



# Standard Test Methods for Polymeric Films Used for Electrical Insulation<sup>1</sup>

This standard is issued under the fixed designation D 2305; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. 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
Dielectric Breakdown Voltage & Dielectric Strength	20 to 25
Extractables	64
Extractables	64 to 69
Heat-Seal Strength	58 to 63
Permittivity and Dissipation Factor	41 to 46
Resistance Method for Measuring the Tendency to Corrode Metals	37 to 40
Sampling	4
Shrinkage	47 to 52
Strain Relief	12 to 19
Surface Resistivity	26 to 30
Tensile Properties	11
Thickness	7 to 10
Volume Resistivity	31 to 36
Water Absorption	52 to 57

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.* For a specific warning statement see 23.1.

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

## 2. Referenced Documents

2.1 *ASTM Standards:*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D-9 D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.07 on Flexible and Rigid Insulating Materials.

Current edition approved ~~Dec. 10, 1999~~; 2002. Published ~~March 2000~~; June 2002. Originally published as D 2305 – 64 T. Last previous edition D 2305 – 959.

- D 149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies<sup>2</sup>
- D 150 Test Methods for A-C Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials ~~Insulating Materials~~ Insulation<sup>2</sup>
- D 257 Test Methods for D-C Resistance or Conductance of Insulating Materials<sup>2</sup>
- D 374 Test Methods for Thickness of Solid Electrical Insulation<sup>2</sup>
- D 570 Test Method for Water Absorption of Plastics<sup>3</sup>
- D 882 Test Methods for Tensile Properties of Thin Plastic Sheetings<sup>3</sup>
- D 883 Terminology Relating to Plastics<sup>3</sup>
- D 1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications<sup>2</sup>
- D 1531 Test Methods for Relative Permittivity (Dielectric Constant) and Dissipation Factor by Fluid Displacement Procedures<sup>2</sup>
- D 1676 Test Methods for Film-Insulated Magnet Wire<sup>2</sup>
- D 1711 Terminology Relating to Electrical Insulation<sup>2</sup>
- D 5032 Practice for Maintaining Constant Relative Humidity by Means of Aqueous Glycerin Solutions<sup>4</sup>
- D 6054 Practice for Conditioning Electrical Insulating Materials for Testing<sup>4</sup>
- E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method<sup>5</sup>
- 2.2 *IEC Standard*:  
Publication 60674–2 Specification for Plastic Films for Electrical Purposes<sup>6</sup>

### 3. Terminology

#### 3.1 Definitions:

3.1.1 Definitions are in accordance with Terminologies D 1711 and D 883 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. Sampling

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

4.2 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.

4.3 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 specimens may be prepared from samples taken from mill rolls prior to slitting to the furnished width.

## CONDITIONING

### 5. Significance and Use

5.1 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 should 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.

### 6. Procedure

6.1 Unless otherwise specified in the individual test methods, test the specimens in the Standard Laboratory Atmosphere  $23 \pm 2^\circ\text{C}$ ,  $50 \pm 5\%$  R.H. prescribed in Practice D 6054.

## THICKNESS

### 7. Significance and Use

7.1 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

<sup>2</sup> Annual Book of ASTM Standards, Vol 10.01.

<sup>3</sup> Annual Book of ASTM Standards, Vol 08.01.

<sup>4</sup> Annual Book of ASTM Standards, Vol 10.02.

<sup>5</sup> Annual Book of ASTM Standards, Vol 14.02.

<sup>6</sup> Available from American National Standards Institute, 11 West 42nd Street, 13<sup>th</sup> Floor, New York, NY 10036.

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.

## 8. Procedure

8.1 Use Method C of Test Methods D 374 for this measurement, with the apparatus modified as follows: Use a presser foot of  $6.25 \pm 0.05$  mm ( $250 \pm 1$  mil) diameter, and an anvil surface, upon which the specimen rests, of at least 50-mm (2-in.) diameter. Apply a force of  $0.84 \pm 0.2$  N ( $3 \pm 0.75$ ) ozf to the specimen. Take ten measurements, equally spaced throughout the specimen.

## 9. Report

9.1 Report the average, maximum, and minimum thicknesses to the nearest  $0.5 \mu\text{m}$  (0.02 mil) for specimens thinner than  $50 \mu\text{m}$  (2 mils) and to the nearest  $1 \mu\text{m}$  (0.04 mil) for specimens  $50 \mu\text{m}$  (2 mils) or more in thickness.

