



Standard Practice for Combustible Gases in the Gas Space of Electrical Apparatus Using Portable Meters¹

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1. Scope

1.1 This field practice covers the detection and estimation of combustible gases in the gas blanket above the oil or in gas detector relays in transformers using portable instruments. It is applicable only with transformers using mineral oil as the dielectric fluid. Gases dissolved in the oil and noncombustible gases are not determined. A method of calibrating the instruments with a known gas mixture is included.

1.2 This practice affords a semi-quantitative estimate of the total combustible gases present in a gas mixture. If a more accurate determination of the total amount of combustible gases or a quantitative determination of the individual components is desired, use a laboratory analytical method, such as Test Method [D3612](#).

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section [7](#).

2. Referenced Documents

2.1 *ASTM Standards:*²

[D3612 Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography](#)

2.2 *IEEE Standard:*³

[C57.104 Guide for the Interpretation of Gases Generated in Oil-Immersed Transformers](#)

3. Summary of Practice

3.1 A sample of gas is diluted to a fixed ratio with air and introduced into the meter at a pressure of approximately one

¹ This practice is under the jurisdiction of ASTM Committee [D27](#) on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee [D27.03](#) on Analytical Tests.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, <http://www.ieee.org>.

atmosphere. Any combustible gases present are catalytically oxidized on the surface of a sensor which is an element of a Wheatstone bridge. When combustible gases oxidize on the surface, they increase the temperature of the element, which changes its resistance and upsets the balance of the bridge.

3.2 The change in the resistance of the indicating elements in the bridge circuit is indicated on a meter, which is usually calibrated to read in percent total combustible gas.

4. Significance and Use

4.1 Arcing, partial discharge, and localized overheating in the insulation system of transformers result in chemical decomposition of the insulating oil and other insulating materials. This may generate various gases, some of which are combustible. Typically, gases are generated in the oil and then partitioned into the gas space according to their individual solubilities. Gases which are highly oil-soluble, such as acetylene, may not be in significant quantities in the gas space until an incipient fault has progressed to a very serious condition or failure of the transformer. Gases such as carbon monoxide and hydrogen which have low solubilities in oil can make up a large fraction of the combustible gases in the gas space. Detection of these gases is frequently the first available indication of a malfunction. Portable combustible gas meters are a convenient means of detecting the presence of generated gases.

4.2 Normal operation of a transformer may result in the formation of some combustible gases. The detection of an incipient fault by this method involves an evaluation of the amount of combustible gases present, the rate of generation of these gases, and their rate of escape from the transformer. Refer to [IEEE C57.104](#) for detailed information on interpretation of gassing in transformers.

5. Interferences

5.1 In this practice it is essential that sufficient oxygen be present in the gas mixture to oxidize the combustible gases. Since the gas blanket in a transformer is usually an inert gas, it is necessary to dilute the sample gas with a known amount of air. This is usually accomplished by either introducing air and the sample gas into the instrument in known ratios through fixed orifices, or by mixing known quantities of air and test

specimen externally by displacement over water before introduction into the instrument. The working range of these instruments is between the low limit of sensitivity and about the lower explosive limit. They generally read off-scale at the high end between the lower explosive limit and the upper explosive limit and may indicate zero when the combustible gas content is above the upper explosive limit.

5.2 Contamination of the sensor can seriously impair the sensitivity and response of the meter. This loss of response does not affect the normal balancing of the bridge circuit, and is not detected by an electrical check of the instrument. It is, therefore, essential to check and calibrate the instrument frequently against a standard combustible gas mixture.

5.3 Since each combustible gas has its own individual instrument response, the values determined by an instrument are dependent upon the kind of combustible gas used for calibration. In order to compare results, a mixture of methane in nitrogen has been selected as the standard calibrating gas.

NOTE 1—Sensor fouling generally impairs the instrument's response to hydrocarbon gases, including methane, but has little effect on response to hydrogen. A comparison of the analyses of known mixtures of methane in nitrogen and hydrogen in nitrogen can therefore be used to indicate the degree of sensor fouling.

6. Apparatus and Materials

6.1 *Portable Combustible-Gas Meter*, consisting of the following components:

6.1.1 *Sensor*, incorporated in a Wheatstone bridge circuit, complete with a suitable battery and controls for balancing and voltage adjustment.

6.1.2 *Meter*, preferably calibrated to read directly in percent total combustible gases.

6.1.3 *Gas-Mixing Device*, for mixing air and sample gas at fixed ratios.

6.2 *Standard Reference Gas*—The standard reference gas shall be a mixture of methane and nitrogen, with the methane content usually between 1 and 3 %. The methane content should be known to the nearest 0.1 %.

7. Hazards

7.1 Safety Hazards:

7.1.1 Gases generated in transformers can be explosive. Therefore, the combustible gas meter should be equipped with a flame arrester.

7.1.2 Dilute the gas sample with air to avoid the possibility of explosion. Never use pure oxygen for this purpose.

7.1.3 Observe normal safety precautions when attaching portable meters to transformers.

7.1.4 Verify that the gas space being sampled is at a positive pressure before attempting to draw a sample.

8. Calibration

8.1 Prepare the instrument for operation and make zero balance and voltage adjustments in accordance with the instructions of the instrument manufacturer and Section 9.

8.2 Mix the standard reference gas with air, and introduce it into the meter in exactly the same manner as used for the sample gas from the transformer.

8.3 Turn the calibration adjustment so the meter indicates the known methane content of the reference standard when the air and reference gas mixture is being tested. Purge the meter with air to remove traces of reference gas and proceed in accordance with Section 9.

9. Procedure

9.1 Prepare the instrument for operation in accordance with the instrument manufacturer's instructions. This may include a warm-up period to allow the battery voltage to stabilize, a voltage adjustment, and an instrument balance or zero adjustment.

9.2 Calibrate the instrument against the standard methane mixture in accordance with Section 8. The frequency of calibration required for individual instruments can be determined by experience. Low readings, due to sensor contamination, can only be detected by a check with a gas of known composition. In any case of doubt, the instrument should be recalibrated.

9.3 If the instrument has a range switch of more than one air-dilution orifice, set it for maximum range or dilution to avoid damage to the instrument. Purge the instrument so it is free of gas from previous tests.

9.4 Introduce the mixture of air and sample in accordance with the instructions of the instrument manufacturer. The flow rate should be moderate and reproducible. The pressure of gas in the oxidation chamber should be atmospheric, and the temperature should be above the dew point of the gas being tested to prevent condensation of moisture on the oxidizing elements.

9.5 Read the percent combustible gas indicated on the meter. If the reading is low, change to a lower range or change the orifice to one admitting less dilution air. If the instrument goes momentarily off-scale on the high side and then returns to zero, the combustible gas content is probably above the upper explosive limit. This can be verified by additional dilution of the sample gas with air to bring the combustible-gas content within the range of the instrument.

9.6 Recheck the zero balance and voltage adjustments of the instrument.

9.7 Record the reading as percent total combustible gases (% TCG). Report digital meter readings to two decimal places, and analog meter readings to the nearest small scale division.

9.8 Purge the instrument to remove sample gas, in order to minimize corrosion and element contamination.

10. Precision and Bias

10.1 *Precision*—It is not possible to specify the precision of the procedure for measuring combustible gases using portable meters because this is a field method in which the electrical apparatus is the sample container, making it impractical to perform interlaboratory testing.

10.2 *Bias*—No information can be presented on the bias of this procedure because this is a field method in which the electrical apparatus is the sample container, making the use of a reference material impractical.

11. Keywords

11.1 combustible gases; gas space; gases; portable meters

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