

Guide for

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

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- British Radio Equipment Manufacturers' Association
- British Steel Corporation
- Department of Energy (Electricity)
- Electric Cable Makers' Confederation*
- Electrical Contractors' Association
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- Electrical Research Association*
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- Electronic Engineering Association
- Engineering Equipment Users' Association
- Health and Safety Executive
- Home Office
- Institution of Electrical Engineers
- Ministry of Defence
- National Coal Board
- Oil Companies Materials Association
- Post Office

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- British Railways Board
- British Lubricants Federation Limited
- Electric Cable Makers Confederation — Supertension Cables Group
- Institute of Petroleum
- The Transmission and Distribution Association (BEAMA)

This British Standard, having been prepared under the direction of the General Electrotechnical Engineering Standards Committee, was published under the authority of the Executive Board and comes into effect on 31 October 1979

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National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Engineering Standards Committee. It is identical with IEC 599 “*Interpretation of the analysis of gases in transformers and other oil-filled electrical equipment in service*” published by the International Electrotechnical Commission (IEC).

Terminology and conventions. The text of the international standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards.

Cross-references

International standard	Corresponding British Standard
IEC 567:1977	BS 5574:1978 Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free dissolved gases (Identical)

NOTE *Textual error.* In the titles of 4.1 and 4.2 the symbols for carbon dioxide and carbon monoxide should be read as if printed in upright type.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Introduction

This standard is the result of a survey carried out jointly by the IEC and the CIGRÉ 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.