

PAPER DEGRADATION

Assessing remaining transformer lifetime

WHAT?

The analysis of insulating paper degradation products in the oil enables the assessment of the ageing of the insulating winding paper. This is generally considered the criterion to estimate the ageing condition or residual life of a transformer.

WHY?

To determine the ageing condition of transformers.

To trigger asset management decisions (replacement strategy and investments) and define appropriate maintenance actions to slow paper ageing.

HOW?

The primary factors in the ageing of insulating winding paper in a transformer are the presence of oxygen and temperature and humidity. These factors cause the winding paper to gradually lose its inherent properties such as mechanical strength.

As the paper ages, it forms ageing by-products such as furans, carbon oxides, water, and methanol which partially dissolve in the insulating oil.

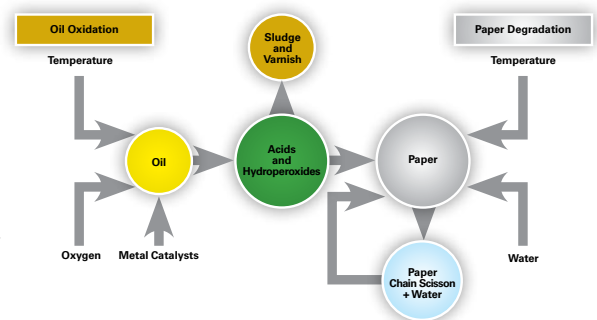
By analyzing and trending these paper-ageing by-products, the ageing condition of the paper (expressed by its degree of polymerization or DPv) can be estimated.

Laborelec uses several chromatographic analyses:

- > Determination of **furanic compounds**: through high-pressure liquid chromatography equipped with ultraviolet detector (HPLC-UV) and ultrahigh-pressure liquid chromatography coupled to a tandem quadrupole detector (UPLC-TQD)
- > Determination of **methanol content**: a headspace extraction, coupled to a gas chromatograph with a mass spectrometer detector (GC-MS)
- > **Dissolved gasses analysis (DGA)**: gas chromatograph equipped with a Thermal Conductivity Detector and Flame Ionization Detector (GC-FID/TCD)

To interpret the furan and methanol analyses accurately, we complement the above-mentioned tests with other physico-chemical analyses such as water content and degree of acidity.

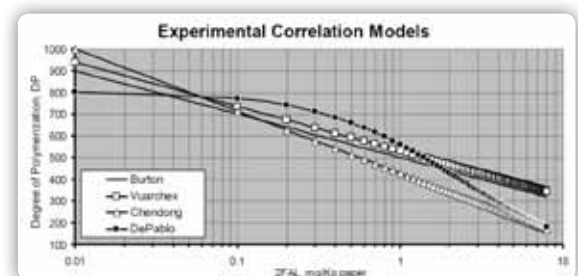
Frequency of analysis: every 12 to 48 months



DEGREE OF POLYMERIZATION

The degree of polymerization (DPv) is the number of glucose molecules in the cellulose polymer of insulating paper. The higher the DPv (or the longer the polymer length) of the insulating paper, the greater its mechanical strength.

DPv new Kraft paper after drying: DPv = ca. 1,000
 DPv end-of-life Kraft paper: DPv = ca. 250 (insufficient properties)



Several models (experimental or based on dismantling experiences) exist for correlating the concentration of 2-furfuraldehyde (2FAL) with the average DPv.

ANALYSIS	METHOD	REQUIRED OIL VOLUME
Degree of polymerization	IEC 60450	
Dissolved gasses (**)	IEC 60567/ASTM D3612	125 ml
Furans	IEC 61198	50 ml
Methanol	Laborelec method	50 ml
Neutralization index, acidity (**)	IEC 62021	25 ml
Water content	IEC 60814	25 ml



(**): Analyses performed under ISO 17025 accreditation—Measurement uncertainties available on demand