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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Oil-filled electrical equipment – Sampling of gases and analysis of free and dissolved gases – Guidance

Matériels électriques immergés – Échantillonnage de gaz et analyse des gaz libres et dissous – Lignes directrices

IEC 60567:2011

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

OIL-FILLED ELECTRICAL EQUIPMENT – SAMPLING OF GASES AND ANALYSIS OF FREE AND DISSOLVED GASES – GUIDANCE

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60567 has been prepared by IEC technical committee 10: Fluids for electrotechnical applications.

This fourth edition cancels and replaces the third edition, published in 2005, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

Since the publication of the third edition, CIGRE TF.D1.01.15 has made progress in several areas of dissolved gas analysis (DGA), notably

a) oil sampling,
b) laboratory analysis and solubility coefficients of gases in non-mineral oils,
c) calibration of the headspace gas extraction method,

d) more sensitive detectors for chromatography,

e) preparation of air-saturated standards and

f) evaluation of gas monitor readings.

These advances are included in this fourth edition.

Sampling of oil for DGA from oil-filled equipment has been moved from IEC 60567 to IEC 60475 as reflected in the revised title of this standard.

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

FDIS	Report on voting
10/849/FDIS	10/872/RVD

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

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 web site 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.

INTRODUCTION

Gases may be formed in oil-filled electrical equipment due to natural ageing but also, to a much greater extent, as a result of faults.

Operation with a fault may seriously damage the equipment, and it is valuable to be able to detect the fault at an early stage of development.

Where a fault is not severe, the gases formed will normally dissolve in the oil, with a small proportion eventually diffusing from the liquid into any gas phase above it. Extracting dissolved gas from a sample of the oil and determining the amount and composition of this gas is a means of detecting such faults, and the type and severity of any fault may often be inferred from the composition of the gas and the rate at which it is formed.

In the case of a sufficiently severe fault, free gas will pass through the oil and collect in the gas-collecting (Buchholz) relay if fitted; if necessary, this gas may be analysed to assist in determining the type of fault that has generated it. The composition of gases within the bubbles changes as they move through the oil towards the gas-collecting relay.

This can be put to good use, as information on the rate of gas production may often be inferred by comparing the composition of the free gases collected with the concentrations remaining dissolved in the liquid.

The interpretation of the gas analyses is the subject of IEC 60599.

These techniques are valuable at all stages in the life of oil-filled equipment. During acceptance tests on transformers in the factory, comparison of gas-in-oil analyses before, during and after a heat run test can show if any hot-spots are present, and similarly analysis after dielectric testing can add to information regarding the presence of partial discharges or sparking. During operation in the field, the periodic removal of an oil sample and analysis of the gas content serve to monitor the condition of transformers and other oil-filled equipment.

The importance of these techniques has led to the preparation of this standard, to the procedures to be used for the sampling, from oil-filled electrical equipment, of gases and oils containing gases, and for subsequent analysis.

NOTE Methods described in this standard apply to insulating oils, since experience to date has been almost entirely with such oils. The methods may also be applied to other insulating liquids, in some cases with modifications.

General caution, health, safety and environmental protection

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

The insulating oils which are the subject of this standard should be handled with due regard to personal hygiene. Direct contact with the eyes may cause 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 standard involve the use of processes that could lead to a hazardous situation. Attention is drawn to the relevant standard for guidance.

Mercury presents an environmental and health hazard. Any spillage should immediately be removed and be properly disposed of. Consult local regulations for mercury use and handling. Mercury-free methods may be requested in some countries.

Environment

This standard is applicable to insulating oils, chemicals and used sample containers.

Attention is drawn to the fact that, at the time of writing of this standard, many insulating oils in service are known to be contaminated to some degree by PCBs. If this is the case, safety countermeasures should be taken to avoid risks to workers, the public and the environment during the life of the equipment, by strictly controlling spills and emissions. Disposal or decontamination of these oils should be carried out strictly according to local regulations. Every precaution should be taken to prevent release of insulating oil into the environment.

OIL-FILLED ELECTRICAL EQUIPMENT – SAMPLING OF GASES AND ANALYSIS OF FREE AND DISSOLVED GASES – GUIDANCE

1 Scope

This International Standard deals with the techniques for sampling free gases from gas-collecting relays from power transformers. Three methods of sampling free gases are described.

