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LONG-TERM STUDY OF CHANGES OF PHYSICO-CHEMICAL PARAMETERS OF TRANSFORMER OILS

SUMMARY

The average age of transformers in service is increasing and approaching the end of design life. Hence there is an increasing need to assess the condition of transformers. The utilities currently use a number of diagnostic techniques to assess the insulation condition of aged transformers. Among them physic-chemical analysis of transformer oil are frequently used.

The article presents the results of many years of routine laboratory testing of oil transformers operated in the EnergiaPro energy company. Oil testing included measurements of total acidity, water content, breakdown voltage, resistivity, tgδ.

Key words: transformer, mineral oil, liquid insulation, diagnostic, oil analysis,

1. INTRODUCTION

Transformers are one of key devices, power engineering relies heavily on, and which determine its reliability. Only their fault-free and correct operation can assure desired safety, reliability and electricity transmission costs. It should be emphasized it is directly linked with human security (uninterruptible power supply for hospitals, telecommunications systems, logistics systems) as well as industrial processes.

Main structural element determining the transformer lifetime is its electrical insulation. Power transformers are insulated with two dielectrics: transformer paper and insulating oil. [1]. Their degradation and ageing processes as continuous, condition-based events and their mutual interaction all have an impact on expected transformer lifetime under normal operating conditions [2], [3]. Normally, structural and assembly mistakes as well as unusual operating risks cause that degradation process to up its pace and consequently increase the unexpected failure rate. This disturbs technological processes at industrial facilities and regular peoples' lives (blackout etc.). Hence preventative maintenance programmes for transformers have to be in place, which reduce the failure frequency. One of most commonly used and effective measures - transformer oil testing - involves sampling transformer oil for its physicochemical properties [4]-[8]. If systematically carried out, it can detect degradation processes in early stages, thus decreasing the risk of failure. This is of particular importance to the increasing use of new types of oils, ie. vegetable oils [9]. With that in mind, this paper presents results of long-term diagnostic examinations monitoring changes in physicochemical properties of transformer oil.

2. RESULTS OF LONG-TERM LABORATORY TESTS

Transformers have been inspected on a regular basis for many years. Their power capacity ranges between 10 MVA to 40 MVA and they were first launched into the market during sixties last century. Figures 1 to 10 show results of systematic transformer oil diagnostics. The data comes from 5 transformers of 40 MVA power capacity and 6 transformers of 16 MVA power capacity. 40 MVA transformers were aged 21-32, whilst 16 MVA transformers were 21-45 years old. The results presented pertain to water content, tgδ, total acidity number, resistivity and breakdown voltage monitored over the last 19 years.

