# The quantitative verification of the TRAFOSEAL II
# Preliminary Report

by

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The qualitative verification of the function of the TRAFOSEAL II [L1, L2] was performed at the 17 MVA furnace transformer with the approx. constant load.

The oil inventory of the transformer main tank was interconnected to the on-line chromatograph [L3], the content of gases in the oil was automatically analyzed twice a day and sampled oil was pumped back.

Applied experimental verification method is based on the dynamic response of the analyzed system at the jump-like change of the boundary condition [L4] which controls the thoughflow of the oil between the main tank and the conservator and therefore subsequently controls the ingress of the atmosperic gases (N2,O2) into the main tank, and vice versa, the escape of „products“ CO, CO2 and H2 from the main tank.

The jump-like change of the oil/gases throuhgflow between both tanks is then ensured by the switching of the TRAFOSEAL II ON and/or OFF. The initial conditions for the experiment are ensured by the degassing of the oil filling of the transformer via the vacuum separator VS-06.

The configuration of the „field“ experiment shows Fig.1

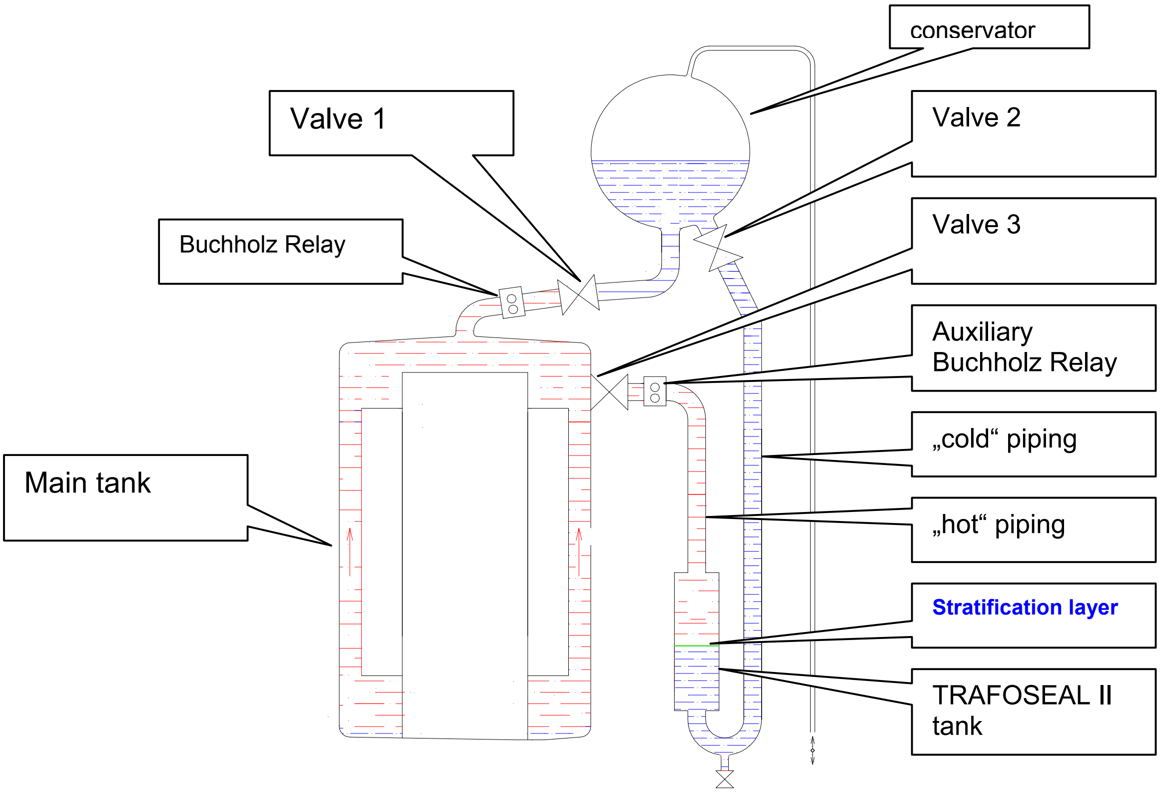

Fig. 1 The schematlic lay-out of the experiment

The experiment was performed following way:

1-Step : the oil filling of the main tank is degassed by the vacuum separator VS-06 (interconnected with the oil filling via sampling cocks) – the Valve 3 remains continuously open during the whole experiment

2- Step: The TRAFOSEAL is switched **ON** (Valve 1 – closed, Valve 2 – open), the separator VS-06 is switched **OFF** (red dart – See Fig,2) , it means:

**the oil filling of the main tank can now free dilatate, but the original free mixing of the (air gases contaminated) oil from the conservator with the oil from the main tank is effectively obstructed by the stratification layer(s) in the TRAFOSEAL tank, an operational oil dilatation in the main tank corresponding temperature deviations is then fully compensated only by the shifting of the stratification layer up and down in the TRAFOSEAL tank**

the increase of contents of all relevant gases in the main tank is measured

3- Step : the oil filling is degassed again by the switching the VS-06 **ON** (green dart, the Valve 1 remains closed, Valve 2 remains open)

4- Step : the VS-06 is switched **OFF** (red dart), the TRAFOSEAL is switched **OFF**,

**the oil freely flows between the main tank and conservator**, **full mixing of oil from the conservator and the main tank**

the increase of the all relevant gases is measured again.

