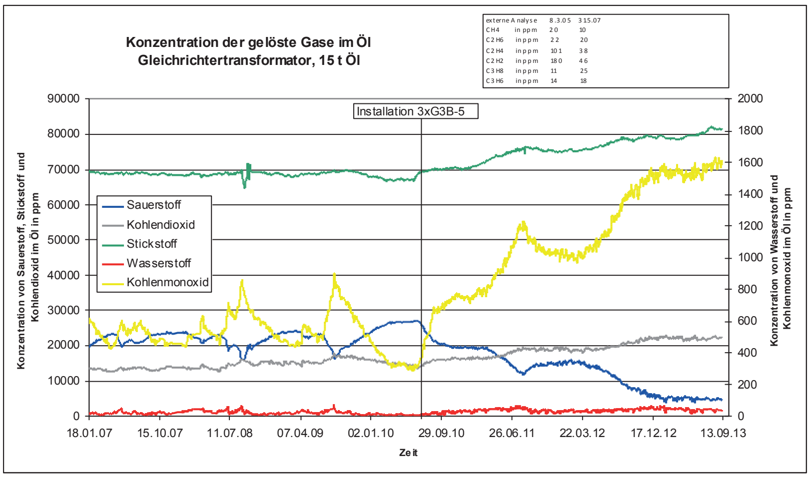

Figure 7: Development of the gas balance for subsequent natural hermetic sealing

Konzentration der gelösten Gase im Öl	Concentration of dissolved gases in oil
Gleichrichtertransformator, 15 (45) t Öl	Rectifier transformer, 15 (45) t oil
Installation 3xG3B-5 (3 x G3B-5/N_2)	Installation 3xG3B-5 (3 x G3B-5/N_2)
Konzentration von Sauerstoff, Stickstoff und Kohlendioxid im Öl in ppm	Concentration of oxygen, nitrogen and carbon dioxide in oil in ppm
Sauerstoff	Oxygen
Kohlendioxid	Carbon dioxide
Stickstoff	Nitrogen
Wasserstoff	Hydrogen
Kohlenmonoxid	Carbon monoxide
Zeit	Time
Konzentration von Wasserstoff und Kohlenmonoxid im Öl in ppm	Concentration of hydrogen and carbon monoxide in oil in ppm
externe Analyse	External analysis

Figure 8: G3B unit with nitrogen supply

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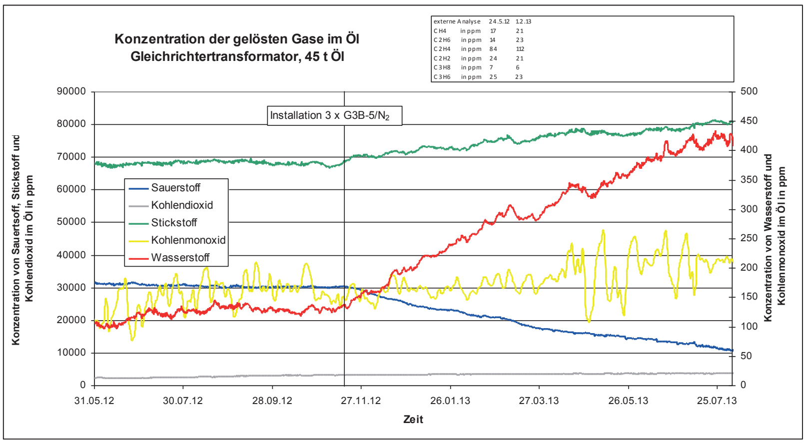

Figure 9: Development of the gas balance for subsequent N2-aided hermetic sealing

Konzentration der gelösten Gase im Öl	Concentration of dissolved gases in oil
Gleichrichtertransformator, 15 (45) t Öl	Rectifier transformer, 15 (45) t oil
Installation 3xG3B-5 (3 x G3B-5/N_2)	Installation 3xG3B-5 (3 x G3B-5/N_2)
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Wasserstoff	Hydrogen
Kohlenmonoxid	Carbon monoxide
Zeit	Time
Konzentration von Wasserstoff und Kohlenmonoxid im Öl in ppm	Concentration of hydrogen and carbon monoxide in oil in ppm
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Figure 10: G3B for smaller power transformers

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Advantages

- Maintenance-free sealing system.
  - Decrease of oxygen concentration in the active component.
  - Prevention of water penetration from outside.
- Ensuring the gas collection function of the Buchholz relay.
- Modular construction to adapt to oil volume and service temperature.
- Installation in existing and new transformers possible.
- Suitable for off-load switches.
- Easy installation.
- Long service life.
- No interference with the oil system of the transformer.

