Designation: D3955 – 13

# Standard Specification for Electrical Insulating Varnishes[1]

This standard is issued under the fixed designation D3955; 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 specification covers the tests and values for electrical insulating varnishes, as supplied, which are suitable for the impregnation and treatment of electrical coils and windings applied by dip process.

1.2 Varnishes, flexible or rigid, included in this specification are:

*Grade DA*—Air-dry
*Grade DO*—Organic solvent containing, baking,
*Grade DM*—Reactive diluent containing,
*Grade DS*—Silicone,
*Grade DW*—Water containing, and
*Grade DT*—Thixotropic.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

NOTE 1—This specification resembles IEC 60455 in title only. The content is significantly different.

## 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
D1711 Terminology Relating to Electrical Insulation
D2519 Test Method for Bond Strength of Electrical Insulating Varnishes by the Helical Coil Test
D3056 Test Method for Gel Time of Solventless Varnishes
D3145 Test Method for Thermal Endurance of Electrical Insulating Varnishes by the Helical Coil Method
D3251 Test Method for Thermal Endurance Characteristics of Electrical Insulating Varnishes Applied Over Film-Insulated Magnet Wire
D3278 Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus
D4733 Test Methods for Solventless Electrical Insulating Varnishes
D4880 Test Method for Salt Water Proofness of Insulating Varnishes Over Enamelled Magnet Wire
D5637 Test Method for Moisture Resistance of Electrical Insulating Varnishes
D5638 Test Method for Chemical Resistance of Electrical Insulating Varnishes

2.2 *Military Specifications:*[3]

MIL-PRF-17672 Hydraulic Fluid, Petroleum, Inhibited
MIL-PRF-17331 Lubricating Oil, Synthetic Base P-D-680, Dry Cleaning Solvent
MIL-D-16791 Detergent, General Purpose, (Liquid, Non-Ionic)

2.3 *Other Standards:*[3]

NEMA MW1000 Magnet Wire
IEC 60455 Resin Based Reactive Compounds Used for Electrical Insulation

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this specification refer to Terminology D1711.

## 4. Flexible or Rigid Classification

4.1 This specification covers both flexible and rigid, solvent (including water) and solventless insulating varnishes.

## 5. Thermal Classification

5.1 The thermal classification of insulating varnishes covered by this specification is determined by using Test Methods D3145 and D3251 in conjunction with 18 AWG magnet wire conforming to MW 35-C and MW 16-C in accordance with NEMA MW1000. Determine the temperature index at 20 000 h.

[1] This specification is 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] Available from Global Engineering Documents, 15 Inverness Way, East Englewood, CO 80112-5704, http://www.global.ihs.com.

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

5.2 The thermal class is determined from the temperature index range as follows:

| Thermal Class | Temperature Index Range |
|---|---|
| 130 | 130.0 to 154.9 |
| 155 | 155.0 to 179.9 |
| 180 | 180.0 to 199.9 |
| 200 | 200.0 to 219.9 |
| 220 | 220.0 and above |

## 6. General Specifications and Qualification Requirements

6.1 All varnishes supplied under this specification must conform to the limits outlined in Table 1, and must meet, or exceed, all specification requirements.

6.2 A varnish supplied under this specification is to be manufactured from one specific formula and one specific process at one or more plants of the same company.

6.3 Changes involved solely with percent nonvolatile content or compatible solvent system, do not require requalification, if agreed upon between supplier and user.

6.4 If any formula or process changes are desired after qualification approval has been granted, conduct the tests in Table 1, except for thermal class.

6.5 If varnishes from different suppliers are to be mixed or used in a common tank or container, determine their compatibility by Test Methods D115. They must be compatible, both in the liquid and solid state, with the varnish currently being used in the system.

6.6 Varnishes containing silicone in any portion, must not be mixed with non-silicone varnishes.

6.7 The qualification requirements of the varnish shall be as mutually agreed upon between supplier and user, with tests to be performed in accordance with the appropriate methods, and limits as shown in Table 1.

6.8 *Preconditioning: Grade DA Varnishes Only*—Precondition all Grade DA varnish specimens, both flexible and rigid, in air at room temperature for seven days prior to carrying out dielectric strength and bond strength tests shown in Table 1.

## 7. Hazards

7.1 It is unsafe to use varnish at temperatures above the flash point without adequate ventilation, especially if the possibility exists that flames or sparks are present. Store varnish in sealed containers.

## 8. Sampling

8.1 Obtain varnish samples and appropriate thinner either from the manufacturer or directly from shipping containers supplied from the manufacturer. It is also acceptable to obtain suitable samples from material in process. It is important that new, or thoroughly cleaned sampling containers be used. It is acceptable to obtain suitable samples by any of a number of procedures commonly used in the industry. Normally, the sample is simply poured from the shipping container. The sample container shall have a tight fitting cover to minimize the loss of solvents. A dipping ladle is an acceptable choice, or, if it is desirable to obtain a sample from various levels, use appropriate sampling techniques.

