



Designation: D4733 – 13

Standard Test Methods for Solventless Electrical Insulating Varnishes¹

This standard is issued under the fixed designation D4733; 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 test methods cover solventless varnishes used primarily as electrical, mechanical, and environmental protection for electrical equipment.

1.2 These test methods are used on solventless varnishes that are applied by dipping (at atmospheric pressure conditions or under vacuum or other certain pressure), spraying, or brushing for the purpose of impregnating or sealing electrical equipment. The following test methods are included:

Property Tests (Uncured):	Section
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Performance Property Tests (cured):	
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1.3 The values stated in inch-pound units are to be regarded as the standard. The values in parentheses are for information only.

1.4 *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.* Specific hazard statements are given in 8.3, 15.5.1, and 15.5.2.

NOTE 1—This test method is related to IEC 60455. Since both methods contain multiple test procedures, many procedures are technically equivalent while others differ significantly.

2. Referenced Documents

2.1 ASTM Standards:²

- D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
- D115 Test Methods for Testing Solvent Containing Varnishes Used for Electrical Insulation
- D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
- D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation
- D168 Test Method for Coke Residue of Creosote (Withdrawn 2006)³
- D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)³
- D923 Practices for Sampling Electrical Insulating Liquids
- D1475 Test Method For Density of Liquid Coatings, Inks, and Related Products
- D1711 Terminology Relating to Electrical Insulation
- D2196 Test Methods for Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer
- D2519 Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test
- D3056 Test Method for Gel Time of Solventless Varnishes
- D3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus
- D3312 Test Method for Percent Reactive Monomer in Solventless Varnishes
- D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus
- D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials
- D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)³
- E176 Terminology of Fire Standards

¹ These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.01 on Electrical Insulating Varnishes, Powders and Encapsulating Compounds.

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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.

³ The last approved version of this historical standard is referenced on www.astm.org.

*A Summary of Changes section appears at the end of this standard

2.2 IEC Standards

IEC 60455 Resin Based Reactive Compounds Used for Electrical Insulation

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in these test methods, refer to Terminology **D1711**. For definitions of terms associated with fire issues, refer to Terminology **E176**.

3.1.2 *gel time, n—of solventless varnish*, the time required at a specified temperature for a solventless varnish to be transformed from a liquid state to a gel as measured with a suitable gel time apparatus.

3.1.3 *thixotropy, n*—the property of a material to thin upon isothermal agitation and to thicken upon subsequent rest.

3.1.4 *varnish, electrical insulating, n*—a liquid resin system that is applied to and cured on electrical components providing electrical, mechanical, and environmental protection.

3.1.4.1 *Discussion*—There are two types of electrical insulating varnish—solvent-containing and solventless. The solvent-containing varnish is solution, dispersion, or emulsion of a polymer or a mixture of polymers in a volatile, nonreactable liquid. The solventless type is a liquid resin system free of volatile, nonreactable solvents.

4. Significance and Use

4.1 The test methods referenced in these test methods are useful for control purposes during the manufacture and use of solventless varnishes.

5. Sampling

5.1 Accurate sampling, whether of the complete contents or only parts thereof, is extremely important from the standpoint of evaluating the quality of the product sampled. In most cases, the detection of contaminants that are not ordinarily dispersed uniformly through the liquid being sampled such as water or solid particles, necessitates taking samples at specific locations where the contaminants are likely to be found. For a liquid having a specific gravity less than one, water and other impurities are most likely to be found on the bottom; whereas in the case of liquids having a specific gravity greater than one, these impurities are most likely to be found on the surface.

5.2 Sampling Fluids Exhibiting Newtonian Viscosity:

5.2.1 Sample solventless varnishes having an approximate viscosity of 25 cP (0.025 Pa·s) or less at 100°F (37.8°C) using the sampling device shown in Fig. 1 of Test Method **D923**. However, if the temperature of the material is below room temperature or if the humidity is above 75 % relative humidity, sample using an aspirator-type sampling device as shown in Fig. 2 of Test Method **D923**.

5.2.2 Sample solventless varnishes having a viscosity from 25 to 650 cP (0.025 to 0.65 Pa·s) at 100°F (37.8°C) and where contact with the atmosphere must be avoided, use a pressure-type sampling device as shown in Fig. 3 of Test Method **D923**.

5.2.3 Sample solventless varnishes having a viscosity above 650 cP at 100°F at 73 ± 10°F (23 ± 5°C). Open the container and mix slowly so as not to entrap air. When the material is

homogeneous, take samples from two or three places on the surface and mix together.

5.3 Sampling Fluids Exhibiting Non-Newtonian Viscosity:

5.3.1 Sample solventless varnishes exhibiting non-Newtonian viscosity in accordance with **5.2.3**.

5.4 Use sample containers and sampling procedures in accordance with Test Method **D923**.

5.5 When a sampling method is needed to determine whether a lot meets the requirements of a material specification, use Practice **D3636** as a guide.

6. Conditioning

6.1 Condition test specimens at standard laboratory condition as specified in Practice **D6054**.

6.2 Deaerate specimens to be used for property evaluation before curing using the vacuum technique recommended by the varnish manufacturer.

TEST METHODS

7. Density

7.1 *Scope*—This test method covers the measurement of the density using a pycnometer. It is particularly applicable where the fluid has too high a viscosity for other methods of testing density. In this test method the density will be expressed as pounds per gallon (grams per millilitre) at 70 to 77°F (20 to 25°C).