Experimental results shows the diagram at Fig. 2.

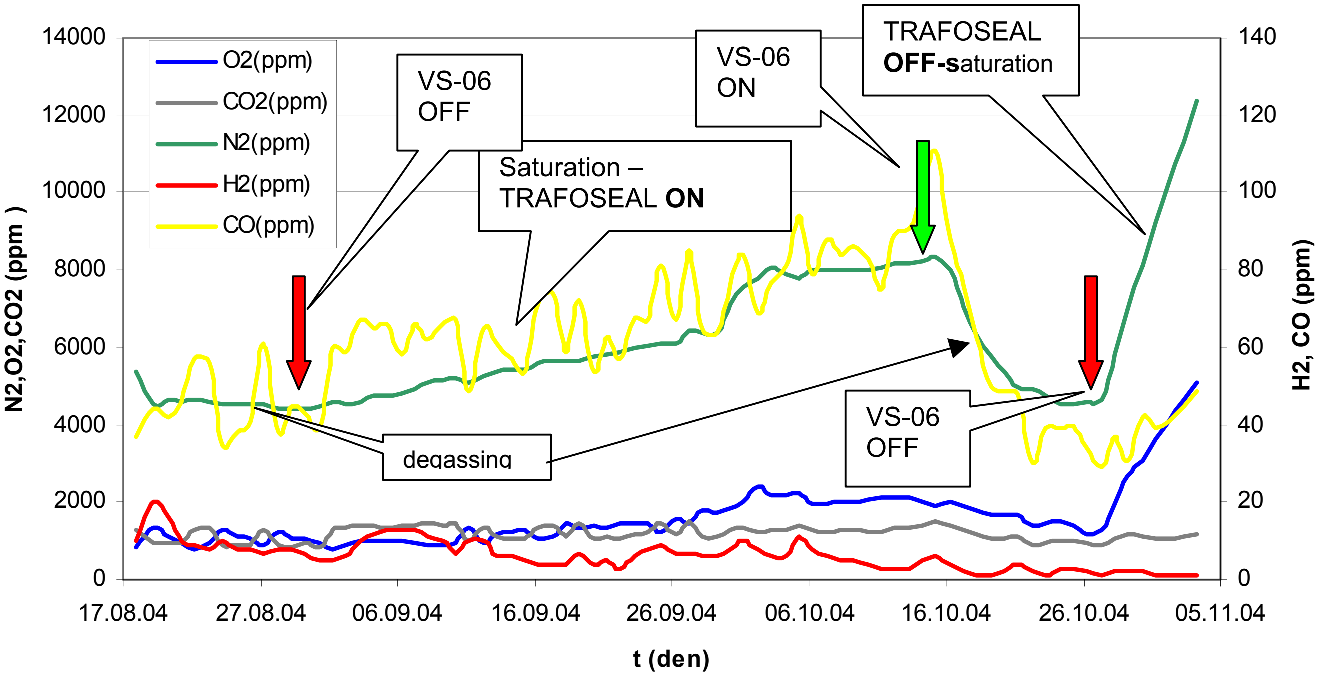

Fig. 2 Time-related reading of gas contents in the main tank

To get the quantitative outputs of the measurement a so-called gradient method is used [L3]. As a “tracer” or “calibration” gas was used N2, because this gas is not markedly consumed in the transformer.

For the quantitative evaluation of the intensity of the contamination of the oil filling of the main tank the method was used which de-facto ulilizes the oil filling of the main tank as a measuring apparatus.

It means the volume of the partially degassed oil in the main tank is regarded as exactly defined and homogenous absorptive capacity with the volume Vn . If we continuously feed the unknow amount of the “tracer” gas in the defined capacity, and we are able continuously read the increase of the content of the “tracer” gas in the oil, then the calculation of the gas inflow is relatively easy.

The increase of the N2 in the main tank can be described by the following differential equation:

(1) $V_n \, . \, dC_{N2,} / dt = v_o \, . \, (C_{N2,kon} - C_{N2,n})$

where:

$V_n$ ...... volume of the oil in the main tank (m3)

$dC_{N2,n} / dt$ saturation gradient (ppm s-1 , here ppm / day)

$v_o$ ....... flow of oil circulating between the main tank and conservator (m3 s-1 here m3 /day)

$C_{N2,kon}$ ....... N2-content in the oil filling of the conservator (ppm)

$C_{N2,n}$ ..... N2-content in the oil filling of the main tank (ppm)

The completely different saturation gradients corresponding free mixing of the oil between the conservator and the main tank (TRAFOSEAL OFF) and the „hermetization“ induced by the TRAFOSEAL II (TRAFOSEAL ON) shows Fig. 3.

