



# Standard Test Methods for Silicone Fluids Used for Electrical Insulation<sup>1</sup>

This standard is issued under the fixed designation D2225; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 These test methods cover the testing of silicone fluids for use in transformers, capacitors, and electronic assemblies as an insulating or cooling medium, or both. These methods are generally suitable for specification acceptance, factory control, referee testing, and research.

1.2 Although some of the test methods listed here apply primarily to petroleum-based fluids, they are, with minor revisions, equally applicable to silicone fluids.

1.3 Silicone fluids are used for electrical insulating purposes because of their stable properties at high and low temperatures and their relative environmental inertness.

1.4 A list of the properties and standards are as follows:

Property Measured	Section	ASTM Test Method
<i>Physical:</i>		
Color	6	D2129
Flash point	7	D92
Fire point	7	D92
Polychlorinated biphenyl content	8	D4059
Pour point	9	D97
Refractive index	10	D1807
Specific gravity	11	D1298, D1481, D4052
Volatility	12	D4559
Viscosity	13	D445, D2161
<i>Chemical:</i>		
Neutralization number	14	D974
Water content	15	D1533
<i>Electrical:</i>		
Relative permittivity	16	D924 <sup>2</sup>
Dielectric breakdown voltage	17	D877 <sup>3</sup>
Dissipation factor	18	D924 <sup>2</sup>
Specific resistance	19	D1169 <sup>2</sup>
Compatibility	20	D5282

1.5 *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.*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and are the direct responsibility of Subcommittee D27.02 on Gases and Non-Mineral Oil Liquids.

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<sup>2</sup> A modified cell cleaning procedure is given for Test Methods D924 and D1169.

<sup>3</sup> A modified cell cleaning procedure is recommended for Test Method D877.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>4</sup>

- D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- D97 Test Method for Pour Point of Petroleum Products
- D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
- D923 Practices for Sampling Electrical Insulating Liquids
- D924 Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
- D974 Test Method for Acid and Base Number by Color-Indicator Titration
- D1169 Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids
- D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- D1481 Test Method for Density and Relative Density (Specific Gravity) of Viscous Materials by Lipkin Bicapillary Pycnometer
- D1533 Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
- D1807 Test Methods for Refractive Index and Specific Optical Dispersion of Electrical Insulating Liquids
- D1816 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes
- D2129 Test Method for Color of Clear Electrical Insulating Liquids (Platinum-Cobalt Scale)
- D2161 Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
- D2864 Terminology Relating to Electrical Insulating Liquids and Gases
- D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

<sup>4</sup> 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.

**D4059** Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

**D4559** Test Method for Volatile Matter in Silicone Fluid

**D4652** Specification for Silicone Fluid Used for Electrical Insulation

**D5282** Test Methods for Compatibility of Construction Material with Silicone Fluid Used for Electrical Insulation

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *fire point*—the temperature at which oil first ignites and burns for at least 5 s when a small test flame is passed across the surface under specified conditions.

3.1.2 *flash point*—the temperature at which vapors above the oil surface first ignite when a small test flame is passed across the surface under specified conditions.

3.1.3 *refractive index*—the ratio of the velocity of light (of a specified wavelength) in air at 25°C to its velocity in the substance under test.

3.1.4 *specific gravity*—the ratio of weight of a given volume of material to the weight of an equal volume of water. In this method, both weights are corrected to weight in vacuum, and the material is at 25°C using hydrometers calibrated at 60/60°F.

3.1.5 *volatility*—the weight of liquid lost when a specified weight of liquid is held at a specified elevated temperature for a specific period of time.

3.1.6 *water content*—the amount of water (mg/kg) dissolved in the liquid.

3.1.7 For additional terms refer to Terminology **D2864**.

### 4. Significance and Use

4.1 Tests covered in this standard may be used for quality control and design considerations.

4.2 Included in each test method is a brief statement describing its significance.

### 5. Sampling

5.1 Accurate sampling, whether of the complete contents or only parts thereof, is extremely important from the standpoint of elevation of the quality of the product sampled. Obviously, examination of a sample that because of careless sampling procedure or contamination in the sampling equipment is not directly representative, leads to erroneous conclusions concerning quality.

