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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Methods of Testing Synthetic Dielectric Fluids For Capacitors[1]

This standard is issued under the fixed designation D 3809; 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 These methods cover testing synthetic dielectric fluids currently in use for capacitors. The methods are generally suitable for specification acceptance, factory control, referee testing, and research. Their applicability to future fluids has not been determined.

1.2 The scope of some of the methods listed here apply to petroleum oils, but have been found suitable for synthetic fluids.

1.3 For polybutene fluids refer to Specification D 2296.

1.4 For silicone fluids refer to Methods D 2225.

1.5 A list of properties and standards are as follows:

Property Measured	Section	ASTM Test Method
Physical:		
Coefficient of thermal expansion	6	D 1903
Flash point	7	D 92
Pour point	8	D 97
Refractive index	9	D 1218
Specific gravity	10	D 1298
Viscosity	11	D 445
Chemical:		
Acid number	12	D 664
Water content	13	D 1533
Electrical:		
Relative permittivity	14	D 924
Dielectric strength	15	D 877
Dissipation factor	16	D 924

1.6 *This standard does not purport to address all of the safety problems, 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 92 Test Method for Flash and Fire Points by Cleveland Open Cup[2]

D 97 Test Method for Pour Point of Petroleum Products[2]

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)[2]

D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration[2]

D 877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes[3]

D 923 Test Method for Sampling Electrical Insulating Liquids[3]

D 924 Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids[3]

D 1218 Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids[2]

D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]

D 1533 Test Methods for Water in Insulating Liquids (Karl Fischer Reaction Method)[3]

D 1807 Test Methods for Refractive Index and Specific Optical Dispersion of Electrical Insulating Liquids[3]

D 1903 Test Method for Coefficient of Thermal Expansion of Electrical Insulating Liquids of Petroleum Origin, and Askarels[3]

D 2225 Test Methods for Silicone Fluids Used for Electrical Insulation[3]

D 2296 Specification for Continuity of Quality of Electrical Insulating Polybutene Oil for Capacitors[3]

D 2864 Terminology Relating to Electrical Insulating Liquids and Gases[3]

3. Terminology Definitions

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

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

3.3 *pour point*—the lowest temperature expressed as a multiple of 5°F (or 3°C), at which the oil is observed to flow when cooled, and examined under prescribed conditions.

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

3.5 *specific gravity*—the ratio of weight of a given volume of liquid 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.

[1] These methods are under the jurisdiction of ASTM Committee D-27 on Electrical Insulating Liquids and Gases and are the direct responsibility of Subcommittee D27.02on Gases and Synthetic Liquids.

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

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

3.6 *total acid number*—the quantity of base, expressed in milligrams of potassium hydroxide (KOH) that are required to titrate all acidic constituents present in 1 g of sample.

3.7 *viscosity*—the resistance of a fluid to a uniformly continuous flow, without turbulence, inertia, or other forces. The viscosity is usually measured by the time of flow of a given quantity of fluid under controlled conditions.

3.8 *water content*—the total quantity of water (expressed in parts per million by weight) in the fluid.

3.9 For additional terms refer to Terminology D 2864.

4. Significance and Use

4.1 Certain synthetic dielectric fluids are used in the manufacture of capacitors because of their chemical, thermal, and electrical properties as well as their environmental acceptability.

4.2 Properties of a synthetic dielectric fluid differ from those of petroleum based fluids. Design considerations and quality control are influenced by these properties as measured by the appropriate tests.

4.3 Each test method has its own brief statement describing its significance.

5. Sampling Procedures

5.1 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, 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 and in addition, results in a loss of time, effort, and expense involved in securing, transporting, and testing the sample.

5.2 Sample synthetic dielectric fluids in accordance with Test Methods D 923.

PHYSICAL METHODS

6. Coefficient of Thermal Expansion

6.1 *Significance*—A knowledge of the coefficient of thermal 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.