7.2 *Procedure*—Test for density in accordance with Test Method **D1475**.

7.3 *Report*—Report the following information:

7.3.1 Identification of the test sample,

7.3.2 The test temperature to the nearest 0.2°F (0.1°C),

7.3.3 Density to the nearest 0.01 lb/gal (0.001 g/mL), and

7.3.4 The mean, the range, and the number of replicate determinations.

8. Flash Point

8.1 *Scope*—This test method covers the determination of the flash point of solventless varnishes. There are two types of materials involved:

8.1.1 Those varnishes having a flash point above 230°F (110°C), and

8.1.2 Those varnishes having a flash point below 230°F (110°C).

8.2 *Summary of Test Method*—A specified amount of sample is added to the instrument. The temperature of the material is increased at a constant rate until a small flame ignites the vapor of the specimen in the tester and propagates a flame across its surface. The temperature at ignition is taken as the flash point.

8.3 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products or assemblies under actual fire conditions.*

8.4 *Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.*

8.5 *Procedure:*

8.5.1 Test the materials of 8.1.1 in accordance with Test Methods D93.

8.5.2 Test the materials of 8.1.2 in accordance with Test Method D3278.

8.6 *Report*—Report information in accordance with the report section of the test method used.

9. Gel Time

9.1 *Scope*—This test method covers the determination of gel time of a solventless varnish mixed with a reactor or catalyst and exposed to elevated temperatures.

9.2 *Significance and Use*—Knowledge of gel time is important for determining shelf life, batch uniformity, and processing characteristics.

9.3 *Procedure*—Test for gel time in accordance with Test Method D3056.

9.4 *Report*—Report the following information:

9.4.1 Identification of the material,

9.4.2 The reactor or catalyst and quantity used shall be described if the reactor or catalyst is supplied in a separate package,

9.4.3 Gel time to the nearest 0.1 min,

9.4.4 Temperature of the bath, and

9.4.5 Liquid used in the bath.

10. Monomer Content

10.1 *Scope*—This test method covers the determination of the percent monomer having a vapor pressure exceeding 0.1 Torr (13 Pa) at 77°F (25°C).

10.2 *Significance and Use*—The percent of reactive monomer in a solventless varnish will affect the viscosity, handling, and processing properties of the uncured resin. The amount of reactive monomer also has the potential to affect the physical and electrical properties of the cured resin.

10.3 *Procedure*—Test for the monomer content in accordance with Test Method D3312.

10.4 *Report*—Report the following information:

10.4.1 Identification of the solventless varnish, and

10.4.2 Percent reactive monomer.

11. Rheological Properties (Non-Newtonian)

11.1 *Scope*—This test method covers the determination of the rheological properties of solventless varnishes that are non-newtonian in character.

11.2 *Significance and Use*—This test method is used to test solventless varnishes that are thixotropic in nature and require specific treatment of the sample in order to determine this property.

11.3 *Procedure*—Test for thixotropy in accordance with Test Method D2196, Method B or C.

11.4 *Report*—Report information as specified in Test Method D2196.

12. Brookfield Viscosity

12.1 *Scope*—This test method covers the determination of viscosity for liquids having flow properties approaching those of the newtonian solutions.

12.2 *Apparatus:*

12.2.1 *Brookfield Viscometer.*

12.2.2 *Thermometer.*

12.2.3 *Water Bath.*

12.2.4 *Stirrer.*

12.3 *Procedure:*

12.3.1 Bring the specimen to a temperature of $77 \pm 2^\circ\text{F}$ ($25 \pm 1.0^\circ\text{C}$) using a water bath and stirrer if necessary. Allow the specimen to sit in the water bath at $77 \pm 2^\circ\text{F}$ until no bubbles are visible in the specimen.

12.3.2 Make all measurements with the Brookfield viscometer at $77 \pm 2^\circ\text{F}$ ($25 \pm 1.0^\circ\text{C}$).

12.4 *Report*—Report information as specified in Test Method D2196.

12.5 *Precision and Bias:*

12.5.1 *Precision*—See Test Method D2196 for a statement of precision.

12.5.2 *Bias*—See Test Method D2196 for a statement of bias.

13. Bond Strength

13.1 *Scope*—This test method covers the determination of the bond strength of an electrical insulating varnish when applied to a helical coil.

13.2 *Significance and Use*—Values obtained by flexural test can provide information with regard to the bond strength of a particular varnish in combination with a particular wire when measured under the prescribed conditions.

13.3 *Procedure*—Perform the test in accordance with Test Method D2519.

13.4 *Report*—Report information in accordance with Test Method D2519.

13.5 *Precision and Bias:*

13.5.1 *Precision*—See Test Method D2519 for a statement of bias.

13.5.2 *Bias*—See Test Method D2519 for a statement of bias.

14. Coating Thickness

14.1 *Scope:*

14.1.1 This test method is used to determine the thickness of a coating obtained with a solventless varnish.

14.1.2 The shear history of the varnish immediately preceding the test has the potential to have an appreciable effect on the coating thickness obtained. This test method specifies the degree of shear of the sample and the rate of withdrawal of the specimen in order to arrive at a reproducible buildup on a test specimen.