



# Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Oils of Petroleum Origin<sup>1</sup>

This standard is issued under the fixed designation D117; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 1. Scope

1.1 This guide describes methods of testing and specifications for electrical insulating oils of petroleum origin intended for use in electrical cables, transformers, oil circuit breakers, and other electrical apparatus where the oils are used as insulating, or heat transfer media, or both.

1.2 The purpose of this guide is to outline the applicability of the available test methods. Where more than one is available for measuring a given property, their relative advantages are described, along with an indication of laboratory convenience, precision, (95 % confidence limits), and applicability to specific types of electrical insulating oils.

1.3 This guide is classified into the following categories: Sampling Practices, Physical Tests, Electrical Tests, Chemical Tests, and Specifications. Within each test category, the test methods are listed alphabetically by property measured. A list of standards follows:

Category	Section	ASTM Method
<i>Sampling:</i>	3	D923, D2759, D3305
<i>Physical Tests:</i>		
Aniline Point	4	D611
Coefficient of Thermal Expansion	5	D1903
Color	6	D1500
Examination: Visual Infrared	7	D1524, D2144
Flash and Fire Point	8	D92
Interfacial Tension	9	D971, D2285
Pour Point of Petroleum Products	10	D97
Particle Count in Mineral Insulating Oil	11	D6786
Refractive Index	12	D1218, D1807
Relative Density (Specific Gravity)	13	D287, D1217, D1298, D1481
Specific Heat	14	D2766

Category	Section	ASTM Method
Thermal Conductivity	15	D2717
Turbidity	16	D6181
Viscosity	17	D88, D445, D2161
<i>Electrical Tests:</i>		
Dielectric Breakdown Voltage	18	D877, D1816, D3300
Dissipation Factor and Relative Permittivity (Dielectric Constant)	19	D924
Gassing Characteristic Under Thermal Stress	20	D7150
Gassing Tendency	21	D2300
Resistivity	22	D1169
Stability Under Electrical Discharge	23	D6180
<i>Chemical Tests:</i>		
Acidity, Approximate	24	D1534
Carbon-Type Composition	25	D2140
Compatibility with Construction Material	26	D3455
Copper Content	27	D3635
Elements by Inductively Coupled Plasma (ICP-AES)	28	D7151
Furanic Compounds in Electrical Insulating Liquids	29	D5837
Gas Analysis	30	D3612
Gas Content	31	D831, D1827, D2945
Inorganic Chlorides and Sulfates	32	D878
Neutralization (Acid and Base) Numbers	33	D664, D974
Oxidation Inhibitor Content	34	D2668, D4768
Oxidation Stability	35	D1934, D2112, D2440
Polychlorinated Biphenyl Content	36	D4059
Relative Content of Dissolved Decay	37	D6802
Sediment and Soluble Sludge	38	D1698
Sulfur, Corrosive	39	D1275
Water Content	40	D1533
<i>Specification:</i>		
Mineral Insulating Oil for Electrical Apparatus	41	D3487
High Firepoint Electrical Insulating Oils	42	D5222

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.01 on Mineral.

Current edition approved Sept. 15, 2010. Published October 2010. Originally published as D117 – 21 T. Last previous edition approved in 2002 as D117 – 02. DOI: 10.1520/D0117-10.

1.4 The values stated in SI units are to be regarded as standard. The values stated in parentheses are provided for information only.

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.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

- D88 Test Method for Saybolt Viscosity
- D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- D97 Test Method for Pour Point of Petroleum Products
- D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
- D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D611 Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents
- D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
- D831 Test Method for Gas Content of Cable and Capacitor Oils
- D877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
- D878 Test Method for Inorganic Chlorides and Sulfates in Insulating Oils
- 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
- D971 Test Method for Interfacial Tension of Oil Against Water by the Ring Method
- D974 Test Method for Acid and Base Number by Color-Indicator Titration
- D1169 Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids
- D1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer
- D1218 Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids
- D1250 Guide for Use of the Petroleum Measurement Tables
- D1275 Test Method for Corrosive Sulfur in Electrical Insulating Oils
- 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
- D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
- D1524 Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field

- D1533 Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
- D1534 Test Method for Approximate Acidity in Electrical Insulating Liquids by Color-Indicator Titration
- D1698 Test Method for Sediments and Soluble Sludge in Service-Aged Insulating Oils
- 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
- D1827 Test Method for Gas Content (Nonacidic) of Insulating Liquids by Displacement with Carbon Dioxide (Withdrawn 2009)<sup>3</sup>
- D1903 Practice for Determining the Coefficient of Thermal Expansion of Electrical Insulating Liquids of Petroleum Origin, and Askarels
- D1934 Test Method for Oxidative Aging of Electrical Insulating Petroleum Oils by Open-Beaker Method
- D2112 Test Method for Oxidation Stability of Inhibited Mineral Insulating Oil by Pressure Vessel
- D2140 Practice for Calculating Carbon-Type Composition of Insulating Oils of Petroleum Origin
- D2144 Practices for Examination of Electrical Insulating Oils by Infrared Absorption
- D2161 Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
- D2285 Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method (Withdrawn 2008)<sup>3</sup>
- D2300 Test Method for Gassing of Electrical Insulating Liquids Under Electrical Stress and Ionization (Modified Pirelli Method)
- D2440 Test Method for Oxidation Stability of Mineral Insulating Oil
- D2668 Test Method for 2,6-*di-tert*-Butyl- *p*-Cresol and 2,6-*di-tert*-Butyl Phenol in Electrical Insulating Oil by Infrared Absorption
- D2717 Test Method for Thermal Conductivity of Liquids
- D2759 Practice for Sampling Gas from a Transformer Under Positive Pressure
- D2766 Test Method for Specific Heat of Liquids and Solids
- D2945 Test Method for Gas Content of Insulating Oils (Withdrawn 2012)<sup>3</sup>
- D3300 Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Under Impulse Conditions
- D3305 Practice for Sampling Small Gas Volume in a Transformer
- D3455 Test Methods for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin
- D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus
- D3612 Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography
- D3635 Test Method for Dissolved Copper In Electrical

