Designation: D 2945 – 90 (Reapproved 2003)

Standard Test Method for Gas Content of Insulating Oils[1]

This standard is issued under the fixed designation D 2945; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the gas content of electrical insulating oils of low and medium viscosities in the general range of 100 SUS and below at 100°F (37.8°C), and is suitable for field or laboratory use.

NOTE 1—For testing insulating oils with viscosities above 100 SUS, see Test Method D 831. For individual gas concentrations, see Method D 3612.

1.2 *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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 831 Test Method for Gas Content of Cable and Capacitor Oils

D 3612 Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

D 3613 Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content

3. Summary of Test Method

3.1 This test method consists essentially of allowing oil to flow into an evacuated chamber as a thin film so that the oil is thoroughly exposed to the vacuum, allowing free volatilization of the gaseous component. The system is brought back to atmospheric pressure, and the evolved gases measured. From the volume of oil degassed in the chamber and the volume of released gas, the percent gas content may be estimated. The apparatus used produces the necessary vacuum without resorting to use of a vacuum pump. This test method partially degases the oil. The degree of degasification varies with the solubility of each gas in the oil.

4. Significance and Use

4.1 In filling electrical apparatus, it is desirable to use low gas content transformer oil in order to prevent foaming and to avoid air pockets that might result in gaseous ionization. This procedure provides a simple method to measure the gas content of the oil, and may be used as a factory-control test and as a control or functional test in installation and maintenance work by utilities.

5. Apparatus

5.1 *Dissolved Gas Content Analyser*—Fig. 1 shows the assembled instrument, not drawn to scale, to permit magnification of small details. A borosilicate glass gas buret, 100-mL capacity, graduated in ⅕-mL divisions, serves as a vacuum chamber. A three-way stopcock, 120° bore with TFE-fluorocarbon plug, 3 stem, 2-mm bore is fused to the buret or joined by a vinyl sleeve so that the joint is vacuum tight.

5.1.1 *Rubber Vacuum Tubing*—About 1200 mm of 8-mm rubber vacuum tubing is securely fastened with a 20-mm Hoffman pinch clamp to the lower tip of the buret, while the other end is secured to a 250-mL capacity leveling bulb.

5.1.2 *Stubs 20 Gage Needle*—A short section, about 40 mm long, is cut and cemented to the three-way stopcock, Fig. 2. This serves to accommodate the vinyl tubing attached to the syringe. All the glassware should be clamped to a suitable 1500 by 700 by 20-mm mounting board with rubber-covered wall-type clamps.

5.1.3 *Metal Rod*, 12 mm, 1500 mm long, fitted with an adjustable leveling bulb support is fastened to the wooden apparatus mounting board as in 5.1.2.

5.2 *Syringe Assembly* (see Fig. 3)—A 50-mL Luer syringe with 5-mL subdivisions or a 5-mL Luer syringe with ⅕-mL subdivisions is fitted with a 150-mm length of 0.8-mm inside diameter capillary vinyl tubing. An upper and lower collar of plastic or metal is attached to the syringe to support the rubber bands required to create positive pressure in the syringe. A20-mm Hoffman pinch clamp is used on the capillary tubing after sampling.

5.3 *Oil Sampler* (see Fig. 3)—A 3.2-mm tee is fitted with a syringe needle stem in one arm and a short length of 6.4-mm. Vinyl tubing is attached to the other arm. During sampling, the tee is attached to the sampling valve and the vinyl capillary tubing of the syringe assembly is attached to the needle of the tee.