## 10. Precision and Bias

10.1 *Precision*—A formal round robin test in accordance with Practice E 691 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.

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

## TENSILE PROPERTIES

### 11. Procedure

11.1 Use Method A of Test Methods D 882. Report data only for the specific tests required by a specification.

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

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

11.4 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.<sup>2</sup>).

## STRAIN RELIEF

### 12. Significance and Use

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

### 13. Apparatus

13.1 *Ovens*, shall be of a forced-convection type capable of maintaining the specified temperature  $\pm 5^\circ\text{C}$ .

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

### 14. Test Specimen

14.1 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.

### 15. Conditioning

15.1 Condition test specimens in accordance with Section 6 before the initial and final measurements are made.

### 16. Procedure

16.1 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.

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

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

### 17. Calculation

17.1 Calculate the linear dimensional change as follows:

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

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

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.

17.2 Average the values obtained for each direction.

## 18. Report

18.1 Report the following information:

18.1.1 Identification of the material tested,

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

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

18.1.4 Any curl at the edges or other visual defects.

## 19. Precision and Bias

19.1 *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.

19.2 *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

## 20. Significance and Use

20.1 The dielectric breakdown voltage and dielectric strength of a film is an indication of its ability to withstand electric stress. This value should be used primarily as an indication of quality and for comparison of different lots or types of the same material. Secondly, this value may 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.

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

20.3 For further details on the significance of this test, refer to Test Method D 149.

## 21. Apparatus

21.1 Use apparatus that conforms to that specified in Test Method D 149, including the 25-mm (1-in.) diameter electrodes described therein. As an exception, the 6.4-mm (1/4-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 D 149.

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.

## 22. Test Specimen

22.1 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.

## 23. Procedure

23.1 Determine the dielectric breakdown voltage in air and dielectric strength in accordance with Test Method D 149, 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, different results may 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.)**

## 24. Application of Voltage

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

## 25. Report

25.1 Unless otherwise specified, report the following information:

- 25.1.1 Average breakdown voltage,
- 25.1.2 Average thickness of breakdown specimens,
- 25.1.3 Average, maximum, and minimum dielectric strength (optional),
- 25.1.4 Ambient medium and ambient condition,
- 25.1.5 Conditioning of specimens,
- 25.1.6 Rate of voltage increase, and
- 25.1.7 Size and material of electrodes used.

## SURFACE RESISTIVITY

### 26. Significance and Use

26.1 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 should be as an indication of quality and for comparison of different lots or types of the same material. Secondly, this test may be used to classify materials into broad groups that differ from each other by at least one power of ten.

### 27. Conditioning

- 27.1 Use one or more of the following conditions (see Practice D 6054):
  - 27.1.1 Condition 18/35/90,
  - 27.1.2 Condition 2/90, or
  - 27.1.3 Condition 2/130.

### 28. Procedure

- 28.1 Determine the surface resistivity in the conditioning atmosphere in accordance with Test Methods D 257, using strip electrodes as shown in Fig. number 3 of that test method.
- 28.2 It is important that the specimens not be contaminated during the placement of the electrodes.
- 28.3 Do not allow the specimens used for test to contact unclean surfaces and do not touch them without wearing clean gloves.
- 28.4 Before testing any film of questionable cleanliness, clean it in accordance with the manufacturer's suggestions.
- 28.5 Cut test specimens to a width of 25 mm (1 in.).
- 28.6 Calculate resistivity by multiplying resistance values by the ratio of the specimen width to the distance between electrodes.
- 28.7 Use an electrification time of 1 min  $\pm$  5 s at 100 V dc  $\pm$  5 V unless otherwise specified (see 23.1).

### 29. Report

29.1 Report all the items listed in Test Methods D 257.

### 30. Precision and Bias

30.1 *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.

30.2 *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

### 31. Significance and Use

31.1 Refer to Test Methods D 257.

### 32. Test Specimen

32.1 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.

### 33. Procedure

33.1 Apply 100 V dc for 1 min unless otherwise specified. Measure the volume resistance in accordance with Test Methods D 257.

### 34. Calculation

34.1 Calculate the volume resistivity in accordance with Test Methods D 257 except that, where no guard electrode is used, the area is based on the 25-mm (1-in.) diameter electrode.

