Quality Control of Gas-in-Oil Analyses using the Natural Internal Standard (NIS)

1. The limitations of the external standard

According to IEC 60567, the quality control of laboratory analyses is performed periodically using external gas-in-oil standards. IEC requirements regard the analysis accuracy of ± 15% as sufficient in order to be suitable for reliable diagnosis. The standard mentions several times that this is only valid as long as faultless samples are taken. Laboratory comparisons in practice with original oil samples confirm the significant influence of sampling. Therefore it needs to be included in quality control. This quality control can then be used consistently for laboratory techniques with integrated sampling or online techniques.

2. The introduction of the natural internal standard (NIS)

NIS means using measuring values from the original oil itself without artificial additions for quality control.
The following NIS approaches have proved to be suitable:

- comparison between calculated and measured solution pressures
- nitrogen saturation of 66,000 ppm N2 ± 8% (similar IEC 60567, Appendix D)

The “Riser Tube Experiment“ in Figure 1 shows the measurable solution pressure. The solution pressure can indeed be measured directly, continuously and with minor deviations using the new technique of the online equilibrium gas (TGM by GATRON GmbH). The general sampling requirements (oil circulation, hermetic conditions) are met. In practice, it has been possible to prove the nitrogen saturation of the vessel oil in air-breathing transformers with the help of the TGM. Deviations may be due to technological reasons (degassing/resaturation, extreme oxygen consumption).
In order to determine the diagnostic suitability, full analyses have to be used (11 individual gases, solution pressure). The comprehensive NIS approach can be developed from the online equilibrium gas because it offers alternatives to sampling and extraction with the help of the known analytic techniques. Consequently, the techniques for gas-in-oil analyses (manual or online) can be differentiated on the basis of periodical or continuous sampling as well as in terms of the three extraction techniques (Figure 2). The fundamental problem of gas-in-oil analyses becomes evident because of potentially fault-prone sampling between the gas concentrations in the original oil (c_i) and the concentrations in the extracted equilibrium gas (x_i). The gas extraction can described by the gas pressure (p) and the solubility coefficient (k_i).

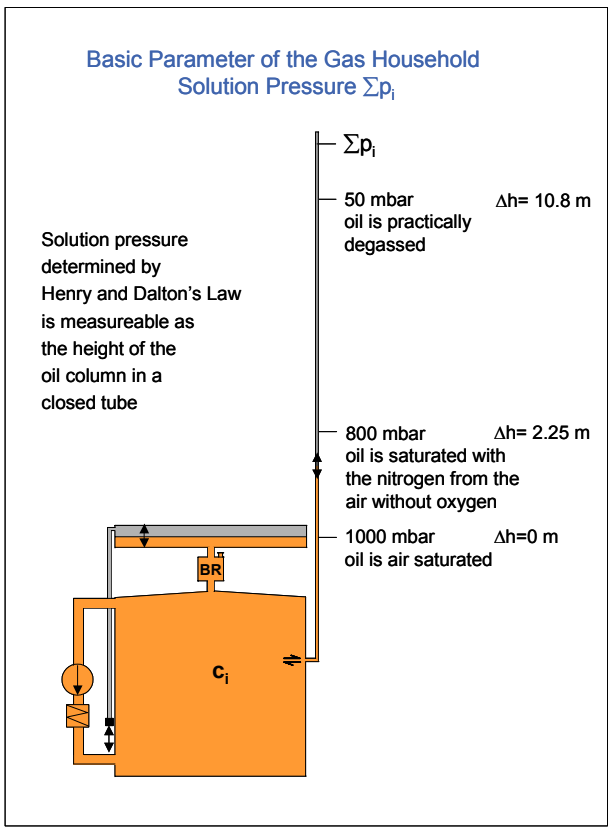

Figure 1: “Riser Tube Experiment“

The differentiating characteristic between the three extraction techniques is the ratio between the gas volume (v_G) and the oil volume (v_{oil}). This may be set using different technical means. The extracted gases are analyzed in a calibrated manner, mainly by means of gas chromatography.

