INTERNATIONAL

Designation: ~~D2305 – 10~~ D2305 – 18

Standard Test Methods for Polymeric Films Used for Electrical Insulation[1]

This standard is issued under the fixed designation D2305; 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~~ Scope*

1.1 These test methods cover the testing of homogeneous organic polymer films not over 2.4 mm (95 mils) thick that are to be used for electrical insulation.

1.2 These test methods are not necessarily applicable to testing films in combinations with a coating, another film, or with other types of substrate, such as fabrics or papers.

1.3 The values stated in SI units are the standard. The values in parentheses are provided for information only.

1.4 The procedures appear in the following sections:

Procedure	Sections
~~Conditioning~~	~~5 and 6~~
Conditioning	6 and 7
~~Dielectric Breakdown Voltage & Dielectric Strength~~	~~20 to 25~~
Dielectric Breakdown Voltage & Dielectric Strength	21 to 26
~~Extractables~~	~~64 to 69~~
Extractables	65 to 70
~~Heat-Seal Strength~~	~~58 to 63~~
Heat-Seal Strength	59 to 64
~~Permittivity and Dissipation Factor~~	~~41 to 46~~
Permittivity and Dissipation Factor	42 to 47
Resistance Method for Measuring the Tendency to ~~Corrode Metals~~	~~37 to 40~~
Corrode Metals	38 to 41
~~Sampling~~	~~4~~
Sampling	5
~~Shrinkage~~	~~47 to 52~~
Shrinkage	48 to 53
~~Strain Relief~~	~~12 to 19~~
Strain Relief	13 to 20
~~Surface Resistivity~~	~~26 to 30~~
Surface Resistivity	27 to 31
~~Tensile Properties~~	~~11~~
Tensile Properties	12
~~Thickness~~	~~7 to 10~~
Thickness	8 to 11
~~Volume Resistivity~~	~~31 to 36~~
Volume Resistivity	32 to 37
~~Water Absorption~~	~~52 to 57~~
Water Absorption	53 to 58

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use. ~~For a specific warning statement see 23.1.~~*

NOTE 1—These test methods are similar to IEC 60674–2.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.07 on ~~Flexible and Rigid~~ Electrical Insulating Materials.

Current edition approved ~~Oct. 1, 2010~~May 1, 2018. Published ~~October 2010~~June 2018. Originally published in 1964. Last previous edition approved in ~~2002~~2010 as ~~D2305 – 02.~~D2305 – 10. DOI: ~~10.1520/D2305-10.~~10.1520/D2305-18.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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
D257 Test Methods for DC Resistance or Conductance of Insulating Materials
D374 Test Methods for Thickness of Solid Electrical Insulation (Metric) D0374_D0374M
D570 Test Method for Water Absorption of Plastics
D882 Test Method for Tensile Properties of Thin Plastic Sheeting
D883 Terminology Relating to Plastics
D1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
D1531 Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures (Withdrawn 2012)[3]
D1676 Test Methods for Film-Insulated Magnet Wire
D1711 Terminology Relating to Electrical Insulation
D5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions
D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *IEC Standard:*

Publication 60674–2 Specification for Plastic Films for Electrical Purposes[4]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminologies D1711 and D883 unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sheet, n*—material greater than 75 mm in width.

3.2.2 *strain relief, n*—relaxation at a specified elevated temperature of induced strains.

3.2.3 *strip, n*—material 75 mm or less in width.

4. Hazards

4.1 *High Voltage:*

4.1.1 Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation.

4.1.2 Solidly ground all electrically conductive parts which it is possible for a person to contact during the test.

4.1.3 Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source.

4.1.4 Thoroughly instruct all operators as to the correct procedures for performing tests safely.

4.1.5 When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available. See section

5. Sampling

5.1 Remove the outer three or more layers down from the roll or stack of material before sampling.

5.2 If the film is known or suspected to be anisotropic for a given property, prepare and mark each test specimen to indicate the axis of maximum orientation. The axis parallel to the direction of extrusion, or casting, is conventionally described as the machine direction and is abbreviated MD. The axis that is normal to both the MD axis and the thickness axis is conventionally described as the transverse direction and is abbreviated TD.

