Application of Modern Diagnostic Techniques to Assess the Condition of Oil and Pressboard

A. Bouaïcha[1, 2], I. Fofana[1, 2] and M. Farzaneh[2]
[1]Canada Research Chair on Insulating Liquids and Mixed Dielectrics for Electrotechnology (ISOLIME), University of Quebec in Chicoutimi, Qc, Canada
[2]International Research Centre on Atmospheric Icing and Power Network Engineering (CenGivre), University of Quebec in Chicoutimi, Qc, Canada

***Abstract*- Aging of oil-paper insulation was investigated under controlled laboratory conditions. Traditional and modern diagnostic tools and techniques are discussed. Insulation condition testing includes common chemical diagnostics such as acidity tests and several new chemical techniques such as determination of relative content of dissolved decay products by spectrophotometry, solid suspension by turbidimetry, Fourier Transform Infrared spectroscopy, and electrical diagnostic techniques that have gained exceptional importance for utility professionals, such as polarisation/depolarisation current and frequency domain dielectric spectroscopy measurements. Based on the preliminary results, the suitability of each method analyzed along with its interpretation scheme. Finally, recommendations for further investigation are presented.**

I. Introduction

It has been established that the service reliability of power transformers largely depends on the condition of the oil-paper insulation. In today's economic climate, it is important to test the condition of the oil-impregnated paper that is mainly used as primary transformer insulation. With increasing age come higher risks of substantial monetary losses due to unexpected failures and outages. The basic objective is to obtain the longest possible service life with minimal lifetime operating costs, and to provide an optimal maintenance schedule for transformer monitoring, repair or replacement. The prime objective of the study of transformer life is to understand the ageing mechanisms in transformer insulation systems.

II.. Experimental Method

Insulation life is normally determined by measuring the time to breakdown. Real-time measurement can be very time-consuming, given that transformer insulation systems are expected to last several decades before failure occurs. Fortunately, accelerated aging procedures can be performed in the laboratory to greatly reduce the lifespan of liquid and/or solid insulation systems.

Pressboard specimens of 81 x 81 mm² were vacuum dried in an oven at 105°C for 24 hours. Samples were then impregnated with dehydrated, degasified oil for an additional 24 hours. Aging was achieved by placing the impregnated pressboard specimens in a convection oven at 100°C and heating them for different periods. The prepared specimens were aged within unsealed vessels (Fig. 1). To simulate the effects of metallic components in the transformer, metallic catalysts (3 g/l each of zinc, copper, aluminium, and iron) were introduced in a filter paper immersed in the oil. The pressboard specimens were placed in beakers containing 2 litres of oil. To simulate the breathing mechanism in free breathing power transformers, vessels were placed in a metallic container with an opening filled with silica gel to prevent external humidity from entering. The entire system was placed in the oven at 100°C. Specimens were heated for 300, 500, 1000, 1500, 2000 and 2500 hours. Electrical and chemical tests were then performed on the aged samples. For the dielectric tests, the test cell for liquid insulation type 2903 and test cell for solid insulants type 2914 manufactured by Tettex were used.

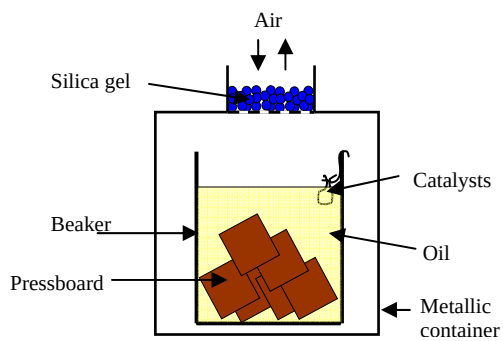

Fig. 1. Schematic representation of aging vessel system.

III. Results and Discussion

A. *Dielectric Test Results*

Dielectric spectroscopy in time or frequency domain offers new opportunities for an off-line, insulation condition assessment of electric power equipment and its predictive maintenance non-destructively and reliably in the field. Frequency Domain Spectroscopy (FDS) was developed from habitual measures such as dielectric loss factor, capacitance and conductivity measurements at power frequency [1, 2]. Polarization and dielectric behaviour under an electric field over time (Time Domain Spectroscopy, TDS) have also attracted research attention [3]. Based on dielectric response, much work has gone into developing interpretation rules to identify the causes of degradation and contamination, to separate water from the aging process [4] and to improve measurement techniques [5, 6]. Details about their basic principles can be found I the literature [1-6].

The dielectric responses in the frequency domain performed with the insulation diagnostic Analyser IDA200 gives the