### 35. Report

35.1 Report all items listed in Test Methods D 257.

### 36. Precision and Bias

36.1 *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.

36.2 *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

### 37. Significance and Use

37.1 Severe electrolytic corrosion may 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.

### 38. Procedure

38.1 Determine the surface resistivity of the film in accordance with Section 28, with the following exceptions:

38.1.1 Condition the specimens for 18 h at a relative humidity of  $96 \pm 2\%$  and  $23 \pm 1^\circ\text{C}$  ( $73 \pm 2^\circ\text{F}$ ). Satisfactory means of obtaining this relative humidity are described in Practice D 5032. 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 D 1000.

### 39. Report

39.1 Report the following information:

39.1.1 Identification of the film,

39.1.2 Width of the film,

39.1.3 Number of measurements, and

39.1.4 Median, minimum, and maximum resistance in megohms.

### 40. Precision and Bias

40.1 *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.

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

## PERMITTIVITY AND DISSIPATION FACTOR

### 41. Significance and Use

41.1 See Test Methods D 150.

### 42. Electrodes

42.1 See Test Methods D 150.

42.2 If tests are to be made over a range of temperatures, apply contacting electrodes to the specimens. For specimens 13  $\mu\text{m}$  (0.5 mil) or more thick, sprayed-on conducting silver paint and evaporated gold and aluminum metals have been found satisfactory for many materials. Before using these, be certain that the solvent in the paint or the environment of the vacuum chamber in which the metal evaporation is performed will not adversely affect the specimens.

42.3 For tests on thin specimens, such as 5.1  $\mu\text{m}$  (0.2 mil), the two fluid immersion methods may be used at room temperature without applying contacting electrodes (see Test Methods D 1531); with this method the permittivity is determined without measuring the specimen thickness. For the two-fluid method, it is recommended that one fluid be air and the other be a dielectric fluid known to have no deteriorative effect on the film's electrical properties at least during the interval of the test. Silicone fluid of 1 or 2  $\text{mm}^2/\text{s}$  (1 or 2-cSt) viscosity has proven satisfactory for many films such as fluorinated ethylene propylene (FEP), polyethylene (PE), polyethylene terephthalate (PET) and polypropylene (PP). Silicone fluid may cause migration of plasticizer in cellulose acetate (CA) film.

42.4 Either two- or three-terminal arrangements may be used with any of the above electrodes.

### 43. Apparatus

43.1 Refer to Test Methods D 150 or D 1531.

43.2 If conducting paint or evaporated metal electrodes are used, the specimen may be contacted by rigid metal surfaces smaller than the applied electrodes.

### 44. Procedure

44.1 Select for testing clean specimens larger than the electrodes. If tests are made at elevated temperatures, expose the specimens to the highest test temperature for a sufficient time to relieve the stresses and to minimize dimensional changes during testing. If contacting electrodes are used, measure the thickness of the specimens over the areas covered, in accordance with Section 8. Apply the electrodes as needed. If silver paint is used, allow the solvent to evaporate overnight or about 2 h at 50°C. Condition the specimens in accordance with Section 6.

44.2 Measure the capacitance and dissipation factor of five single-sheet specimens with applied voltage not exceeding 50 V, measure the electrode diameter, and calculate permittivity in accordance with Test Methods D 150 or D 1531, using the applicable corrections.

### 45. Report

45.1 Report all the items listed in Test Methods D 150 or D 1531.

### 46. Precision and Bias

46.1 *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.

46.2 *Bias*—This test method has no bias because the value for permittivity and dissipation factor is determined solely in terms of this test method itself.

## SHRINKAGE

### 47. Significance and Use

47.1 The shrinkage test gives an indication of the dimensional changes that may occur when a film is exposed to elevated temperatures during a manufacturing process or while in service. This test is especially appropriate when small dimensional changes are to be detected.

### 48. Apparatus

48.1 *Ovens*, shall be of a forced-convection type capable of maintaining the specified temperature  $\pm 5^\circ\text{C}$ .

48.2 Microscale with a dial indicator reading to 0.013 mm (0.0005 in.) or less, or an equivalent optical system.

### 49. Test Specimen

49.1 From a wrinkle-free area of the film sample prepare six specimens, each approximately 200 by 280 mm (8.5 by 11 in.), with three specimens having the longer dimension in the machine direction, and three with the longer dimension in the transverse direction.