5.3 Prepare test specimens suitable for each test from samples that have been cut across the entire width of the sampled material. If the width of strip material is too small to permit preparation of specimens of the required dimensions, then it is acceptable to prepare specimens from samples taken from mill rolls prior to slitting to the furnished width.

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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.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

CONDITIONING

6. Significance and Use

6.1 Many electrical and physical properties of films vary significantly with changes in temperature and humidity. Properties of thin plastic films can change very rapidly; therefore, the specimen needs to be in the stated conditioning environment when the test is being performed. When the test is performed in a different environment, note these conditions and the time of exposure to this new environment.

7. Procedure

7.1 Unless otherwise specified in the individual test methods, test the specimens in the Standard Laboratory Atmosphere 23 ± 2°C, 50 ± ~~5 % R.H. prescribed in Practice~~ 10 % R.H.~~D6054.~~

THICKNESS

8. Significance and Use

8.1 The determination of film thickness is frequently necessary to ensure (*1*) the satisfactory production of electrical equipment, and (*2*) the maintenance of desired electrical properties of the film during the use of the electrical equipment. Some properties, such as dielectric strengths, vary with the thickness of the material; other properties, such as permittivity, cannot be calculated without a proper determination of thickness unless special techniques are used.

9. Procedure

9.1 Use Method C of Test Methods D374 for this measurement, with the apparatus modified as follows: Use a presser foot of 6.25 ± 0.05 mm (250 ± 1 mil) diameter, and an anvil surface, upon which the specimen rests, of at least 50-mm (2-in.) diameter. Apply a force of 0.84 ± 0.2 N (3 ± 0.75) ozf to the specimen. Take ten measurements, equally spaced throughout the specimen.

10. Report

10.1 Report the average, maximum, and minimum thicknesses to the nearest 0.5 µm (0.02 mil) for specimens thinner than 50 µm (2 mils) and to the nearest 1 µm (0.04 mil) for specimens 50 µm (2 mils) or more in thickness.

11. Precision and Bias

11.1 *Precision*—A formal round robin test in accordance with Practice E691 has not been conducted. Persons familiar with this method have determined that two test results can be expected (with a probability of 95 %) to agree within 3 %. Each test result is the average of 10 thickness readings taken on a single sample of polyimide film in one laboratory in which a multiple number of operators used the same apparatus.

11.2 *Bias*—This test method has no bias because the value for thickness is determined solely in terms of this test method.

TENSILE PROPERTIES

12. Procedure

12.1 Use Method A of Test Methods D882. Report data only for the specific tests required by a specification.

12.2 Prepare five specimens in each of the two principal directions, each 12 by 200 mm (0.5 by 8 in.).

12.3 Unless otherwise stated, measure the tensile strength and tensile elongation, with initial jaw separation of 100 ± 2 mm (4.0± 0.08 in.) and rate of jaw separation of 50 ± 2 mm (2 ± 0.08 in.)/min.

12.4 For each specimen, record the thickness and width prior to the application of the tensile force. Use these values to calculate the tensile strength for each specimen. Report the tensile strength in MPa (lbf/in.^{2}).

STRAIN RELIEF

13. Significance and Use

13.1 The strain relief test gives an indication of the dimensional changes that have the potential to occur when a film is exposed to elevated temperatures during a manufacturing process or while in service.

14. Apparatus

14.1 *Ovens,* shall be of a forced-convection type capable of maintaining the specified ~~temperature± 5°C.~~temperature ±5°C.

14.2 Scale, graduated in 0.25-mm (0.01-in.) divisions with a total length of at least 300 mm (12 in.).

15. Test Specimen

15.1 Prepare test specimens 25 mm (1 in.) wide and at least 300 mm (12 in.) long. When sheets or rolls are greater than 300 mm wide, also cut specimens in the transverse direction.

16. Conditioning

16.1 Condition test specimens in accordance with Section 67 before the initial and final measurements are made.

17. Procedure

17.1 Mark gage lines on five specimens approximately 25 mm (1 in.) in from the ends of the specimen at a gage distance of 250 mm (10.0 in.). Determine the initial gage distance by measuring both edges of each specimen. Hang the specimen freely in the oven at the time and temperature specified for the material. Determine the final gage distance by measurement after conditioning.