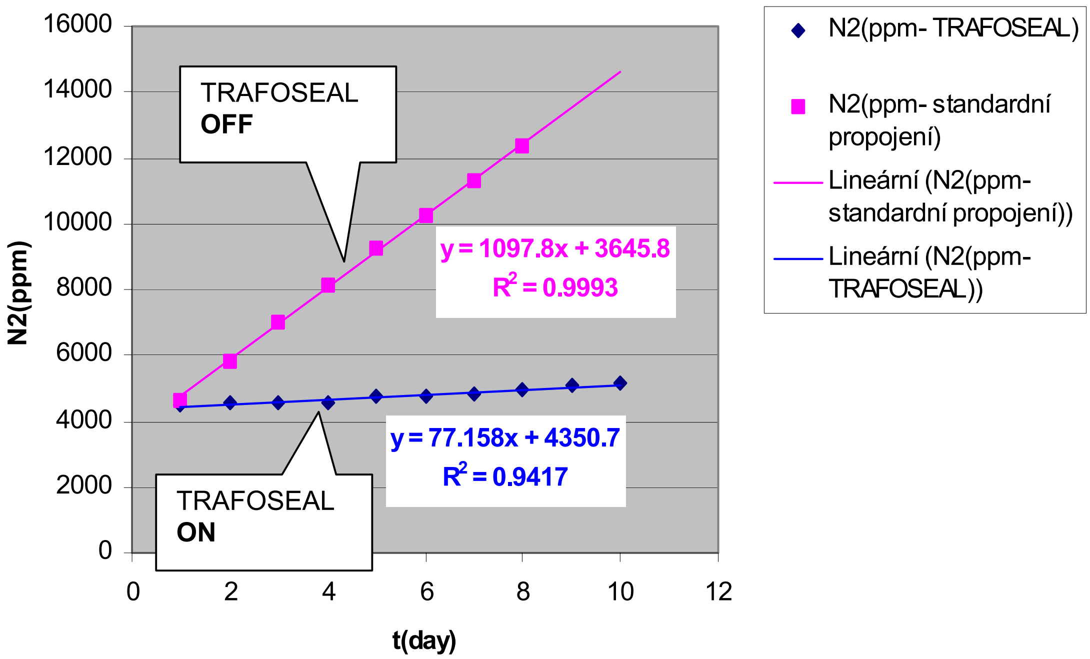

Fig. 3 The comparison of saturation curves – TRAFOSEAL ON / OFF

Initial sections of both saturation curves are nearly linear and we can therefore use a linear approximation of the saturation tangent ( both $R^2$ are over 0.94).

The virtual throughflow $\mathbf{v_o}$ of the oil between main tank and the conservator can be then easy calculated by the equation:

(2) $\mathbf{v_o} = V_n \, . \, dC_{N2,n} / dt / (C_{N2,kon} - C_{N2,n})$ (m3 day-1)

Example:

Let suppose that: the oil volume of the main tank Vn = 14.2 m3, and the TRAFOSEAL is **OFF** and :

- ☐ the N2-saturation gradient is $dC_{N2,n}$ / dt = **1 098 ppm/day** – See Fig.3
- ☐ the N2-value in the conservator is constant (fully saturated) , say N2 = 65 000 ppm,
- ☐ the initial N2-level in the main tank = 4200 ppm

then the virtual troughflow between the conservator and the main tank is:

$v_o$ = ( 14.2 . 1097 ) / ( 65 000 – 4200) = 0.256 m3 / day

But for the regime - TRAFOSEAL **ON -**, and approx. the same initial conditions, we get the more then one magnitude lower saturation gradient:

$dC_{N2,n}$ / dt = **77 ppm /day** – See Fig.3

and the virtual throughflow between main tank-conservator will of course change the same way

$v_o$ = ( 14.2 . 77 ) / ( 65 000 – 4200) = 0.018 m3 /day

The effectivity ratio of the TRAFOSEAL II can be then described as the ratio of both virtual throughflows:

ε = 0,018 / 0.256 = 0.07

It subsequently means that the ingress of the atmospheric gases is due TRAFOSEAL very strongly reduced at ca 7% of the original value.

The evaluation of both throughflows are inevitably not absolutely exact, because the N2-level in the conservator was not measured in this case, but the comparison of saturation gradients (TRAFOSEAL OFF / ON) or better corresponding throughflows, give us already a very good conception how effective the TRAFOSEAL actually is.

The more precise evaluation, based on parallel reading of N2-levels in the main tank and in the conservator, is already tested.

Conclusion:

The first quantitative verification of the hermetization efectivity of the TRAFOSEAL II clearly shows, that this technology is a very good alternative to clasic hermetization methods of power transformers:.

- ☐ TRAFOSEAL II can be installed without any adaptation at any transformer
- ☐ no maintenance or monitoring is necessary
- ☐ stratification layer as the sealing element is indestructible

References:

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