SLOVENSKI STANDARD
SIST HD 397 S1:1998

01-februar-1998

Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service (IEC 60599:1978)

Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service

Interpretation der Analyse von Gasen von in Betrieb befindlichen Transformatoren und anderen ölgefüllten elektrischen Betriebsmitteln

Interprétation de l'analyse des gaz dans les transformateurs et autres matériels électriques rempllis d'huile, en service

Ta slovenski standard je istoveten z: **HD 397 S1:1979**

ICS:

29.040.10	Izolacijska olja	Insulating oils

SIST HD 397 S1:1998 **en**

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INFORMATION SHEET

HD 397 S1

Issue 3 1988-01-20

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RD: IEC 599 (1978) ed 1; IEC/SC 10A (not appended)

The Harmonization Document consists of the following :

- Title Page

Related to Directive: -

date of ratification	:	1979-09-27
date of announcement	:	
date of latest publication	:	1980-07-01
date of withdrawal	:	

List of national deviations

LIST OF NATIONAL STANDARDS IS GIVEN OVERLEAF

AT :

BE : NOS

CH : SEV/ASE 3431.1980

DE : SP (DIN VDE 0370 Teil 7/10.82)

DK : NOS

ES : UNE 21 320 XXIX

FI :

FR : NR (CEI 599)

GB : BS 5800 : 1979

GR :

IE :

IT : CEI 10-10 (1983)

LU :

NL :

NO : NEN 36.74B

PT :

SE : NOS

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

NORME DE LA CEI

INTERNATIONAL ELECTROTECHNICAL COMMISSION

IEC STANDARD

Publication 599

Première édition — First edition

1978

Interprétation de l'analyse des gaz dans les transformateurs et autres matériels électriques remplis d'huile, en service

Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERPRETATION OF THE ANALYSIS OF GASES IN TRANSFORMERS AND OTHER OIL-FILLED ELECTRICAL EQUIPMENT IN SERVICE

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 10A, Hydrocarbon Insulating Oils, of IEC Technical Committee No. 10, Liquid and Gaseous Dielectrics.

The drafts were discussed at the meetings held in Baden-Baden in 1975 and in Moscow in 1977. As a result of this latter meeting, a draft, Document 10A(Central Office)37, was submitted to the National Committees for approval under the Six Months' Rule in November 1977.

The following countries voted explicitly in favour of publication:

Australia	Netherlands
Austria	Norway
Belgium	Poland
Canada	South Africa (Republic of)
Czechoslovakia	Spain
Denmark	Sweden
France	Switzerland
Germany	Turkey
Hungary	United Kingdom
Ireland	United States of America
Italy	Yugoslavia

Other IEC publication quoted in this standard:

Publication No. 567: Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment and for the Analysis of Free and Dissolved Gases.

INTERPRETATION OF THE ANALYSIS OF GASES IN TRANSFORMERS AND OTHER OIL-FILLED ELECTRICAL EQUIPMENT IN SERVICE

1. *Introduction*

This standard is the result of a survey carried out jointly by the IEC and the CIGRE in order to compare available methods of interpretation of gas in oil analysis. One hundred examples were collected of faulty transformers for which the actual fault had been identified by internal examination and the gas dissolved in oil and sometimes the Buchholz gas, had been analyzed. The diagnostic methods given in this standard were applied. All these methods of interpretation appear to be capable of discriminating reliably between electrical faults and thermal faults. Exceptions were rare and they perhaps reflect occasional misjudgement rather than the inadequacy of the methods.

2. Scope

Electrical discharges or thermal stresses in the oil or solid insulation, for example, paper pressboard etc, of an oil-filled transformer cause degradation of these materials with the formation of gases of various types. To some extent these gases dissolve in the oil, but using techniques described in IEC Publication 567, Guide for the Sampling of Gases and of Oil from Oil-filled Electrical Equipment and for the Analysis of Free and Dissolved Gases, they may be removed from a sample of the oil and analyzed quantitatively by gas chromatography. This standard describes how the concentrations of dissolved gases or of free gases may be interpreted to diagnose the condition of a transformer in service and suggest future action.