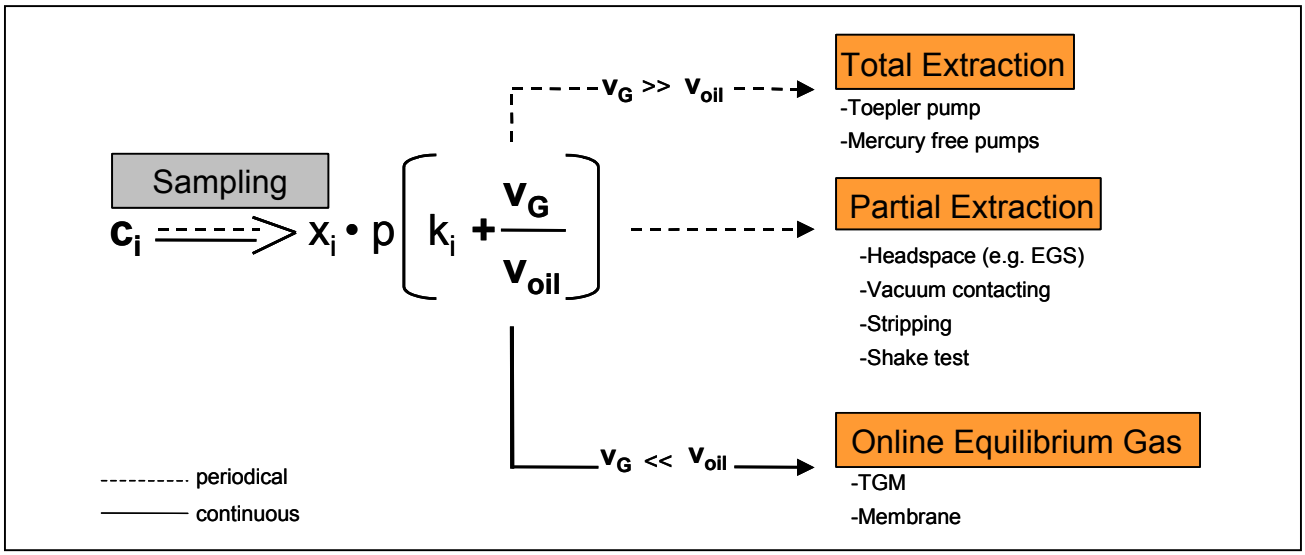

Figure 2: Sampling and extraction techniques for gas-in-oil analyses

For quality control, the following comprehensive NIS criterion may be formulated:

Full analyses with different sampling and extraction techniques only show completely identical results if these are simultaneously identical with the actual values in the original oil too.

Accuracy limits for full analyses (without sampling):
nitrogen, oxygen, solution pressure ±8% (measured solution pressure ±1%)
fault gases ±15% (analogous IEC 60567)

3. Practical application

The diagnostic suitability of results of gas-in-oil analyses can be proved by comparing a technique of total or partial extraction with a technique of the online equilibrium gas. The monitoring needs to be within the double accuracy limits for full analyses. For this, a minimum of two such techniques which are free of sampling faults must be found The successful search is shown in the extensive descriptions of the TGM and EGS procedures (Extraction Gas Sampler by GATRON GmbH) in the GATRON paper “Comparison of the accuracy of Real Gas Analyses in Oil (TGM/EGS)”. This means that NIS application has started.

For practical monitoring the following advantages are expected:

- full quality monitoring with NIS-checked analytical techniques
- diagnostic suitability can be proved at any time by application in parallel with online equilibrium gas
- declaration of original oil samples for round robin tests
- labelling of suitable analytical techniques (manual, online) with the brand name

N_2IS based ! ®

If properly applied, analytical techniques marked in this way guarantee the accuracy of the gas concentrations in the original oil which is required for reliable diagnostics. This can be proved on request.

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