The techniques for sampling oil from oil-filled equipment such as power and instrument transformers, reactors, bushings, oil-filled cables and oil-filled tank-type capacitors are no longer covered by this standard, but are instead described in 4.2 of IEC 60475:2011.

Before analysing the gases dissolved in oil, they are first extracted from the oil. Three basic methods are described, one using extraction by vacuum (Toepler and partial degassing), another by displacement of the dissolved gases by bubbling the carrier gas through the oil sample (stripping) and the last one by partition of gases between the oil sample and a small volume of the carrier gas (headspace). The gases are analysed quantitatively after extraction by gas chromatography; a method of analysis is described. Free gases from gas-collecting relays are analysed without preliminary treatment.

The preferred method for assuring the performance of the gas extraction and analysis equipment, considered together as a single system, is to degas samples of oil prepared in the laboratory and containing known concentrations of gases ("gas-in-oil standards") and quantitatively analyse the gases extracted. Two methods of preparing gas-in-oil standards are described.

For daily calibration checks of the chromatograph, it is convenient to use a standard gas mixture containing a suitable known amount of each of the gas components to be in a similar ratio to the common ratios of the gases extracted from transformer oils.

The techniques described take account, on the one hand, of the problems peculiar to analyses associated with acceptance testing in the factory, where gas contents of oil are generally very low and, on the other hand, of the problems imposed by monitoring equipment in the field, where transport of samples may be by un-pressurized air freight and where considerable differences in ambient temperature may exist between the plant and the examining laboratory.

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.

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60475:2011, *Method of sampling insulating liquids*

IEC 60599, *Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis*

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

ASTM D2780, *Standard Test Method for Solubility of Fixed Gases in Liquids*

3 Sampling of gases from gas-collecting (Buchholz) relays

3.1 General remarks

It is important to bear in mind that receiving a qualitative and a representative sample is crucial for obtaining a reliable diagnosis of the electrical equipment. Even the most sophisticated extraction or diagnosis methods cannot overcome faulty samples.

Gas samples from relays should be taken from the equipment with the minimum delay after gas accumulation has been signalled. Changes in composition caused by the selective re-absorption of components may occur if free gases are left in contact with oil.

Certain precautions are necessary when taking gas samples. The connection between the sampling device and the sampling vessel shall avoid the ingress of air. Temporary connections should be as short as possible. Any rubber or plastic tubing used should have been proved to be impermeable to gases.

Gas samples should be properly labelled (see Clause 4) and analysed without undue delay to minimize hydrogen loss (for example, within a maximum period of one week).

Oxygen, if present in the gas, may react with any oil drawn out with the sample. Reaction is delayed by excluding light from the sample, for example, by wrapping the vessel in aluminium foil or suitable opaque material.

Of the three methods described below, the syringe method is recommended. The other two methods are alternatives to be used exclusively in case of serious hindrance.

Sampling into a sampling tube by liquid displacement using transformer oil as a sealing liquid is simple, but the different solubilities of the gas components may need to be taken into account if the gas quantity is such that some oil remains in the tube.

The vacuum method requires skill to avoid contaminating the sample by leakage of air into the system. It is particularly true where the gas to be sampled may be at less than atmospheric pressure (for example, some sealed transformers).

3.2 Sampling of free gases by syringe

3.2.1 Sampling equipment

NOTE Figures in brackets refer to those circled numbers in the relevant figure.

See Figure 1. The equipment shall be as follows:

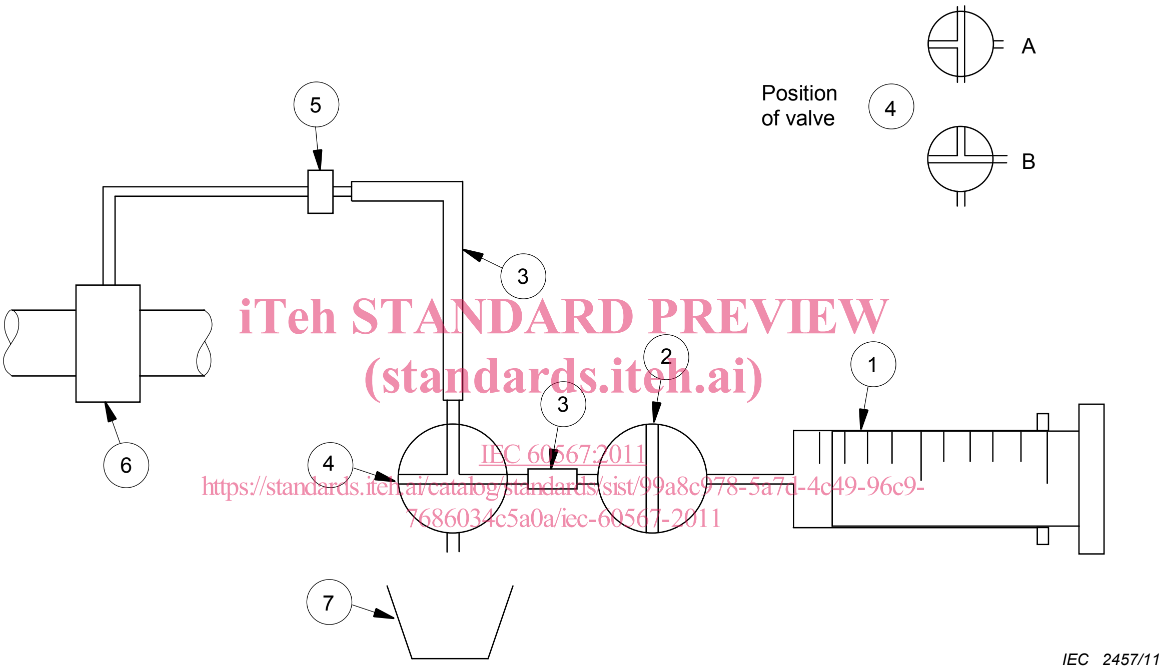
a) Impermeable oil-resistant plastic or rubber tubing (3) provided with a connecter to fit onto a suitable sampling connection of the gas-collecting relay. To avoid cross-contamination, the tubing should be used only once.

b) Gas-tight syringes of suitable volume (1) (25 ml to 250 ml). Medical or veterinary quality glass syringes with ground-in plungers may be suitable; alternatively, syringes with oil-proof seals may be used. The syringe should be fitted with a cock enabling it to be sealed. It is often convenient to use the same syringes for both gas sampling and for oil sampling (see 4.2.2 of IEC 60475:2011).

The gas tightness of a syringe may be tested by storing an oil sample containing a measurable quantity of hydrogen for at least two weeks and analysing aliquots for hydrogen at the beginning and end of the period. An acceptable syringe will permit losses of hydrogen of less than 2,5 % per week. General experience suggests that all-glass syringes leak less than those using plastic seals. Improvement of the gas tightness may be obtained by the use of a lubricant such as a light grease or transformer oil.

It is a good practice to test the integrity of syringes and valve system before the sampling. A recommended procedure appears in Annex B of IEC 60475:2011.

c) Transport containers should be designed to hold the syringe firmly in place during transport, but allow the syringe plunger freedom to move, and prevent its tip from contacting the container, whatever its position during transportation.



Key

1	syringe	5	equipment sampling valve
2	stopcock	6	gas-collecting relay valve
3	rubber connecting tubing	7	waste vessel
4	three-way valve		

Figure 1 – Sampling of gas by syringe

3.2.2 Sampling procedure

The apparatus is connected as shown in Figure 1. The connections should be as short as possible and filled with oil at the start of sampling.

The sampling valve (5) is opened. If sampling from a gas-collecting relay on a transformer fitted with a conservator, a positive pressure will exist; the three-way valve (4) is carefully turned to position A and the oil in the connecting tubing (3) allowed to flow to waste (7). When gas reaches the three-way valve (4), the latter is turned to position B to connect the pre-lubricated syringe (1). The stopcock (2) is then opened and the syringe allowed to fill under the hydrostatic pressure, taking care that its plunger is not expelled. When a sufficient sample has been taken, the stopcock (2) and sampling valve (5) are closed and the apparatus is disconnected.