Additional options

- Monitoring of oxygen, moisture and hydrogen in the gas chamber possible.
- Active drying of gas chamber possible with regenerable external dryer
- Nitrogen supply during resaturation.

The breather buffer box was developed by Gatron in Greifswald.

It is manufactured by Eisenwerk Bassum Werk Peenemünde.

The box is distributed and installed by EMB GmbH in Barleben near Magdeburg.

Elektromotoren und Gerätebeau Barleben GmbH (EMB) was founded in 1992 in the framework of the privatization of East German companies after the reunification of the two German states.
Transformer protection relays have been manufactured in Barleben for more than 60 years now.

The patented monitoring device developed in 1921 by the German engineer Max Buchholz as a combined flow and gas collection relay has proved to be an inevitable unit for transformer protection.
Nothing has been changed to date to the principal construction and mode of operation.

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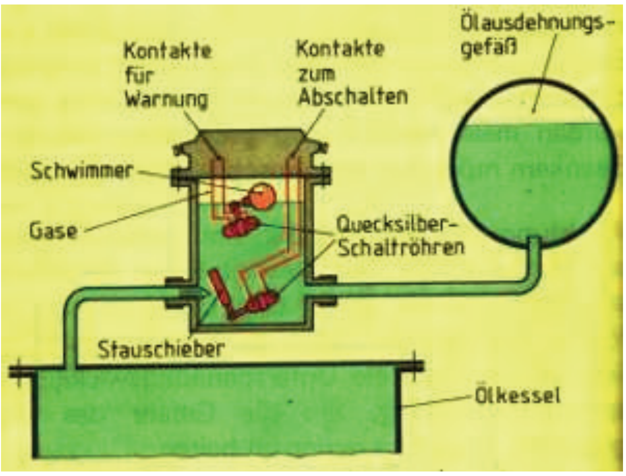

Figure 11: Principal construction of the Buchholz relay

Kontakte für Warnung	Alarm contacts
Schwimmer	Float
Gase	Gases
Stauschieber	Damper
Kontakte zum Abschalten	Disconnection contacts
Ölausdehnungsgefäß	Oil conservator
Quecksilberschaltröhren	Mercury contact tubes
Ölkessel	Oil tank

The principal construction shown in Figure 11 originates from the 50ies of the past century. In addition to mercury contact tubes, magnet contact tubes or microswitches are used today. The lower switching system is normally provided with a float as well.

Due to its relatively simple construction, ease of operation, high reliability, freedom from maintenance and very long life, the Buchholz relay has proved to be for several decades now one of the most important protective devices of the transformer worldwide.
The information which can be derived from the fault gas (composition, quantity, when produced) is significant for the early detection of transformer malfunction and may prevent subsequent damage when gathered in due time.

The function of the Buchholz relay in its usual form is a purely mechanical one and does not allow the detection of gas accumulation. Longterm, low-energy faults produce low gas quantities over a longer period whilst energy-rich faults produce large gas quantities within a short period. The Buchholz relay is unable to recognize this difference as it does not provide adequate information about when gas was generated or over what period of time it was accumulated. Therefore, the existing risk can be estimated only roughly. As the generation of a signal requires a very large gas volume, at the time of the release of the signal the basic fault may already have reached an advanced stage. The chemical analysis of the collected gases carried out in order to identify the fault, can be falsified by old gases contained or a long retention time.

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The intention now was to develop a Buchholz relay with geometrical dimensions just slightly different from those of a standard unit, but able to detect even small gas quantities and show the generation of gas over time. The result is the Buchholz relay of NM series.

Figure 12: EMB Buchholz relay of NM series

The sensor is integrated in the Buchholz relay. It allows analogue measurement of gas volumes between 30 cm^3 and 300 cm^3. The original function of the relay is not affected by the measuring device. The necessary electronic devices are accommodated in the terminal box of the Buchholz relay.

The normal function of the Buchholz relay is supplemented by a capacitive level sensor. The measurement range is 30 cm^3 to 300 cm^3. Measurements beyond this range are theoretically possible, however, because of response of the upper switching system they are not relevant. Analogue level measurements are performed continuously so that the gas generation over time and the dissolution of gas during extended retention periods are recorded as well. The supply voltage of the sensor is 24 volts. This voltage is available on the control box or control cabinet of the transformer.
Plug-in connection is in the terminal box of the relay. The Buchholz relay of NM series is suitable for outdoor installation.

By developing the Buchholz relay of NM series EMB succeeded in overcoming the disadvantages of the standard Buchholz relay, namely lack of signalization and representation of the generation of gas over time.

Buchholz relays of the NM series are components perfectly suitable as monitoring systems of transformers.

Buchholz relays of the NM series are, however, also suitable for separate applications where they offer optimum sensing and evaluation options for monitoring and protecting transformers.

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