### 50. Procedure

50.1 Condition specimens before initial measurements in accordance with Section 6.

50.2 Measure the length of each specimen to the nearest 0.25 mm (0.01 in.) at two marked distances, using a metal scale calibrated to 0.25 mm (0.01 in.).

50.3 Unless otherwise stated suspend the specimens in an oven operating at  $200 \pm 2^\circ\text{C}$  ( $392 \pm 3.6^\circ\text{F}$ ). The specimens must be freely exposed to the circulating air, but prevented from curling and sticking to adjacent specimens. Remove the specimens after  $30 \pm 3$  min.

50.4 Condition in accordance with 6.1.

50.5 After conditioning, repeat measurements made in 50.2, over the same distances. For each specimen, average the two measurements before and after heating, and calculate the shrinkage to the nearest 0.01 % as follows:

$$\% \text{ shrinkage} = \frac{\text{initial measurement} - \text{final measurement}}{\text{initial measurement}} \times 100 \quad (2)$$

50.6 Average the results for the three specimens cut in each direction.

### 51. Report

51.1 Report the average shrinkage to the nearest 0.01 % separately in each direction.

**52. Precision and Bias**

52.1 *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.

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

**WATER ABSORPTION****53. Significance and Use**

53.1 Refer to Test Method D 570

**54. Test Specimen**

54.1 Prepare three specimens 76 mm (3 in.) by 25 mm (1 in.) by the thickness of the material.

**55. Procedure**

55.1 Test the three specimens in accordance with the 24 h immersion procedure of Test Method D 570, using distilled water at  $23 \pm 1^\circ\text{C}$  ( $73 \pm 2^\circ\text{F}$ ).

**56. Report**

56.1 Report all items listed in Test Method D 570.

**57. Precision and Bias**

57.1 Refer to Test Method D 570 for precision on material thickness of 0.13 mm (0.005 in.) or greater.

57.2 No statement of precision has been made for material thickness less than 0.13 mm (0.005 in.) and no activity is planned to develop such a statement. This method is known to be less precise for thinner materials.

57.3 This test method has no bias because the value for water absorption is determined solely in terms of this test method itself.

**HEAT-SEAL STRENGTH****58. Significance and Use**

58.1 The heat-seal strength test gives an indication of bond strength that may occur when a heat sealable film is bonded to either the coated or uncoated side of another film.

**59. Apparatus**

59.1 Provide a heated jaw sealer having the following characteristics:

59.1.1 Electrically heated with flat stainless steel pressing surfaces 25 mm (1 in.) wide and at least 50 mm (2 in.) long to accommodate the end of a 25-mm (1-in.) wide specimen.

59.1.2 Capable of maintaining the specified test temperature.

59.1.3 Equipped with a timer that will open the jaws after a preset pressing time,  $\pm 1$  s.

59.1.4 Calibrated to apply a pressure to the specimen area within the jaws of  $138 \pm 7$  kPa ( $20 \pm 1$  psi).

**60. Test Specimen**

60.1 From each sample cut five pairs of specimen pieces, each  $25 \pm 1$  mm ( $1.0 \pm 0.04$  in.) wide. Place the two pieces of each pair together, either coated side to coated side or coated side to bare side, depending upon the value to be determined.

**61. Procedure**

61.1 Place the specimen pair in the jaw sealer, with a suitable thin film or other material to prevent adhesion to the jaws. Close the sealer and hold for 20 s at  $350^\circ\text{C} \pm 2^\circ\text{C}$  ( $662 \pm 3.6^\circ\text{F}$ ) unless otherwise specified. When the sealer opens, remove the specimen and allow to cool to room temperature.

61.2 Place the unsealed ends of the specimen in the jaws of a CRE (constant rate of extension) tensile testing machine, with a jaw spacing of 50 mm (2 in.). No tension should be applied to the specimen in mounting it in the jaws. Operate the machine with a jaw separation rate of 300 mm/min (12 in./min) or 250 mm/min (10 in./min) to pull apart the two pieces of the specimen. Record the maximum value of force required to separate the specimen.

61.3 For each sample and orientation of coating, calculate the average of the values obtained on the five specimens.

**62. Report**

62.1 Report the average heat-seal strength per width of specimen to the nearest g/25 mm (g/in.).

**63. Precision and Bias**

63.1 *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.

63.2 *Bias*—This test method has no bias because the value for heat seal strength is determined solely in terms of this test method itself.