The methods of interpretation have been developed for power transformers wound with copper conductors, insulated with cellulosic paper or pressboard-based solid insulation and filled with hydrocarbon mineral oil, in service on power networks; until further experience has been gained, the methods should be applied with caution in relation to other materials. The methods may also apply in principle to instrument transformers, oil-filled cables, switchgear, etc., but insufficient experience is available to formulate suitable interpretation and limits.

In any case, the indication obtained must be viewed only as a guide; any resulting action must be undertaken with proper engineering judgement.

3. Recommended basic method for interpreting gas analysis

3.1 *Gases generated from oil*

The basic diagnosis is founded upon the types and relative quantities of gases generated by decomposition of oil under various fault conditions: it will be appreciated that oil, either alone or as an impregnant, is present practically everywhere that a fault can arise in a large oil-filled transformer. The most significant gases generated by decomposition of oil are hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), and acetylene (C_2H_2).

Note. — The hydrocarbons quoted above are by no means the only ones generated; for example, C_3 hydrocarbons and C_4 hydrocarbons, are also formed; but experience to date has shown that a satisfactory diagnosis can be made without taking account of these gases, and in the interests of simplicity they have been omitted from the method of interpretation described below.

Where cellulosic materials are involved at a fault, further gases, chiefly carbon dioxide (CO_2) and carbon monoxide (CO) are also generated but the information obtained from concentrations of these is supplementary to the basic diagnosis, as explained in Clause 4.

The relative quantities of the above gases vary in ways characteristic of how the energy available to decompose the oil is released at the fault and hence in ways characteristic of the type of fault, if a fault is present.

Partial discharges occur in case of fault of low-level energy (breakdown in gas-filled voids surrounded by oil or oil-impregnated material); the main cause of decomposition in this case is ionic bombardment of the oil molecules and the major gas produced is hydrogen. In other cases, decomposition of oil is mainly caused by heat, with variations in the types of hydrocarbons produced as the temperature rises. Thus a little decomposition occurs at normal operating temperatures, producing mainly hydrogen and methane. Higher temperatures and higher energies are caused by hot-spots or conductor overheating: temperatures from a little above normal operating temperatures (say, 150 °C) to as high as 1 000 °C may occur in such cases to decompose the oil. The principal gas produced by low temperature hot-spots is CH_4, but as the fault temperature rise, C_2H_6 and C_2H_4 appear in increasing quantities. In the much higher temperatures occurring at sparking, flashovers, or in power arcing where temperatures of over 3 000 °C may be produced, C_2H_2 becomes significant. The recommended method of codifying these changing concentrations to enable ready diagnosis of a fault is given in Sub-clause 3.3.

Note. — The techniques described apply only where there is a single or a predominant type of fault present; where there are two or more types of fault each producing considerable quantities of gas, additional information by extended periods of observation may be required.

3.2 *Levels at which dissolved gases are significant*

Before proceeding with any diagnosis method it is necessary to be satisfied that the measured gas concentrations are significant. There are two questions to be answered:

1) Are the measured values well above the sensitivity of the analysis methods and equipment?

2) If they are, are the gas concentrations high enough to warrant further investigation as to whether there may be a fault in the transformer?

The answer to the first question depends on the analysis method and equipment. IEC Publication 567 sets requirements for the sensitivity of the analysis. Before considering that any gas is present in significant quantity, its concentration should be at least ten times these sensitivity limits.

The answer to the second question relates to the likelihood of a gas being present in a transformer due to normal operating conditions, without any fault being present. Even in a new or newly reimpregnated transformer, gases may be present in quantities sufficient to be misleading; sources of these gases may be:

— gases formed during the refining processes and not completely removed by oil degassing;

— gases formed during drying and impregnating the transformer in the factory;

— gases formed on the occasion of previous faults and not completely removed from the oil-impregnated insulation before being refilled with degassed oil;

— gases formed during repairs by brazing, welding, etc.