17.1.1 Use a marking technique that does not affect the properties or dimensions of the material.

17.1.2 Adjust the air flow in the oven so that the specimens do not whip.

18. Calculation

18.1 Calculate the liner dimensional change as follows:

$$\text{Linear change, \%} = \left[(D_t - D_v)/D_v\right] \times 100 \tag{1}$$

where:

D_t = final dimensions, in. (mm), and
D_v = original dimension, in. (mm).

A negative value denotes shrinkage, and a positive value indicates expansion.

18.2 Average the values obtained for each direction.

19. Report

19.1 Report the following information:

19.1.1 Identification of the material tested,

19.1.2 Test conditions (time and temperature), including the conditioning of the test specimens,

19.1.3 Average percentage linear change and maximum deviations, in both machine and transverse directions of the film, and

19.1.4 Any curl at the edges or other visual defects.

20. Precision and Bias

20.1 *Precision*—This test method has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

20.2 *Bias*—This test method has no bias because the value for strain relief is determined solely in terms of this test method itself.

DIELECTRIC BREAKDOWN VOLTAGE AND DIELECTRIC STRENGTH

21. Significance and Use

21.1 The dielectric breakdown voltage and dielectric strength of a film is an indication of its ability to withstand electric stress. This value needs to be used primarily as an indication of quality and for comparison of different lots or types of the same material. Secondarily, this value will potentially be useful as a design criterion, particularly when considering short term exposures, providing that sufficient experience has been gained to give an adequate correlation between this test and the proposed end uses.

21.2 Unless special precautions are taken, these test results will potentially be just a measure of the quality of the electrode surfaces and the electrical apparatus. This is especially true with thinner films.

21.3 For further details on the significance of this test, refer to Test Method D149.

22. Apparatus

22.1 Use apparatus that conforms to that specified in Test Method D149, including the 25-mm (1-in.) diameter electrodes described therein. As an exception, the 6.4-mm (¼-in.) diameter electrodes are permitted where only narrow tape is available; and note such exceptions in the report. For further details on electrodes refer to the electrode section of Test Method D149.

NOTE 2—Tests made with different size electrodes are not necessarily comparable. In many cases, a change in electrode size can make a significant difference in test results. Take care to keep electrodes parallel, clean, and free of pits.

23. Test Specimen

23.1 Test clean specimens only. Surface contamination can form dents when the electrodes are applied to the specimen or can alter the electrical field pattern, or both, to give erroneous results.

NOTE 3—To help prevent the specimen from becoming contaminated during the test, it is recommended that the tests be made in a clean, air-conditioned room supplied with filtered air.

24. Procedure

24.1 Determine the dielectric breakdown voltage in air and dielectric strength in accordance with Test Method D149, and in accordance with the applicable sections of this test method. Unless otherwise specified, make ten breakdown measurements, equally spaced throughout the specimen.

NOTE 4—When testing films in a medium other than air, it is possible that different results will be obtained.

~~(**Warning**—*Lethal voltages are a potential hazard during the performance of this test. It is essential that the test apparatus, and all associated equipment electrically connected to it, be properly designed and installed for safe operation. Solidly ground all electrically conductive parts which it is possible for a person to contact during the test. Provide means for use at the completion of any test to ground any parts which were at high voltage during the test or have the potential for acquiring an induced charge during the test or retaining a charge even after disconnection of the voltage source. Thoroughly instruct all operators as to the correct procedures for performing tests safely. When making high voltage tests, particularly in compressed gas or in oil, it is possible for the energy released at breakdown to be sufficient to result in fire, explosion, or rupture of the test chamber. Design test equipment, test chambers, and test specimens so as to minimize the possibility of such occurrences and to eliminate the possibility of personal injury. If the potential for fire exists, have fire suppression equipment available.*)~~

25. Application of Voltage

25.1 Unless otherwise specified, use the short-time test method with a rate of rise of 500 V/s.

26. Report

26.1 Unless otherwise specified, report the following information:

26.1.1 Average breakdown voltage,

26.1.2 Average thickness of breakdown specimens,

26.1.3 Average, maximum, and minimum dielectric strength (optional),

26.1.4 Ambient medium and ambient condition,

26.1.5 Conditioning of specimens,

26.1.6 Rate of voltage increase, and

26.1.7 Size and material of electrodes used.

SURFACE RESISTIVITY

27. Significance and Use

27.1 Surface resistivity is of value for determining the suitability of a material under severe service conditions such as high temperature and high humidity. Its primary use needs to be as an indication of quality and for comparison of different lots or types of the same material. Secondarily, it is possible that this test will be used to classify materials into broad groups that differ from each other by at least one power of ten.