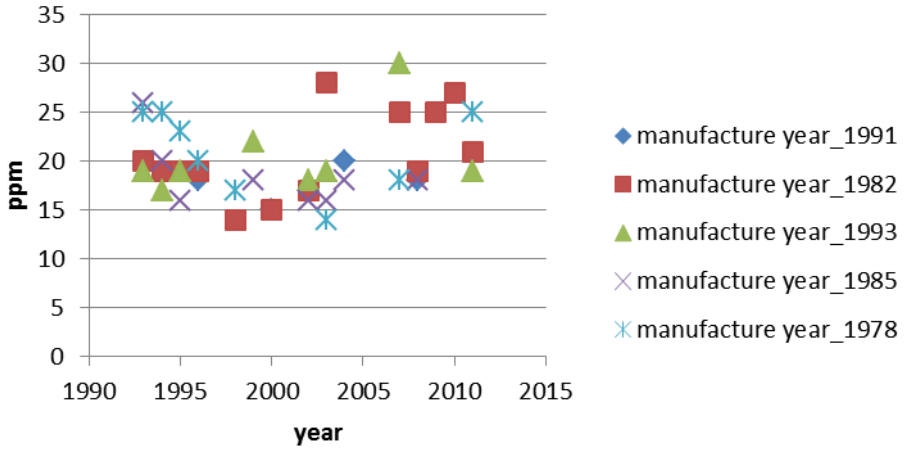

Figure 1 – Water content in oil samples measured for tested 40 MVA transformers

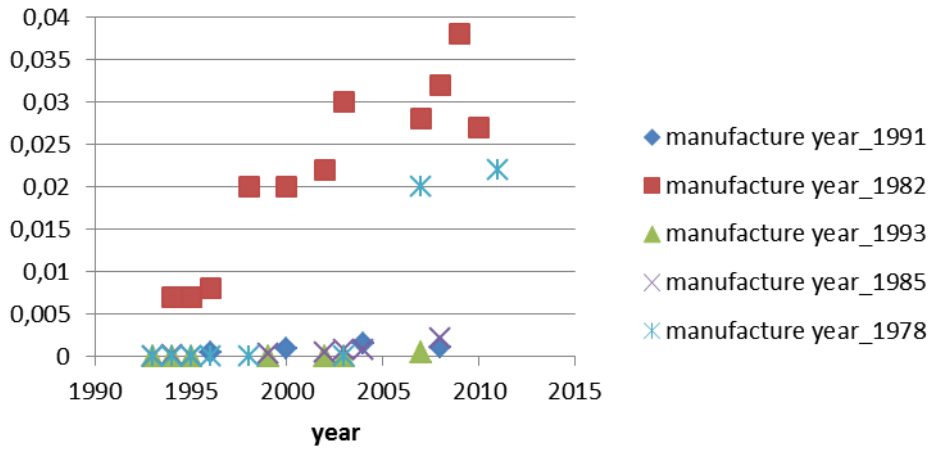

Figure 2 – Loss factor of oil samples measured for tested 40 MVA transformers

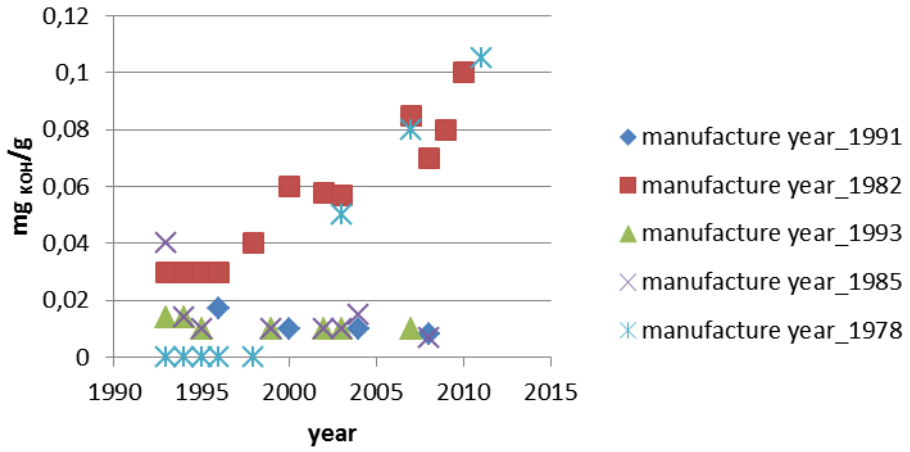

Figure 3 – Total acidity of oil samples measured for tested 40 MVA transformers

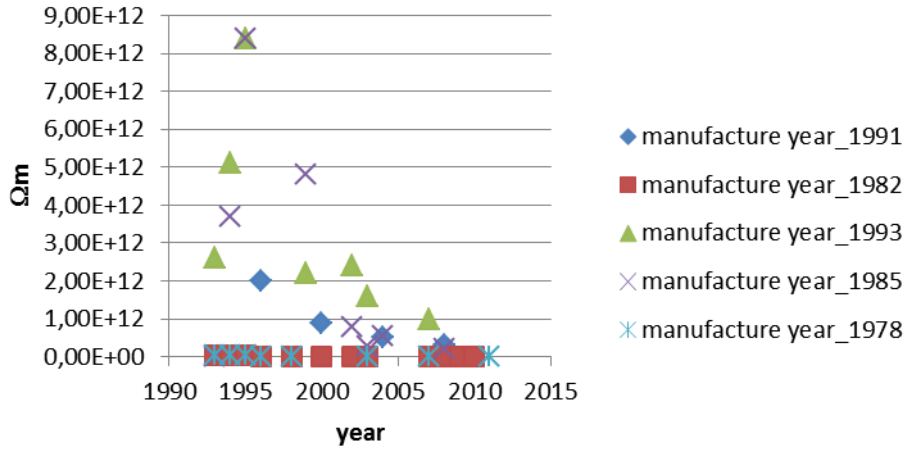

Figure 4 – Resitivity of oil samples measured for tested 40 MVA transformers

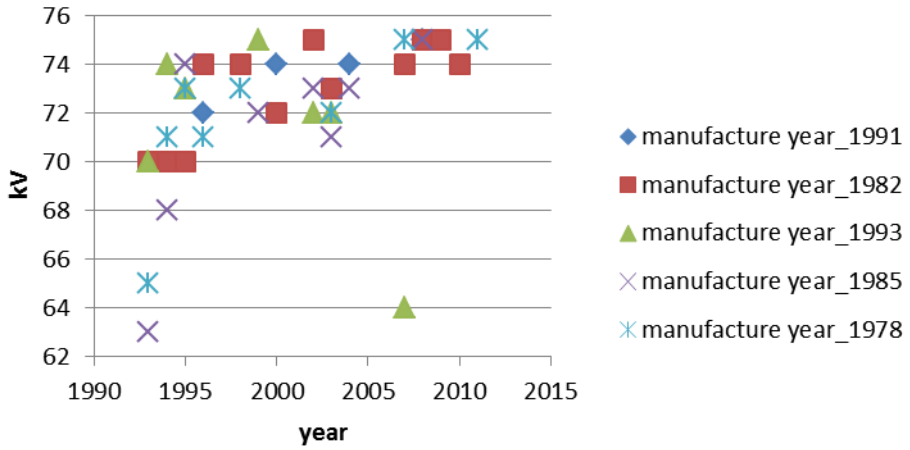

Figure 5 – Breakdown voltage of oil samples measured for tested 40 MVA transformers

