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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method [1]

This standard is issued under the fixed designation D 2285; 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 a comparatively rapid procedure particularly applicable for field use for measuring, under nonequilibrium conditions, the interfacial tensions of electrical insulating oils of petroleum origin against water. This test method has been shown by experience to give a reliable indication of the presence of hydrophilic compounds. This test method may not be applicable for highly viscous insulating fluids.

1.2 *This standard does not purport to address 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:*

D 971 Test Method for Interfacial Tension of Oil Against Water by the Ring Method [2]

D 1298 Practice for Density (Specific Gravity) or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method [3]

3. Summary of Test Method

3.1 Interfacial tension is determined by measuring the volume of a drop of water formed in oil. A larger water drop means a higher interfacial tension. The instrument is calibrated to read approximately in millinewtons per metre (dynes per centimetre). The measurement is completed within 1 min after the formation of the water drop in oil.

4. Significance and Use

4.1 This test method indicates the presence of hydrophilic compounds. These compounds can be an indicator of contaminants in new oil and in used oil, oxidation or deterioration of the oil or materials of construction in contact with the oil.

5. Apparatus

5.1 *Tensiometer*[4] that provides a simple way of injecting a measured quantity of water into oil. The scale attached to the piston forcing the water into the oil is graduated in millinewtons per metre (dynes per centimetre).

5.2 *Test Specimen Container*—Glass beaker or transparent cylindrical vessel having a minimum diameter of 1 in. (25.4 mm).

5.3 *Needle*, supplied with the tensiometer having a blunt end with a 90° angle. Follow manufacturer's guidelines for selection.

6. Preparation of Apparatus

6.1 Wipe the needle free of oil with clean lint free paper, avoiding any upward motion that may embed a bit of fiber on the sharp needle. Do not use an oil solvent on the needle or barrel.

6.2 Force distilled water through the barrel and needle to clean the inside. Only when contamination is suspected should detergents or solvents be used for cleaning, followed by a thorough rinsing with distilled water. Detergents will lower interfacial tension results

6.3 Clean the test specimen container by removing any residual oil with petroleum naphtha (see Note 1) or other suitable hydrocarbon solvents followed by washing with a detergent solution. Rinse thoroughly with tap water, then distilled water.

NOTE 1—**Warning:** Petroleum naphtha is flammable and harmful if inhaled.

7. Calibration of Apparatus

7.1 Interfacial tension, in millinewtons per metre (dynes per centimetre), is determined by the following equation:

[1] This test method is under the jurisdiction of ASTM Committee D-27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.07 on Physical Test.

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[2] *Annual Book of ASTM Standards,* Vol 10.03.

[3] *Annual Book of ASTM Standards,* Vol 05.01.

[4] Use a tensiometer that employs the drop weight principle for measuring interfacial tension. The sole source of supply of the apparatus known to the committee at this time is a tensiometer available from Gerin Corp., 1109 7th Avenue, Neptune, NJ 00753. If you are aware of alternative suppliers, please provide this information to ASTM headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

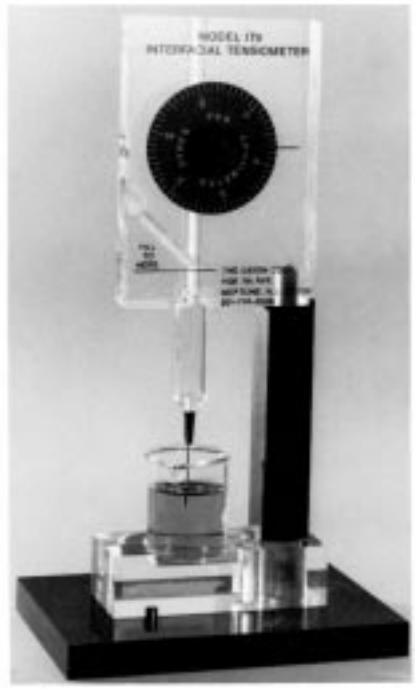

FIG. 1 Vertical Interfacial Tensiometer

Interfacial tension, m $N/m = R_1(D - d)(S/R_2)$

where:

R_1 = reading of dial (divisions per drop) of water in oil,
R_2 = reading of dial (divisions per drop) of water in air,
D = density of water at measuring temperature (0.998 at 20°C and 0.997 at 25°C),
d = density of oil at measuring temperature (If density is not known, use 0.885 average density), and
S = surface tension of water in air (72.75 at 20°C and 71.97 at 25°C).

7.2 Thus, the only calibration is in the R_2 value, and this requires a measurement of the volume, in terms of divisions on the scale, of a drop of water expelled into air, which is saturated with water vapor to minimize evaporation. By properly selecting the needle size and dial scale, the R_2 value is set to approximately nine divisions on the scale.

7.3 Calibrate the tensiometer daily to ensure accurate results.

7.4 Perform the calibration check as follows:

7.4.1 Fill the tensiometer barrel with distilled water, preferably at a temperature of 25 ± 1°C.

7.4.2 Expel air from the barrel and then clamp the barrel into position on the mounting stand.

7.4.3 Place a glass beaker containing at least 12.7 mm (½ in.) of distilled water on the mounting stand, bringing the water surface to within 6.4 mm (¼ in.) below the needle. This ensures the air surrounding the needle is saturated with water vapor.

7.4.4 Note reading on the scale, then expel a single drop of water and note difference of scale reading.

7.4.5 The average of ten such "drops in air" is taken as the orifice calibration of water in air, that is, the R_2 value.

7.5 Any reading deviating as much as 0.2 scale divisions from the average is discarded. If any reading is 0.4 or more scale divisions from the average, check instrument for contamination and repeat calibration. Air leaks in the barrel and dust in the needle are the usual source for variations. Variations can also cause unrepeatable results.

7.6 Prepare a correction curve showing the total multiplier versus density, *d*, using oils with a suitable range of known densities. For an oil having a density different from the "average density" oil, apply the correction factor to the observed scale reading.

8. Procedure

8.1 Apparatus, test specimen, and water should be at a common temperature ± 1°C, preferably around 25°C.

8.2 Fill the barrel with distilled water.

8.3 Expel air from the barrel and clamp the tensiometer into its mount.

8.4 Pour oil into the test specimen container to a depth of at least 25.4 mm (1 in.). Do not filter. Place the container on the table so that the needle tip is immersed about 12.7 mm (½ in.).

NOTE 2—This test method is a comparatively rapid procedure particularly applicable for field use. Therefore, filtration adds an undesirable extra step. Also, it is anticipated that oil samples drawn from electrical equipment in the field will not contain heavy oil sludge, such as may be found in samples taken at the end of laboratory oxidation tests, which would interfere with the determination of interfacial tension.

8.5 Note the reading on the scale; then expel a trial drop. Note the difference in scale readings.

8.6 Expel about ¾ of the volume of water found in 8.5 and allow this drop to remain suspended on needle (age) for about 30 s.

8.7 Slowly release enough water to cause the drop to fall so that total time to expel the drop is between 45 and 60 s.

8.8 Note the volume of water in the drop in terms of divisions on the scale. This reading will give the interfacial tension of an oil of average density.

8.9 If more accurate readings are desired, apply the correction factor for the density of the oil under test, using the curve made during the calibration.

9. Precision and Bias

9.1 The precision and bias have not been determined. This is a rapid procedure for use under field conditions. It gives a semiquantitative answer that is subject to significant error. For instances where a test value of known precision is required, use Test Method D 971.

10. Keywords

10.1 drop-weight method; electrical insulating oil; IFT; interfacial tension; oil