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Guidance on the interpretation of carbon dioxide and 2-furfuraldehyde as markers of paper thermal degradation in insulating mineral oil

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A list of organizations represented on this committee can be obtained on request to its secretary.

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TECHNICAL REPORT

Guidance on the interpretation of carbon dioxide and 2-furfuraldehyde as markers of paper thermal degradation in insulating mineral oil

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GUIDANCE ON THE INTERPRETATION OF CARBON DIOXIDE AND 2-FURFURALDEHYDE AS MARKERS OF PAPER THERMAL DEGRADATION IN INSULATING MINERAL OIL

FOREWORD

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IEC TR 62874, which is a Technical Report, has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

The text of this standard is based on the following documents:

Enquiry draft	Report on voting
10/903/DTR	10/917A/RVC

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

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This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The cellulosic solid insulation of transformers and other electrical apparatus is subject to thermal degradation during their operational lifetime. This results in a progressive loss of paper's mechanical properties, such as tensile strength, which are related to the duration of the technical life of the equipment [3,4] [1].

During its thermal degradation process (also called "ageing" in this Technical Report), cellulose forms several by-products, some of which may be detected by means of insulating oil's chemical analysis [1,2]. The concentration and rate of increase of those by-products can be used as a tool to estimate the progress of paper thermal degradation in transformers and other electrical apparata in service.

For this reason, IEC technical committee 10 has prepared this Technical Report for the monitoring of insulating oil parameters related to cellulose ageing and the interpretation of results, as a guidance to the thermal degradation evaluation of insulating paper.

This Technical Report is based on the evaluation of cellulose ageing by-products content in insulating oil, and their rate of formation during the life of the oil-immersed electrical equipment. Statistical reference values reported in Annex A of this Technical Report are based on data collected by TC10. The final report of CIGRE WG D1.01.TF13 [7] was taken as a source of information concerning mechanisms and parameters influencing the formation of furanic compounds.

NOTE Methods for the estimation of actual degree of polymerization (DP) values of paper, which are widely available in literature, were not applied within this Technical Report. This is due to the fact that a number of different models have been developed and reported, and they often lead to different results. Moreover, the applicability of those models has not been sufficiently proven by comparison with field experience to be included into an IEC standard.

Health and safety

This Technical Report does not purport to address all the safety problems associated with its use. It is the responsibility of the user of the Technical Report to establish appropriate health and safety practices and determine the applicability of regulatory limitations prior to use.

The mineral oils which are the subject of this Technical Report should be handled with due regard to personal safety and hygiene. Direct contact with eyes may cause slight irritation. In the case of eye contact, irrigation with copious quantities of clean running water should be carried out and medical advice sought.

Some of the tests specified in this Technical Report involve the use of processes that could lead to a hazardous situation. Attention is drawn to the relevant standard for guidance.

Environment

This Technical Report involves mineral oils, chemicals and used sample containers. The disposal of these items should be carried out in accordance with current national legislation with regard to the impact on the environment. Every precaution should be taken to prevent the release into the environment of mineral oil.

[1] Figures in square brackets refer to the Bibliography

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GUIDANCE ON THE INTERPRETATION OF CARBON DIOXIDE AND 2-FURFURALDEHYDE AS MARKERS OF PAPER THERMAL DEGRADATION IN INSULATING MINERAL OIL

1 Scope

IEC TR 62874, which is a Technical Report provides guidance for the estimation of consumed thermal life of transformers' cellulosic insulators, through the analysis of some compound dissolved in the insulating mineral oil. A comparison between analytical results of 2-furfural (2-FAL) and carbon oxides and their correspondent typical values estimated for different families of equipment gives information on the estimated thermal degradation of papers.

The ageing rate of insulating papers can be evaluated, in short time ranges (e.g. 1 year), by regularly monitoring 2-FAL and carbon oxides content in the oil and by comparing them to typical rates of increase.

A statistical approach for the estimation of paper thermal degradation, and the evaluation of ageing rate is given.

Typical values for concentrations and rates of increase of the parameters related to paper ageing were extrapolated from a statistical database collected, and are reported in Annex A. They may be used as a rough guide, but they should not be considered as threshold values.

This Technical Report is only applicable to transformers and reactors filled with insulating mineral oils and insulated with Kraft paper. The approaches and procedures specified should be taken as a practical guidance to investigate the thermal degradation of cellulosic insulation, and not as an algorithm to calculate the actual degree of polymerization (DP) of papers.

The paper thermal life evaluation protocol described in this Technical Report applies to mineral oil impregnated transformers and reactors, insulated with Kraft paper. Any equipment filled with insulating liquids other than mineral oil (i.e. esters, silicones) or insulated with solid materials other than Kraft paper (i.e. TUP – thermally upgraded Kraft paper, synthetic polymers) is outside of the scope of this Technical Report.

This Technical Report is applicable to equipment that has been submitted to a regular monitoring practice during the service, and for which maintenance and fault history is known.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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