The oil in the syringe is expelled by inverting the syringe and applying gentle pressure to the plunger.

Label carefully the sample (see Clause 4).

3.3 Sampling of free gases by displacement of oil

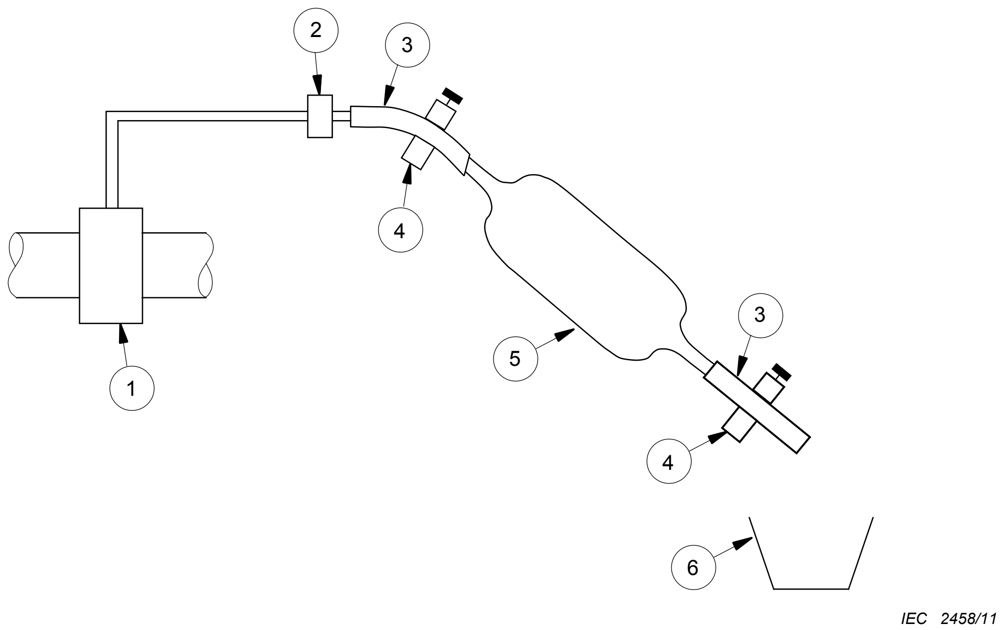
This method is reliable only where the gas sample is at or above atmospheric pressure. The apparatus is shown in Figure 2.

The sampling tube (5), typically of 100 ml capacity, is preferably of glass since the operator can then see how much oil remains in it during gas sampling. The sampling tube is filled with oil from the transformer on site. Before being used as described below, the connecting tube (3) should also be filled with oil.

The open end of the connecting tube (3) is fitted onto the gas-sampling valve (2). The sampling valve and inlet stopcock of the sampling tube are opened. The sampling tube is inclined so that its closed end is the lowest point. The outlet stopcock on the sampling tube is then opened, allowing oil to run out to waste (6), drawing first any oil from the connection between relay and sampling valve, and the gas from the relay, into the sampling tube.

Sampling is complete when the gas-collecting relay is completely filled with oil or when nearly all oil has gone from the sampling tube.

Both stopcocks (4) on the sampling tube and the sampling valve (2) are closed and then the connections removed.



Key

1	gas collecting relay valve	4	stopcock
2	equipment sampling valve	5	sampling tube
3	oil-resistant connecting tubing	6	waste vessel

