Redfox C-Ty

for a more safe operation

- by monitoring the total gas content and giving an alarm when a preset threshold is passed.
- by degassing, dewatering and filtering an improvement of the electrical breakthrough voltage is obtained.
- by degassing the oil is kept gas
- hungry which is leading to a large margin to free gas bubbles in the oil.

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A safe operation.

The safety of operation is high on a transformer, you can not argue with that. As long as the insulating ability of the oil and cellulose are in good shape there are seldom, as expected, any problems with the safety of operation of the transformer. But as also expected the transformer status is degrading with time, since otherwise no transformers would be exchanged. So therefore one could state that the elder the transformer is the more undefined is the status of the transformer and the larger the risk for problems and thereby the larger the tendency to exchange the transformer.

<u>The safety of operation is affected by continuous degassing</u>

- by keeping the transformer status in good condition over long period of time
- by reducing the risk of emergency stop due to free gas bubbles in the oil.
- by giving an alarm at an early stage, normally long time before an action must be taken.
- by a fast and easy determination of type and size of a fault.

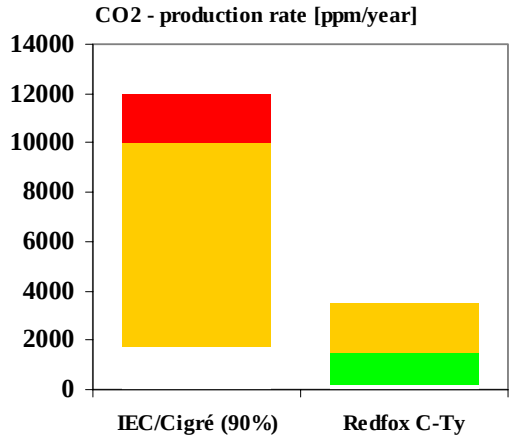
<u>The condition of the transformer is affected!</u>

The oil and cellulose are keeping their high insulating properties.

One effect is that the electrical breakthrough voltage of the oil is increasing upon filtering and dewatering. Redfox C-Ty is filtering the oil by use if a 3 µm particle filter and is reducing the water content to 10 – 15 ppm. The experience for an oil that before degassing exhibit a low electrical breakthrough voltage of 35 kV/2.5mm, exhibit an improvement to acceptable values about 70 kV/2.5mm after some months of operation.

The continuous degassing is reducing the chemical degradation of oil and cellulose. From this follows a preservation of the mechanical strength of the cellulose The degree of polymerization, so called DP – value, gives indirect a measure of the mechanical strength. The DP-value is gradually decreasing over a transformer life time due to the degradation and is finally at a threshold value corresponding to the cassation limit of the transformer.

The gain in life time, i.e. the rate of the chemical degradation of the cellulose, is a consequence of reduction of oxygen and water in the oil and the cellulose. The ageing is dominated by an oxidation process where oxygen and cellulose are consumed and carbon dioxide, CO_2, and water are produced. This is empirically verified by comparison between the production flow of carbon dioxide before start and after about a year of degassing. Normally, for a transformer with open expansion vessel the production flow of carbon dioxide is reduced with about a factor of 2-4 times upon degassing with Redfox C-Ty. In the figure below the CO_2-production in ppm/year for transformers equipped with Redfox C-Ty are shown in comparison with 90% -typical values for all transformers according to IEC and Cigré.

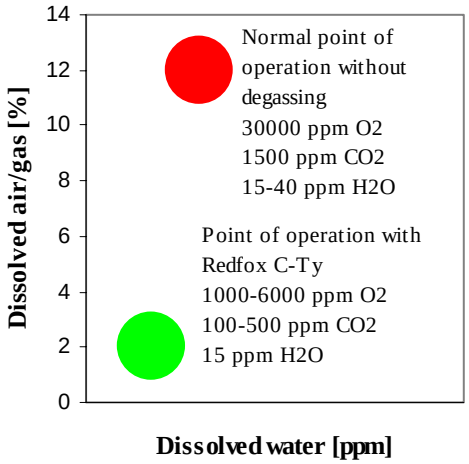


The reduced ageing rate which is a consequence of the degassing affect the safety of operation by reducing the risk of breakdown due to mechanical influence caused by thunder or electrical chock wave.