8.2 The quantity of sample is that required as indicated in 9.1.

## 9. Quality Conformance Tests

9.1 *General Requirements*—From each batch of varnish, take a 2-qt (2-L) sample and test. The values must meet the limits listed for specification requirements shown in Table 1, or as agreed upon between supplier and user.

9.2 *Inspection and Preparation for Delivery*—Select samples and inspect to verify conformance with the requirements in Section 6.

## 10. Keywords

10.1 varnish, air-dry; varnish, electrical; varnish, silicone; varnish, solvent containing; varnish, thixotropic; varnish, water containing

**TABLE 1 Specification Requirements**

| Grade | | ASTM Test Method | Minimum Thermal Class | | | | | |
|---|---|---|---|---|---|---|---|---|
| Class | Type of Magnet Wire Over which Varnish is Applied | | DA | DO | DM | DS | DW | DT |
| 130 | MW 35-C and MW 16-C | D3251 and D3145 | Class 130 for both wire types and both test methods | | | | | |
| 155 | MW 35-C and MW 16-C | D3251 and D3145 | Class 155 for both wire types and both test methods | | | | | |
| 180 | MW 35-C and MW 16-C | D3251 and D3145 | Class 180 for both wire types and both test methods | | | | | |
| 200 | MW 35-C and MW 16-C | D3251 and D3145 | Class 200 for both wire types and both test methods | | | | | |
| 220 | MW 35-C and MW 16-C | D3251 and D3145 | Class 220 for both wire types and both test methods | | | | | |
| Dielectric strength, V/mil, min, on metal panels | | D115/D4733 | | | | | | |
| Conditioned 24 h at 23°C and 50 % RH | | | 1500 | 2000 | 1500 | 1800 | 2000 | 1500 |
| Conditioned 24 h at 23°C and 96 % RH | | | 975 | 1500 | 1125 | 1350 | 1500 | 1125 |
| Conditioned 24 h at 23°C in deionized water | | | 900 | 1500 | 1125 | 1350 | 1500 | 1125 |
| Bond strength (minimum pounds) over 18 AWG | | D2519 | | | | | | |
| MW 16-C or MW 35-C | | | | | | | | |
| Flexible at 77°F/300°F (25°C/150°C) | | | 5/0 | 10/1 | 10/1 | 6/0.5 | 20/1 | 15/2 |
| Rigid at 77°F/300°F (25°C/150°C) | | | NA[A] | 20/3 | 25/4 | NA | 25/3 | 30/5 |
| Salt water proofness | | D4880 | | | | | | |
| over MW 35-C or MW 16-C | | | 100[B] | 100[B] | 100[B] | 100[B] | 100[B] | 100[B] |
| Moisture resistance | | D5637 | | | | | | |
| percent retained, min | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Chemical resistance | | D5638 | | | | | | |
| minimum percent retained after 168 h at 73°F (23°C) | | | | | | | | |
| Hydraulic fluid[C] | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Lubricating oil[D] | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Cleaning fluid[E] | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Distilled water | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Detergent solution[F] | | | 50 | 50 | 50 | 50 | 50 | 50 |
| Storage life, months min[G] | | | 12 | 12 | 6 | 6 | 6 | 6 |
| Viscosity (cps at 77°F (25°C)) | | D115/D4733 | 80–1200 | 100–1200 | 100–1300 | 80–240 | 100–1300 | 15 000[H] 5000[I] |
| Thixotropic index, min | | D4733 | NA | NA | NA | NA | NA | 1.1 |
| % Nonvolatile matter, min | | D115 | 30 | 40 | NA | 40 | 35 | NA |
| Variation in specific gravity/density (% of reported value) | | D115/D4733 | ±1.0 | ±1.0 | ±1.0 | ±1.0 | ±1.0 | ±1.0 |
| Build as received (mils, min) | | D115/D4733 | 0.9 | 0.9 | 0.3 | 0.5 | 0.8 | 1.1 |
| Flash point (°F (°C), min) | | D93/D3278 | 73 (23)[J] | 73 (23)[J] | 200 (93)[J] | 73 (23)[J] | 194 (90)[J] | 200 (93)[J] |
| Drying time (h at °F (°C)) max | | D115 | 3 at 230 (110) | 2 at 300 (150) | NA | 6 at 390 (200) | 2 at 300 (150) | NA |
| Variation in gel time (% of reported value) | | D3056 | NA | NA | ±10.0 | NA | NA | ±10.0 |

[A] Not applicable.
[B] Passing is defined as 7 of 9 specimens still passing at specified time.
[C] In accordance with MIL-PRF-17672.
[D] In accordance with MIL-PRF-17331.
[E] In accordance with P-D-680[1,1,2-trichloro 1,2,2-trifluoroethane].
[F] Detergent per MIL-D-16791, non-ionic detergent (1 lb per 2¼ gal water).
[G] As warranted by the manufacturer.
[H] Maximum at 2 r/min.
[I] Maximum at 20 r/min.
[J] Or as agreed to by supplier and user.

## SUMMARY OF CHANGES

Committee D09 has identified the location of selected changes to this specification since the last issue, D3955–04(2009), that may impact the use of this specification. (Approved April 1, 2013)

*(1)* Changes made in 8.1.