Figure 2 – Sampling of free gases by oil displacement

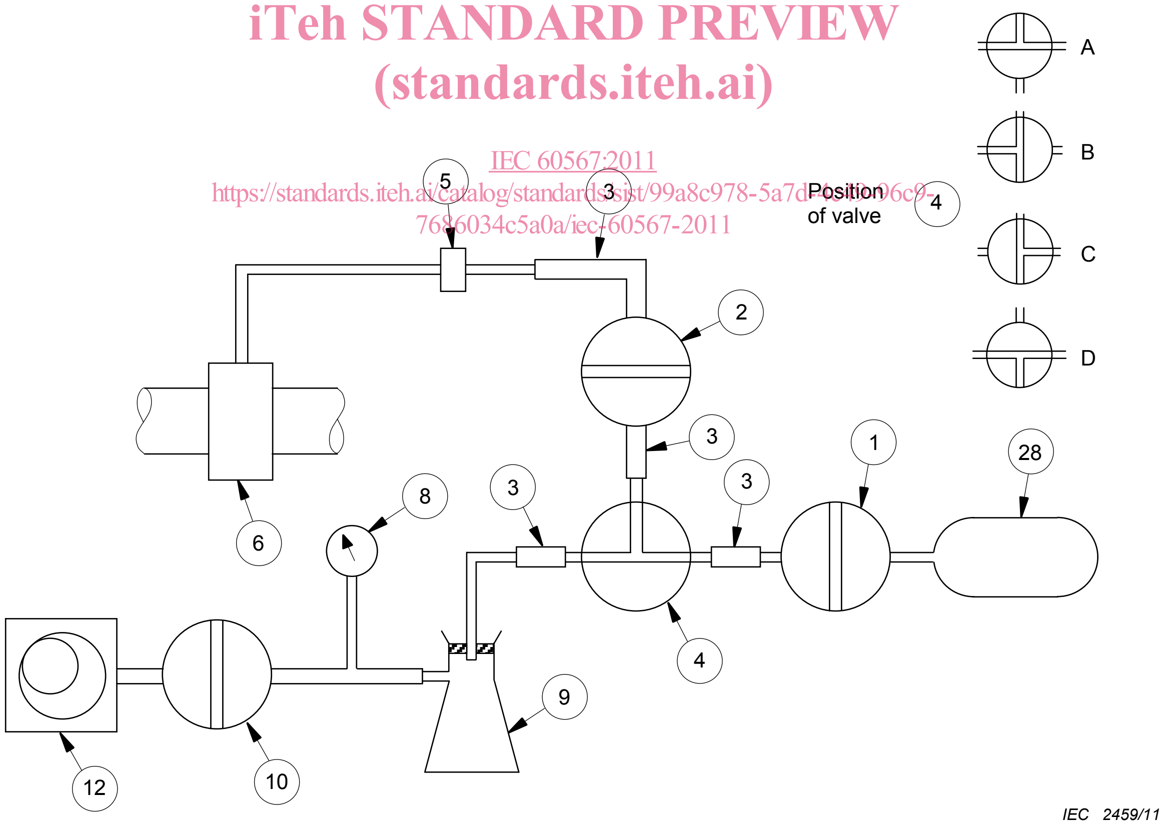
3.4 Sampling of free gases by vacuum

The apparatus is connected as shown in Figure 3. With the equipment sampling valve closed, stopcocks (1), (2) and (10) open, and the three-way valve (4) turned to position A, the vacuum pump (12) is allowed to evacuate the connecting tubing, the trap and the sampling vessel.

A satisfactory vacuum will be below 100 Pa. The system should be checked for leaks by closing the pump suction stopcock (10) and observing that no appreciable change in vacuum occurs. Over a time equal to that which will be taken for sampling, the pressure should not increase by more than 100 Pa. Similarly, the stopcock (1) on the sampling tube should be vacuum tight to the same degree over several weeks.

If the connecting tubing between the equipment sampling valve (5) and the gas-collecting relay is filled with oil, the three-way valve (4) is turned to position (B). The equipment sampling valve (5) is carefully opened and oil allowed to flow into the trap (9). When the end of the oil stream is observed to reach the three-way valve (4), it is turned to position D to evacuate the oil from it. Thereafter, valve (4) is turned to position C. When sampling is complete, stopcock (1) is closed first, then the equipment sampling valve (5) closed and the apparatus disconnected.

If the connecting tubing between the equipment and the sampling valve is empty of oil, the procedure for draining oil is omitted and the three-way valve (4) used in position C after evacuating and testing that the apparatus is leak tight.



Key

1 vacuum tight stopcock
2 vacuum tight stopcock
3 rubber connecting tubing
4 vacuum tight three-way valve
5 equipment sampling valve
6 gas collecting relay valve
8 vacuum gauge
9 trap
10 vacuum tight stopcock
12 vacuum pump
28 sampling tube

Figure 3 – Sampling of free gases by vacuum