The risk for an emergency stop is reduced!

The primary effect of the continuous degassing is that the oil is heavily under-saturated concerning the gas content. The oil is said to be gas hungry upon degassing. This means that the more undersaturated the oil the faster the gas is reabsorbed. Thereby the oil is conveyed an increased margin against the dangerous situation, the risk situation where free gas bubbles appear in the oil. Free bubbles which indirect means that the oil loses the insulating properties. How this margin work is described in the following example:

A transformer is assumed to contain 10 m^3 of oil. The oil dissolves by nature at +30 ^oC about 10% or 1000 litres of air. If this transformer start to produce gasses over a certain extent, the oil will become oversaturated after some time and free air/gas – bubbles will appear in the transformer. The gas watch will pay for attention and some action must be taken. The difference between normal point of operation and degassed point of operation is illustrated in figure below.



If the same transformer is continuously degassed with Redfox C-Ty, after some time only 100-150 litres of air will be dissolved in the oil. This implies that by degassing a deficit of 800-900 litres is accomplished. This deficit represents the above mentioned margin volume that is allowed to be dissolved into the transformer oil before the limit of saturation is reached. If gases with high Bunsen-coefficients are formed, larger volumes can be dissolved before oversaturation occur and vice versa. This means that 10000 litres of carbon dioxide can be dissolved to compare with only about 400 litres for hydrogen.

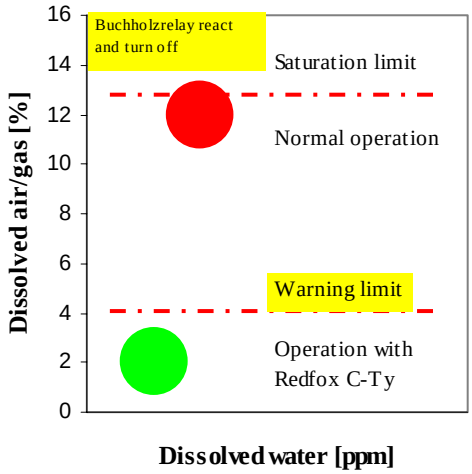
The example can speech for it self. The risk for dangerous event is radically decreased since eventual gas bubbles will be reabsorbed into the gas hungry oil with high speed and with a large capacity. Experiments have shown that the degassed oil reabsorbs 25 – 50 times faster than the non degassed oil.

How much new production flow can be accepted upon continuous degassing by use of Redfox C-Ty before emergency actions? If we assume that the oil gas content may rise to 5% in an error situation, i.e. the sum of partial pressures is max 500 mbar, the Redfox C-Ty can remove about 100 litres /24h. Accordingly, suppose a fault is generating less than 100 litres/24h, Redfox C-Ty will be able to avoid that the sum of partial pressures of dissolved gases overcome above stated 500 mbar.

Continuous monitoring under operation!

The Redfox C-Ty degasser equipment is including a monitoring system giving a call in case of the amount of dissolved gasses overcome a certain, by the operator, preset threshold value. The gas content or, to be more precise, the sum of the partial pressure of the gases is a feature that is monitored by the Redfox.

To be accurate the vapor pressure of present water is also included. A alarm circuit is closed if the sum of partial pressures and vapour pressure is increasing over the preset threshold value. The alarm function can be connected further via telephone wire or via GSM modem (available additional equipment).



If the transformer is starting to gas, the amount of gas removed by the Redfox unit will increase. The monitored absolute pressure or sum of partial pressures and vapour pressure in the vacuum chamber of the Redfox will also increase as a consequence of the increased gassing in the transformer. This is illustrated in the figure above.