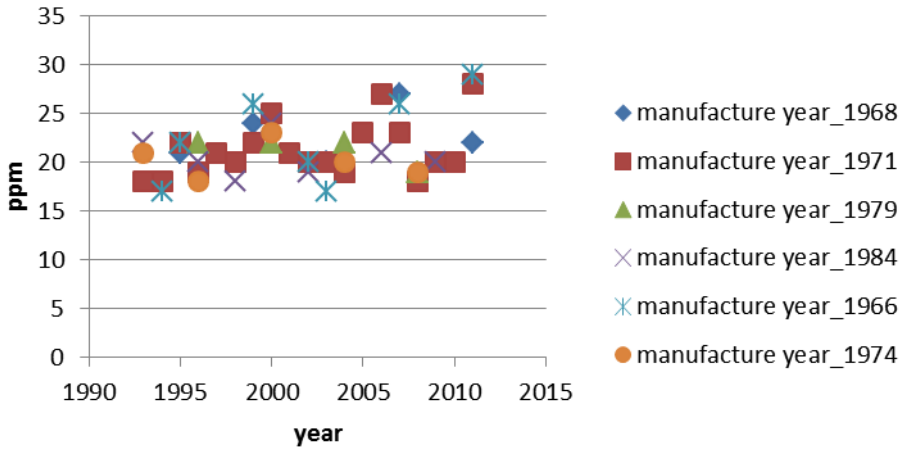

Figure 6 – Water content in oil samples measured for tested 16 MVA transformers

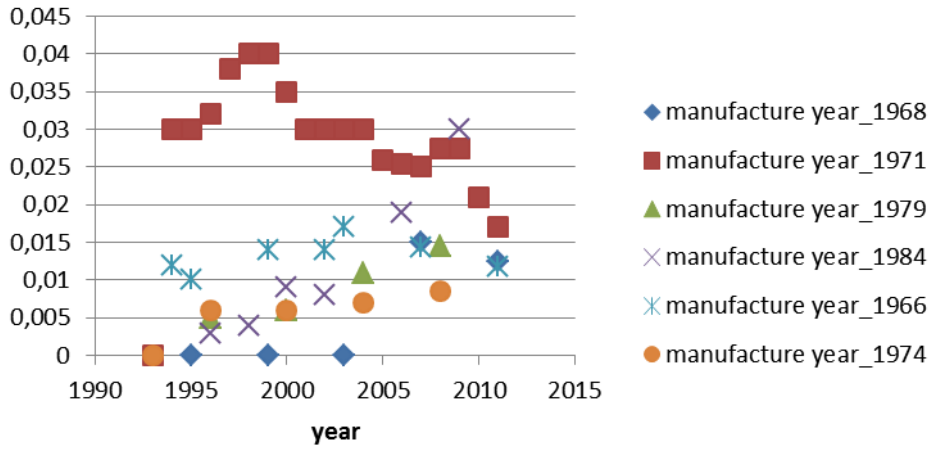

Figure 7 – Loss factor of oil samples measured for tested 16 MVA transformers

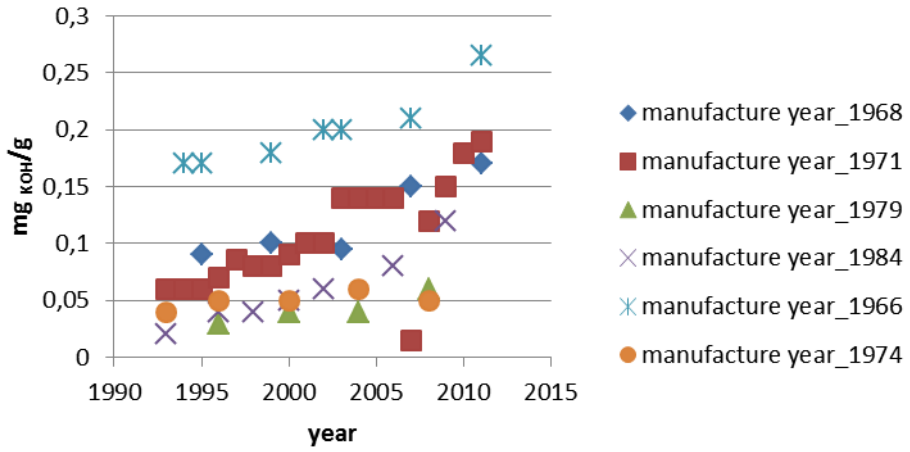

Figure 8 – Total acidity of oil samples measured for tested 16 MVA transformers

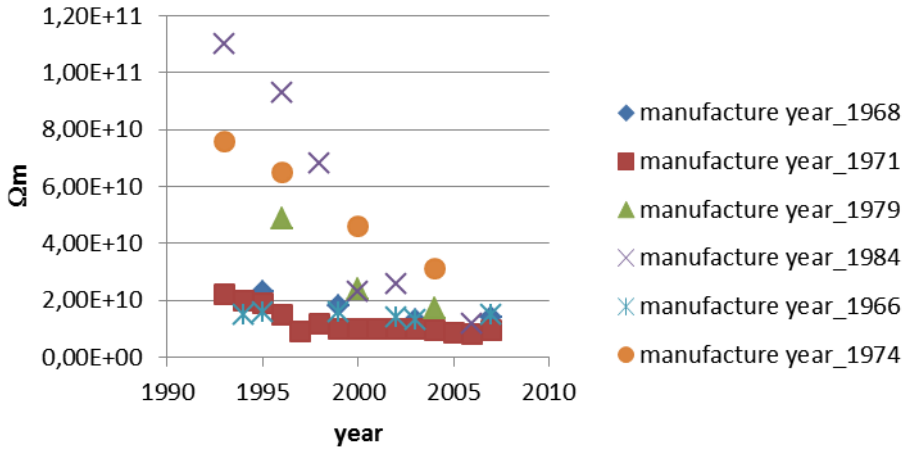

Figure 9 – Resistivity of oil samples measured for tested 16 MVA transformers

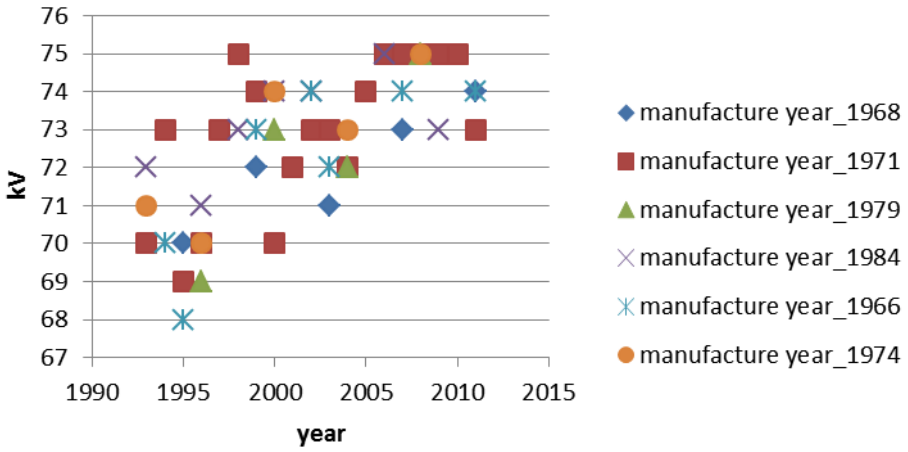

Figure 10 – Breakdown voltage of oil samples measured for tested 16 MVA transformers

Diagnostics is performed according to internal requirements. Transformer oil is considered as meeting the technical requirements, if the water content is less than 40 ppm, measured dielectric loss factor at 50 Hz and at 50 ^{0}C is less than 0.10, the acid value of less than 0.4 mg_{KOH} / g, the resistivity measured at 50 ^{0}C is not less than 2 GΩm a breakdown voltage is not less than 40 KV. If one of the measured parameters is close to acceptable values limits suggests a generally increased frequency of diagnosis. Generally speaking, the systematic sampling of oil from transformers and supervised determining their physico-chemical parameters is a method for early detection of hazardous initiate aging processes and the associated prevent the introduction of failure.

4. CONCLUSION

Although tests showed all physicochemical parameters of transformer oil normal, some tendencies were observed, which diverge within the same transformer groups. It was noted, that those changes have different characteristics within both transformer groups and cross-group correlations between parameters are different as well. Hence that data is inconclusive. No generalisations could be made. Nonetheless, a vast database storing changes in physicochemical properties of transformer oil monitored for many years can become a mine of knowledge for individuals dealing with transformer diagnostics and evaluation of their lifetime.

5. REFERENCES

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