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

- Insulating Oil By Atomic Absorption Spectrophotometry
- D4052** Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
- D4059** Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography
- D4768** Test Method for Analysis of 2,6-Ditertiary-Butyl Para-Cresol and 2,6-Ditertiary-Butyl Phenol in Insulating Liquids by Gas Chromatography
- D5185** Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
- D5222** Specification for High Fire-Point Mineral Electrical Insulating Oils
- D5837** Test Method for Furanic Compounds in Electrical Insulating Liquids by High-Performance Liquid Chromatography (HPLC)
- D6180** Test Method for Stability of Insulating Oils of Petroleum Origin Under Electrical Discharge
- D6181** Test Method for Measurement of Turbidity in Mineral Insulating Oil of Petroleum Origin (Withdrawn 2012)<sup>3</sup>
- D6786** Test Method for Particle Count in Mineral Insulating Oil Using Automatic Optical Particle Counters
- D6802** Test Method for Determination of the Relative Content Of Dissolved Decay Products in Mineral Insulating Oils by Spectrophotometry
- D7150** Test Method for the Determination of Gassing Characteristics of Insulating Liquids Under Thermal Stress at Low Temperature
- D7151** Test Method for Determination of Elements in Insulating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

## SAMPLING

### 3. Sampling

3.1 Accurate sampling, whether of the complete contents or only parts thereof, is extremely important from the standpoint of evaluation of the quality of the product sampled. Obviously, careless sampling procedure or contamination in the sampling equipment will result in a sample that is not truly representative. This generally leads to erroneous conclusions concerning quality and incurs loss of the time, effort, and expense involved in securing, transporting, and testing the sample.

3.2 Sample the insulating oil in accordance with Practices **D923**, **D2759** and **D3305** as appropriate.

## PHYSICAL PROPERTIES

### 4. Aniline Point

4.1 *Scope*—This test method covers the determination of the aniline point of petroleum products, provided that the aniline point is below the bubble point and above the solidification point of the aniline-sample mixture.

4.2 *Summary of Test Method:*

4.2.1 *Test Method D611*—Equal volumes of aniline and test specimen or aniline and test specimen plus *n*-heptane are

placed in a tube and mixed mechanically. The mixture is heated at a controlled rate until the two phases become miscible. The mixture is then cooled at a controlled rate, and the temperature at which the two phases separate is recorded as the aniline point.

4.3 *Significance and Use*—The aniline point of an insulating oil indicates the solvency of the oil for some materials that are in contact with the oil. A higher aniline point implies a lower aromaticity and a lower degree of solvency for some materials.

### 5. Coefficient of Thermal Expansion

5.1 *Scope*—This test method covers the determination of the coefficient of thermal expansion of electrical insulating liquids of petroleum origin.

5.2 *Definition:*

5.2.1 *coefficient of thermal expansion*—the change in volume per unit volume per degree change in temperature. It is commonly stated as the average coefficient over a given temperature range.

5.3 *Summary of Test Method*—The specific gravity of insulating oils is determined at two temperatures below 90°C and separated by not less than 5°C nor more than 14°C. Test methods used may be **D287**, **D1217**, **D1298**, or **D1481**. The calculation of average coefficient of thermal expansion over this temperature range is given in Test Method **D1903**.

5.4 *Significance and Use*—A knowledge of the coefficient of expansion of a liquid is essential to compute the required size of a container to accommodate a volume of liquid over the full temperature range to which it will be subjected. It is also used to compute the volume of void space that would exist in an inelastic device filled with the liquid after the liquid has cooled to a lower temperature.

### 6. Color

6.1 *Scope*—This test method covers the visual determination of color of a wide variety of liquid petroleum products, including mineral insulating oils.

6.2 *Summary of Test Method:*

6.2.1 *Test Method D1500*—The test specimen is placed in a glass sample jar (an ordinary 125-mL test specimen bottle is satisfactory for routine tests). The color of the sample by transmitted light is compared with a series of tinted glass standards. The glass standard matching the sample is selected, or if an exact match is not possible, the next darker glass is selected. The results are reported numerically on a scale of 0.5 to 8.0.

6.3 *Significance*—A low color number is an essential requirement for inspection of assembled apparatus in a tank. An increase in the color number during service is an indicator of deterioration or contamination of the insulating oil.

### 7. Examination

7.1 *Scope:*

7.1.1 Both visual examination and qualitative infrared absorption are described in this section. The test methods are:

7.1.2 *Test Method D1524*—This is a visual examination of mineral insulating oils that have been used in transformers, oil