5.2 Sample the silicone fluid in accordance with Test Methods **D923**.

## PHYSICAL METHODS

### 6. Color

6.1 *Significance*—The chief significance of color as applied to silicone fluid lies in the fact that if the fluid is colored, some degree of contamination exists that may affect the physical, chemical, and electrical properties of the fluid.

6.2 *Procedure*—Determine the color in accordance with Test Method **D2129**.

### 7. Flash and Fire Points

7.1 *Significance*—The flash and fire points of a silicone insulating fluid indicates the limit to which the material may be heated, under the specified test conditions, before the emitted vapors form a flammable mixture in air. Unusually low flash or fire points for a given product may indicate contamination.

7.2 *Procedure*—Determine the flash and fire points in accordance with Test Method **D92**.

### 8. Polychlorinated Biphenyl Content

#### 8.1 Scope:

8.1.1 *Test Method D4059*—describes a quantitative technique for determining the concentration of polychlorinated biphenyls (PCB's) in electrical insulating liquids.

#### 8.2 Definition:

8.2.1 *PCB concentration*—is normally expressed in units of parts per million (PPM) on a weight by weight basis. Standard chromatograms of Aroclors 1242, 1254, and 1260 are used to determine the concentration of PCB in the sample.

8.3 *Summary of Test Method*—Following dilution of the sample in a suitable solvent, the solution is treated to remove interfering substances. A small portion is then injected into a packed gas chromatographic column where the components are separated and their presence measured by an electron capture or halogen-specific electrolytic conductivity detection. The method is made quantitative by comparing the response of a sample to that of a known quantity of one or more standard Aroclors obtained under the same conditions.

8.4 *Significance and Use*—United States regulations require that electrical apparatus and electrical insulating fluids containing PCB be handled and disposed of through the use of specific procedures as determined by the PCB content of the fluid. The results of this test method can be useful in selecting appropriate handling and disposal procedures.

### 9. Pour Point

9.1 *Significance*—The pour point is important as an index of the lowest temperature to which the material may be cooled without seriously limiting the degree of circulation of the fluid.

9.2 *Procedure*—Determine the pour point in accordance with Test Method **D97**.

### 10. Refractive Index

10.1 *Significance*—The refractive index is often useful for the detection of some types of contamination and for the identification of the molecular makeup of the various types of silicone insulating fluids.

10.2 *Procedure*—Determine the refractive index in accordance with Test Methods **D1807**.

### 11. Specific Gravity

11.1 *Significance*—Silicone insulating fluids are usually sold on a weight basis. The values for the specific gravities must frequently be known to calculate the volume of fluid present at any given temperature.

11.2 *Procedure*—Determine the specific gravity in accordance with Test Methods [D1481](#) or [D4052](#) and Practice [D1298](#).

## 12. Volatility

12.1 *Significance*— High values may indicate contamination of the silicone with other organic materials, inadequate removal of volatile components, or contamination with a depolymerization catalyst.

12.2 *Procedure*—Determine volatility in accordance with Test Method [D4559](#).

## 13. Viscosity

13.1 *Significance*— The viscosity of a silicone fluid is important during the process of impregnation.

13.1.1 At operating temperatures the viscosity of a silicone fluid is a principal factor affecting heat transfer by convection flow of the fluid.

13.2 *Procedure*—Determine the viscosity in accordance with Test Method [D445](#). The kinematic viscosity may be converted to absolute viscosity in accordance with Test Method [D2161](#).

## CHEMICAL METHODS

### 14. Neutralization Number

14.1 *Significance*— In the inspection of unused silicone fluids, the neutralization number is of importance as a quality index of purity. Properly refined silicone fluids are free from mineral acids and alkalis.

14.1.1 Since final oxidation products of silicone fluids are not acidic, small changes in the neutralization number of used silicone fluids may indicate the solution of basic or acidic materials from the various solid materials in contact with the silicone or the deterioration of such soluble materials to form basic or acidic materials.

14.2 *Procedure*—Determine the neutralization number in accordance with Test Method [D974](#).

### 15. Water Content

15.1 *Significance*— Under high humidity conditions, polydimethylsiloxane fluids can absorb moisture up to about 250 ppm by weight at 25°C. High levels of water content will significantly lower the resistivity and dielectric breakdown voltage of the fluid.