6.2 *Procedure*—Determine the coefficient of thermal expansion in accordance with Test Method D 1903.

7. Flash Point

7.1 *Significance*—The flash point of a synthetic fluid reveals the limit to which the material may be heated under the specified test conditions before the emitted vapors become a fire hazard. An unusually low flash point for a given product indicates the presence of hazardous, volatile, combustible, contaminants in the insulating liquid.

7.2 *Procedure*—Determine the flash point in accordance with Test Method D 92.

8. Pour Point

8.1 *Significance*—The pour point of a synthetic fluid gives an indication of the temperature below which it may not be possible to extract the fluid from its container.

8.1.1 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.

8.2 *Procedure*—Determine the pour point in accordance with Test Method D 97.

9. Refractive Index

9.1 *Significance*—The refractive index is useful in the detection of various types of contamination or in the identification of the molecular makeup of a synthetic insulating fluid.

9.2 *Procedure*—Determine the refractive index in accordance with Test Method D 1218.

10. Specific Gravity

10.1 *Significance*—Synthetic fluids are usually sold on a weight basis. The values for the specific gravities must frequently be known to calculate, at any given temperature, the volume of fluid present. Specific gravity has some significance in determining the quality since some of the synthetics are miscible but have different specific gravities. The specific gravity has no significance on the suitability of the fluid as an insulating medium.

10.2 *Procedure*—Determine the specific gravity in accordance with Test Method D 1298.

11. Viscosity

11.1 *Significance*—The viscosity of a synthetic fluid is important when using the fluid as an impregnant.

11.1.1 The viscosity of a synthetic fluid used in a capacitor, at the temperature of impregnation, is the principal factor in controlling the rate of impregnation.

11.2 *Procedure*—Determine the viscosity in accordance with Test Method D 445.

CHEMICAL METHODS

12. Acid Number

12.1 *Significance*—The acid number of a synthetic fluid is of importance as a quality index of purity. An increasing acid number may be an indication of deterioration of the synthetic fluid, or contamination, or both.

12.2 *Procedure*—Determine the acid number in accordance with Test Method D 664.

13. Water Content

13.1 *Significance*—The test is significant in that it will show the presence of water that may not be evident from electrical tests.

13.2 *Procedure*—Determine the water content in accordance with Test Methods D 1533.

ELECTRICAL METHODS

14. Relative Permittivity (Dielectric Constant)

14.1 *Significance*—Synthetic insulating fluids are used to function as the dielectric of a capacitor and it is desirable to have the highest possible value of relative permittivity, so that the capacitor may be physically as small as possible.

14.2 *Procedure*—Determine the relative permittivity in accordance with Test Method D 924.

15. Dielectric Strength

15.1 *Significance*—The dielectric strength of a synthetic dielectric fluid is important as a measure of its ability to withstand electric stress without failure. It may also serve to indicate the presence of contaminating agents, such as water, dirt, or conducting particles in the fluid, one or more of which may be present simultaneously when low dielectric strength values are found by test. A high dielectric strength is not a certain indication of the absence of all contaminants.

15.2 *Procedure*—Determine the dielectric strength in accordance with Test Method D 877.

16. Dissipation Factor [4]

16.1 *Significance*—The dissipation factor of a synthetic fluid is a measure of the power (energy per cycle) dissipated in a unit volume of the fluid under specified conditions of voltage gradient and current density. Dissipation factor may be useful as a means for quality control and as an indication of changes in the fluid resulting from deteriorating and contaminating influences.

16.2 *Procedure*—Determine the dissipation factor of a synthetic fluid in accordance to Test Method D 924.

17. Report

17.1 If a report is required, use the separate reports detailed in the specific referenced methods used.

18. Precision and Bias

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

[4] For practical purposes the values of power factor and dissipation factor are equivalent due to the relationship shown in Equation 8 of Method D 150, Test for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials, Vol 10.02 of the *Annual Book of ASTM Standards*. The majority of the bridges measure dissipation factor.