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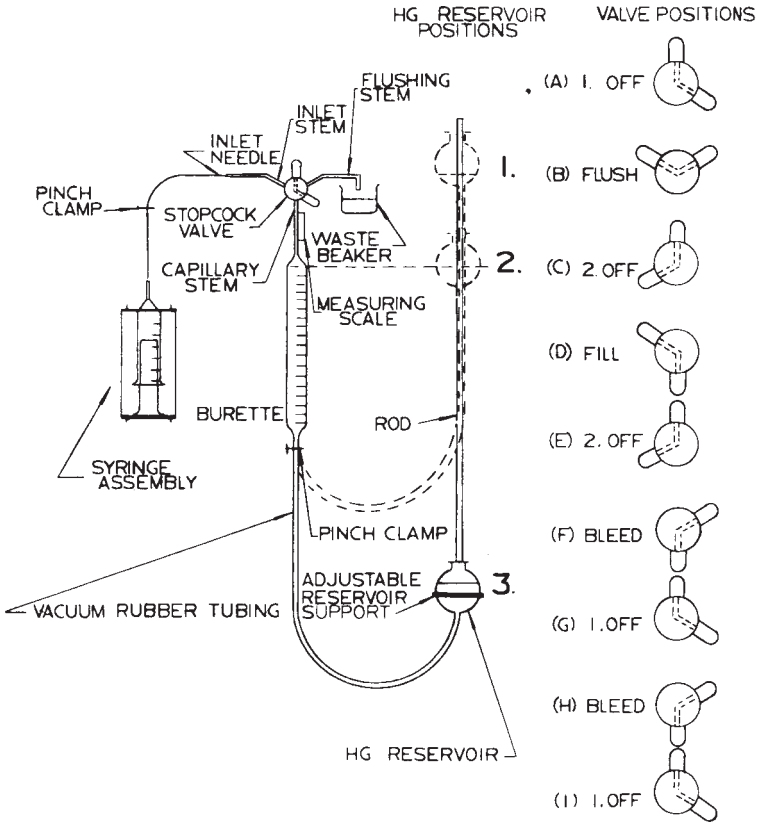
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.



1 gas buret, capacity 100 mL, graduated in ⅕-mL divisions
1 stopcock, 120° bore with TFE fluorocarbon plug, 3 stems, 2-mm bore
1 leveling bulb, capacity 250 mL
1 beaker, capacity 250 mL
1200 mm (4 ft) vacuum rubber tubing, 8-mm (3⁄16-in.) inside diameter
2 rubber tubing clamps, adjustable, cadmium-plated steel
2-pinch clamps, Hoffman swivel jaw, screw compressor, ¾ by 1 in. for vinyl tubing for 5 and 50-mL syringes
1 pinch clamp, Hoffman screw compressor for rubber tubing, ¾ by 1 in.
6 clamps, wall type with wood screw to support buret, stopcock, and rod
1 leveling bulb support, adjustable, Fisher-Castaloy-R, self-locking
1 rod, diameter 12 mm (½ in.), length 1500 mm (58 in.)
1 syringe, Luer, resistance glass, 50 mL, subdivisions 5 mL
1 syringe, Luer, resistance glass, 5 mL, subdivisions ⅕ mL
Vinyl tubing, 2.6-mm (1⁄16-in.) inside diameter, wall thickness 1.3 mm (1⁄32 in.), length 150 mm (6 in.)
4.5 kg (10 lb) mercury
1 needle, 50 mm long, Stubbs gage 20
1 wooden board 1500 by 700 by 20 mm (58 by 28 by ⅞ in.)

Components for Gas-Content Apparatus

FIG. 1 Dissolved Gas Content Analyser

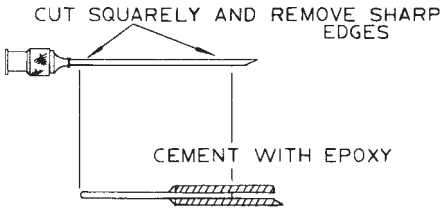


FIG. 2 Detail of Needle Inlet

5.4 *Mercury Reservoir*—A 250-mL capacity leveling bulb is filled with 4.5 kg (10 lb) of mercury.

6. Sampling

6.1 Samples should be drawn in accordance with Methods D 3613. An alternative sample container and method are given in the Sampling section of Test Method D 831.

6.2 An effective method is to take the sample directly from the pressurized line into the sampling syringe. The syringe is maintained under slight positive pressure during the taking of the sample, during sample transfer, and during the introduction of the sample into the analyzer. This can be accomplished by

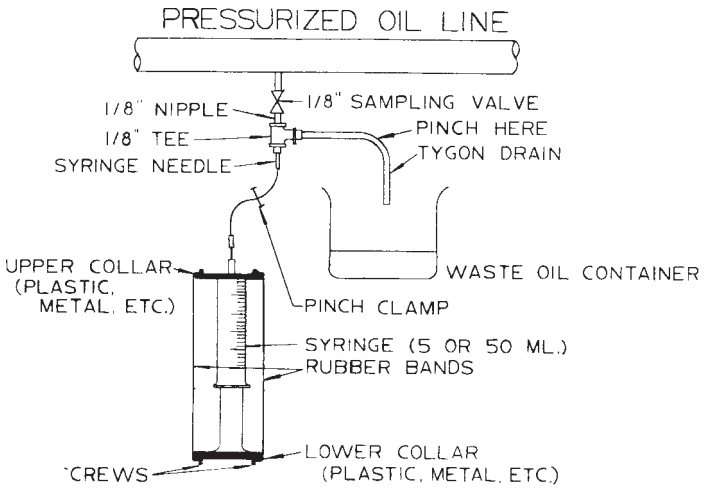


FIG. 3 Oil Sampler

attaching rubber bands to the syringe to force the barrel into the syringe or by similar means.