28. Conditioning

28.1 Use one or more of the following conditions (see Practice D6054):

28.1.1 Condition 18/35/90,

28.1.2 Condition 2/90, or

28.1.3 Condition 2/130.

29. Procedure

29.1 Determine the surface resistivity in the conditioning atmosphere in accordance with Test Methods D257, using strip electrodes as shown in Fig. number 3 of that test method.

29.2 It is important that the specimens not be contaminated during the placement of the electrodes.

29.3 Do not allow the specimens used for test to contact unclean surfaces and do not touch them without wearing clean gloves.

29.4 Before testing any film of questionable cleanliness, clean it in accordance with the manufacturer's suggestions.

29.5 Cut test specimens to a width of 25 mm (1 in.).

29.6 Calculate resistivity by multiplying resistance values by the ratio of the specimen width to the distance between electrodes.

29.7 Use an electrification time of 1 min ± 5 s at 100 V dc ± 5 V unless otherwise specified (see ~~23.1~~24.1).

30. Report

30.1 Report all the items listed in Test Methods D257.

31. Precision and Bias

31.1 *Precision*—This test method has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

31.2 *Bias*—This test method has no bias because the value for surface resistivity is determined solely in terms of this test method itself.

VOLUME RESISTIVITY

32. Significance and Use

32.1 Refer to Test Methods D257.

33. Test Specimen

33.1 Prepare five specimens by depositing a 25-mm (1-in.) diameter electrode of silver conductive paint or evaporated metal on each side of the film. Take special care so that the circles on the two sides are in register.

NOTE 5—Use a silver paint whose solvent will not cause crazing or otherwise affect the test specimen.
NOTE 6—For films greater than 0.12 mm (5 mils) in thickness, a guard electrode is usually required.

34. Procedure

34.1 Apply 100 V dc for 1 min unless otherwise specified. Measure the volume resistance in accordance with Test Methods D257.

35. Calculation

35.1 Calculate the volume resistivity in accordance with Test Methods D257 except that, where no guard electrode is used, the area is based on the 25-mm (1-in.) diameter electrode.

36. Report

36.1 Report all items listed in Test Methods D257.

37. Precision and Bias

37.1 *Precision*—This test method has been in use for many years, but no information has been presented to ASTM upon which to base a statement of precision. No activity has been planned to develop such information.

37.2 *Bias*—This test method has no bias because the value for volume resistivity is determined solely in terms of this test method itself.

RESISTANCE METHOD FOR MEASURING THE TENDENCY TO CORRODE METALS

38. Significance and Use

38.1 Severe electrolytic corrosion has the potential to cause open circuit failures, leakage current paths, or weak pitted wires. The resistance test method is of value as an indirect indication of the possible corrosive effect of a film on metals under conditions of high humidity when, and if, subjected to an electrical potential. While other factors also are of importance in controlling metal corrosion, the total amount of electrolytic corrosion of the metal is proportional to the currents carried by the film.

39. Procedure

39.1 Determine the surface resistivity of the film in accordance with Section ~~28~~29, with the following exceptions:

39.1.1 Condition the specimens for 18 h at a relative humidity of ~~96±~~ 96 ± 2 % and 23 ± 1°C (73 ± 2°F). Satisfactory means of obtaining this relative humidity are described in Practice D5032. Make at least five determinations for surface resistivity at this environmental condition using an electrification time of 15 s and a voltage of 100 to 130 V dc.

NOTE 7—Apparatus found satisfactory for these measurements is described in Test Methods D1000.

40. Report

40.1 Report the following information:
40.1.1 Identification of the film,
40.1.2 Width of the film,
40.1.3 Number of measurements, and
40.1.4 Median, minimum, and maximum resistance in megohms.