A new steady state condition for the gas content is reached and registered by the analogue pressure indicator. If and when the pressure overcomes the preset threshold value an alarm function is activated. The Redfox is still in operation until the absolute pressure overcomes 500 mbar.

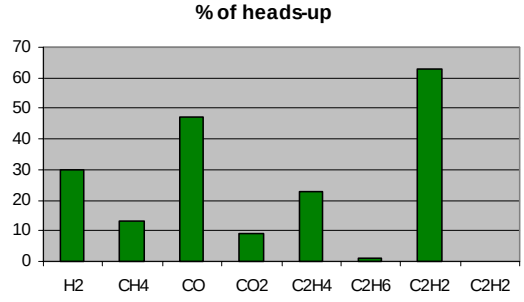
The monitoring or supervision system is also sensitive to faults on the Redfox equipment, for instance leakage of oil or substantial drop in vacuum pressure. The supervision system will turn of the Redfox unit and will activate the alarm function. At shutdown of electricity the hydraulic connections to the transformer will automatically be blocked.

<u>The flow of fault gasses are measured!</u>
The degassing in the Redfox takes place independent of the surroundings, i.e. no air or water from outside will pass through the Redfox unit. Therefore, the moisture and the gasses removed by Redfox originate either from the transformer expansion vessel or is generated by degradation of oil and cellulose inside the transformer. There are only nitrogen, oxygen and carbon dioxide present in the air so it is thereby easy to separate the gasses arising from degradation or from expansion vessel.

The degassing of the oil is on a continuous basis. After some time when the gas content in the oil has reached a new stationary condition the gasses removed by Redfox C-Ty are collected for analysis and determination of flow. The removed amounts of gasses can then be said to correspond to the new produced gasses in the transformer, accept of those being transported into the transformer via the expansion vessel.

The result of the analysis is a far better result than if the analysis is based on oil analysis on remaining gasses or without degassing. Without degassing, the remaining gasses in the oil will vary since the exchange of gasses in the expansion vessel will vary with temperature and operation condition of the transformer.

Beside the more correct analysis, direct values on the flow of the new produced gasses are obtained. This enables a secure status control. In addition to the possibility to determine the ageing rate on oil and cellulose, the production rate of the fault gasses can be related to experience values, heads up – and alarm values recommended by Cigré and IEC. This is illustrated in the figure below in % of head-up values. Acetylene has two rods, one for communicating OLTC and one for non communicating OLTC.



Now and then one can hear the statement that continuous degassing is whipping away the gasses from the oil needed for DGA analysis. At least for Redfox degasser this is an incorrect statement. Redfox degasser is not whipping away the gasses; Redfox is only reducing the amount of dissolved gasses in the oil.

This is taking place down to about 10-20% of normal gas content without degassing. The reduction of fault gasses through Redfox follows the same physical laws as the corresponding reduction to air in the expansion vessel. An important difference is that the removal in the expansion vessel always varies with thermal and other unknown conditions whilst the removal via the Redfox is almost constant over time. The degassing will therefore improve the reliability of the analysis. This implies that a DGA – analysis bases on the removed gasses from the Redfox normally have less relative variations of measured gas values between different occasions compared to the situation without degassing. Even more false is the statement if one considers the possibility to direct measure the production rate of the fault and ageing gasses. The measurement is carried out via a collection of the removed gasses at a time when the gas content has reached a relative constant level. The production rate of the different gasses is obtained in a fast and accurate way. A fast and accurate method to receive knowledge about gas production rate is of cause a key to a secure analysis of an eventual fault in the transformer.

To sum up, one can state that continuous with Redfox enable a more accurate DGA-analysis than without Redfox. In addition with degassing follow the possibility to diagnose type and size of a fault as well.

The Redfox equipment can be combined with special gas or moisture sensors with inbuilt thresholds. There is also the possibility to install a SMS modem for attention upon increased gas content or malfunction of the equipment.