6.3 For highly degassed oils, the oil must not be drawn into the syringe by pulling at the barrel. For oils fully saturated, or with a high gas content, the sampling procedure is less critical. However, it is desirable in all cases to obtain samples under a positive pressure.

6.4 An example of a sampling arrangement for highly degassed oils is shown in Fig. 3. After attaching the syringe with its capillary vinyl tubing, the ⅛-in. sampling valve is opened just enough to provide a steady flow through the ¼-in. drain tubing without forcing the syringe barrel. After that, the drain tubing is squeezed by fingers which will create sufficient back pressure to overcome tension of rubber bands to fill the syringe. When full, release the drain tubing and allow the syringe to empty itself into the tee. This is repeated several times with the syringe in vertical position to expel any possible air bubbles from the syringe and inspect visually. After the last filing, a pinch clamp is attached to the syringe tubing, the sampling valve is turned off, and the syringe is transferred with its tubing and closed pinch clamp to the analyzer for test.

7. Procedure

7.1 The mercury (Hg) reservoir is in position (1) from the previous test. Fill the buret with mercury up to the very top of the capillary tube. If there is residual oil visible below the three-way cock, discharge it by manipulating the cock to the BLEED position **(F).** After expelling the oil, return the cock to the (1) OFF position **(A).** Mount the syringe assembly on support. Attach the tubing to the needle on the inlet stem and remove the clamp from the tubing.

7.2 Turn the valve counterclockwise to FLUSH position (B). Oil from the syringe will flush out air as well as oil sample from the previous test. Continue flushing until the marking on the syringe barrel coincides with the next syringe cylinder graduation. Turn the valve counterclockwise to the second OFF position **(C).**

7.3 Move the mercury reservoir from position 1 to position 3 to evacuate chamber. Adjust the pinch clamp at the bottom of the buret to permit slow descent of the mercury column until the level of the mercury coincides with the zero graduation of buret. Tighten pinch clamp slightly to stop the movement of the mercury column. A slight trace of oil will not affect the results.

7.4 Turn the valve counterclockwise towards the FILL position (D) and allow the oil to enter the buret slowly. Oil should flow as a film on the inside walls of the buret. When the barrel has traversed 10 mL (for oil fully saturated—1 mL), turn the valve clockwise to the second OFF position **(E).**

NOTE 2—During introduction of the sample, do not allow the barrel to reach the bottom of the syringe bore. This would create negative pressure in the syringe tubing and conceivably, air could be sucked into the oil, thus creating an erroneously high reading.

7.5 Change the reservoir from position 3 to position 2. Allow 1 min for the oil in the buret to degas. Loosen the clamp slightly at the bottom of the buret to permit the column of mercury to rise slowly in the buret. Adjust the position of the mercury reservoir so that the surfaces of the mercury in the reservoir and in the buret are level.

7.6 The gas bubble will be located adjacent to the stopcock valve at the top of the capillary stem. Turn the valve clockwise to the BLEED position **(F)** to permit a small amount of oil to enter the capillary stem from the flushing stem. This will lower the gas bubble in the capillary stem to a position where the stem's bore is cylindrical and where the length of the bubble can be easily read. Allow the bubble to reach a position approximately 25 mm below the cock and then turn the valve counterclockwise to the first OFF position **(G).**

7.7 Measure the length of the gas bubble in the capillary stem. It is recommended that a scale be prepared, graduated in 0.01-mL gas volume, and attached to the stem. For a stopcock of 2-mm nominal bore, 0.01-mL volume corresponds to a length of 4 mm.

7.8 Move the mercury reservoir from position 2 to position 1. Turn the valve clockwise to the BLEED position (H) and allow the oil to flush out into the waste beaker. When the mercury touches the valve, turn the valve counterclockwise to the first OFF position **(I).**

7.9 Discard the first reading because it might be affected by residual oil from previous tests. The average from at least two additional tests should be used to compute the gas content.

8. Calculation

8.1 Calculate the volume percent of gas as follows:

$$V = G \times 100/S$$

where:
V = volume %, mL,
G = volume of extracted gas, mL, and
S = volume of oil sample, mL.

9. Precision and Bias

9.1 The precision and bias of this test method have not been determined due to the difficulty in obtaining a uniform set of samples for round-robin use.