## EXTRACTABLES

### **64. Extractables**

#### 64.1 Use Significance and Use

64.1 Low-molecular-weight material in polymeric film that can be extracted during processing can affect the end-use application of the film. These tests give an indication of the amount of low-molecular-weight material present in the film.

64.2 Two test methods are acceptable—one described in Test Methods D 1676, with modifications following, and one defined in this standard.

### **65. Extraction by Refrigerant—Modifications to Test Methods D 1676**

65.1 Use the Method for Extractables of Film-Insulated Magnet Wire by Refrigerants of Test Methods D 1676 with the following changes:

#### 645.1.1 Specimen preparation prior to extraction:

645.1.1.1 Cut a convenient number and size of pieces from the film sample to make a total specimen weight of  $4.8 \pm 0.8$  g. Weigh to the nearest 0.1 mg.

645.1.1.2 Anneal the film specimens at  $150 \pm 3^\circ\text{C}$  ( $302 \pm 5^\circ\text{F}$ ) for  $15 \pm 1$  min. Remove the film specimens from the oven with clean tongs and allow to cool in a desiccator for a minimum of 30 min.

645.1.1.3 Transfer the film specimens with clean tongs to an analytical balance and weigh to the nearest 0.1 mg.

#### 645.2 Specimen Preparation Following Extraction:

645.2.1 Dry the film specimens in an oven at  $150 \pm 3^\circ\text{C}$  ( $302 \pm 5^\circ\text{F}$ ) for  $15 \pm 1$  min.

645.2.2 Remove the film specimens from the oven with clean tongs and allow to cool in a desiccator for a minimum of 30 min.

645.2.3 Transfer the film specimens with clean tongs to an analytical balance and weigh to the nearest 0.1 mg to obtain the final specimen weight.

## EXTRACTION BY XYLENE – ALTERNATE TEST METHOD FOR DETERMINING EXTRACTABLES

### **66. Test Specimen**

66.1 From each sample cut  $25 \text{ mm} \times 76 \text{ mm}$  (1 in.  $\times$  3 in.) strips. Punch a small hole in each strip about 13 mm ( $\frac{1}{2}$  in.) from one end.

66.2 Weigh out approximately 10 g of the  $25 \text{ mm} \times 76 \text{ mm}$  (1 in.  $\times$  3 in.) samples and thread sample strips onto light-gauge copper wire.

### **67. Procedure**

67.1 Anneal sample strips and wire in oven for 30 min at  $200^\circ\text{C} \pm 2^\circ\text{C}$ .

67.2 Remove from oven and cool in dessicator for  $\sim 30$  min.

67.3 Fit a 5 litre flask with water-cooled condenser and powerstat-controlled heating mantle.

67.4 Add 2.5 – 3 litres of xylene to flask.

67.5 After samples and wires have cooled, weigh to  $\pm 0.001$  g and insert into neck of flask.

67.6 Adjust powerstat to produce gentle boiling of the xylene.

67.7 Allow samples to remain in boiling xylene about 24 h.

67.8 Remove samples, dry excess xylene with paper towel, and hang samples in a fume hood to air dry in forced-air current.

67.9 After samples have dried, hang samples and wire in oven for  $2 \text{ h} \pm 5 \text{ min}$  at  $200^\circ\text{C} \pm 2^\circ\text{C}$ .

67.10 Remove and cool in dessicator for  $\sim 30$  minutes.

67.11 Weigh samples and wire to  $\pm 0.001$  g.

67.12 Weigh wire to  $\pm 0.001$  g.

### **68. Report**

68.1 Calculate the percentage of extractables as follows:

$$\frac{i \times 100}{(\text{original weight of sample} + \text{wire}) - (\text{weight of wire})} \quad (3)$$

### **69. Precision and Bias**

69.1 *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.

69.2 *Bias*—This test method has no bias because the value for percentage of extractables is determined solely in terms of this test method itself.

**70. Keywords**

6570.1 conditioning; dielectric breakdown; dielectric strength; dissipation factor; elongation; extractables; FEP fluorocarbon; film; heat aging; heat-sealable; heat-seal strength; high humidity; permittivity; polymer films; strain relief (shrinkage); surface resistivity; tensile strength; thickness; volume resistivity

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or [service@astm.org](mailto:service@astm.org) (e-mail); or through the ASTM website ([www.astm.org](http://www.astm.org)).*