15.2 *Procedure*—Determine water content in accordance with Test Method [D1533](#).

## ELECTRICAL METHODS

### 16. Relative Permittivity (Dielectric Constant)

16.1 *Significance*— Silicone insulating fluids are used to insulate components of an electrical network from each other and from ground. For this use, it is generally desirable to have the capacitance as small as possible, consistent with acceptable chemical properties and design considerations.

16.2 *Procedure*—Determine the relative permittivity in accordance with Test Method [D924](#). An alternative method of

cleaning the test cells is to use multiple rinses of isopropanol followed by a thorough rinsing with methylene chloride and dry with clean, dry, warm air.

### 17. Dielectric Breakdown Voltage

17.1 *Significance*— The importance of the dielectric breakdown voltage of a silicone liquid is as a measure of its ability to withstand electrical stress without failure. It may also indicate the presence of contaminating materials, such as water, conducting solid particles, dissolved contaminants, or the decomposition products resulting from an electric arc. A high dielectric breakdown voltage, however, is not a certain indication of the absence of all contaminants.

17.2 *Procedure*—Determine the dielectric breakdown voltage in accordance with Method [D877](#), with the following modification:

17.2.1 Fill the test cup by tilting it at a 45° angle. As the liquid approaches the tilted top edge of the cup, slowly rotate the cup to an upright position while continuing to pour sample into the cup. This will reduce the amount of air bubbles in the sample and prevent bubbles from being trapped under the electrodes.

17.2.2 Make one breakdown on each of the specified fillings of the test cup.

17.2.3 Clean the electrode surfaces after each breakdown by one of the following methods:

17.2.3.1 *Method A*—After each breakdown and before the cup is emptied, pass the electrode-spacing gage through the electrode gap twice. Then empty the cup. This will clean the electrodes of any semisolid breakdown products and they will flow out when the cup is emptied.

17.2.3.2 *Method B*—Empty the cup. Wipe the electrode surfaces with a lintless paper or cloth. This is best accomplished by folding the lintless paper over a clinical tongue depressor. Flush the test cup with clean silicone fluid and empty the cup.

17.3 Test Method [D1816](#) may be used to determine the dielectric breakdown voltage following provided that the discharge energy limits of Section 1.4 of the test method are met.

17.3.1 Determine the dielectric breakdown voltage in accordance with Test Method [D1816](#).

### 18. Dissipation (Power) Factor

18.1 *Significance*— Dissipation (power) factor of a silicone fluid is an indication of the energy dissipated as heat in the fluid. It is useful as a means for quality control and as an indication of changes in the fluid resulting from deteriorating and contaminating influences.

18.2 *Procedures*—Determine the dissipation factor in accordance with Test Method [D924](#). An alternative method of cleaning the test cells is to use multiple rinses of isopropanol followed by a thorough rinsing with methylene chloride and dry with clean, dry, warm air.

## 19. Specific Resistance (Resistivity)

19.1 *Significance*— The specific resistance of a silicone insulating fluid is a measure of its electrical insulating capability in d-c apparatus. High resistivity reflects low content of free ions and ion-forming particles, and normally indicates a low concentration of conductive contaminants.

19.2 *Procedure*—With the exception of the procedure for cleaning the test cells, determine the specific resistance in accordance with Test Method **D1169**. An alternative method of cleaning the test cells is to use multiple rinses of isopropanol followed by a thorough rinsing with methylene chloride and dry with clean, dry, warm air.

## COMPATIBILITY TESTING

### 20. Compatibility

20.1 *Significance*— It is very important to know how other construction materials will affect silicone liquid or the converse.

20.1.1 Incompatibility of the silicone fluid with the materials of construction can affect the usable life and operation of major apparatus and equipment, such as transformers and capacitors.

20.1.2 Compatibility tests are usually made at high temperatures, and for specific time periods. They may consist of physical methods, chemical methods, electrical methods, or all types, depending upon the particular application.

20.2 *Procedure*—Determine compatibility of silicone fluids with materials of construction in accordance with Test Methods **D5282**.

### 21. Report

21.1 The report shall consist of the separate reports detailed in the specific methods used.

### 22. Precision and Bias

22.1 Use the precision and bias statements for each referenced method.

### 23. Keywords

23.1 electrical insulating fluid; silicone fluid

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