



**Designation: D3394 – 94 (Reapproved 2009) D3394 – 16**

# Standard Test Methods for Sampling and Testing Electrical Insulating Board<sup>1</sup>

This standard is issued under the fixed designation D3394; 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 sampling and testing of electrical insulating boards. These boards are porous, usually fibrous sheets used for dielectric and structural purposes in electrical apparatus.

1.2 These test methods are not intended for testing vulcanized fibre or molded laminated sheets.

1.3 These test methods are applicable to board materials having a nominal thickness of at least 0.030 in. (0.76 mm).

NOTE 1—For materials thinner than 0.030 in. (0.76 mm) see Test Methods D202.

1.4 The test methods appear in the following sections:

	Sections	ASTM Method Reference
Apparent Density	18 – 23	
Aqueous Extract Characteristics	36 – 42	D202
Ash Content	43 – 46	T 413
Compatibility with Dielectric Liquids	47 – 52	D664, D877, D924, D971, D974, D1169, D1500, D1816, D3455, D3487
Compressibility	79 – 85	
Conditioning	11	D685
Degree of Polymerization	86 – 89	D4243
Dielectric Strength in Air	53 – 59	D149
Dielectric Strength in Oil	60 – 65	D149, D2413, D3426
Dimensions of Sheets	12 – 17	
Moisture Content	31 – 35	D644
Oil Absorption	72 – 78	
Reports	10	
Sampling	6 – 9	D3636
Shrinkage	24 – 30	D644
Tensile Properties	66 – 71	D202

1.5 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.

1.6 *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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**D149** Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

**D202** Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation

**D374** Test Methods for Thickness of Solid Electrical Insulation (Metric) D0374\_D0374M

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and are the direct responsibility of Subcommittee D09.01 on Electrical Insulating Products.

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<sup>2</sup> 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.

- D586 Test Method for Ash in Pulp, Paper, and Paper Products (Withdrawn 2009)<sup>3</sup>  
 D644 Test Method for Moisture Content of Paper and Paperboard by Oven Drying (Withdrawn 2010)<sup>3</sup>  
 D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration  
 D685 Practice for Conditioning Paper and Paper Products for Testing  
 D877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes  
 D924 Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids  
 D971 Test Method for Interfacial Tension of Oil Against Water by the Ring Method  
 D974 Test Method for Acid and Base Number by Color-Indicator Titration  
 D1169 Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids  
 D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)  
 D1816 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes  
 D2413 Practice for Preparation of Insulating Paper and Board Impregnated with a Liquid Dielectric  
 D2865 Practice for Calibration of Standards and Equipment for Electrical Insulating Materials Testing  
 D3426 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Using Impulse Waves  
 D3455 Test Methods for Compatibility of Construction Material with Electrical Insulating Oil of Petroleum Origin  
 D3487 Specification for Mineral Insulating Oil Used in Electrical Apparatus  
 D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials  
 D4243 Test Method for Measurement of Average Viscometric Degree of Polymerization of New and Aged Electrical Papers and Boards  
 E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications  
 2.2 TAPPI Standard:  
 T 413 Determination of Ash in Paper<sup>4</sup>

### 3. Terminology

#### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *electrical insulating board—board, n*—a sheet structure, usually composed of cellulosic fibers, utilized for dielectric or structural purposes or both in a variety of electrical apparatus. Board is herein arbitrarily differentiated from paper in that it is at least 0.030 in. (0.76 mm) thick and is manufactured only in sheets of limited length. Other names for these products are pressboard, transformer board, fuller board, and press pan.

### 4. Summary of Test Methods

4.1 This standard is a compilation of test methods for electrical insulating board. Provisions are included for sampling, testing, and judging acceptability of a given quantity of board.

### 5. Reagents

5.1 Reagents shall conform to the requirements set forth in Test Methods **D202**.

## SAMPLING

### 6. Scope

6.1 This test method covers the determination of lot acceptability of electrical insulating board. It is designed for the purpose of determining acceptability of all or that portion of a shipment to a customer identified by a manufacturer's lot number. It is not intended to cover internal board mill quality control plans. The method is intended for use in conjunction with product specifications for electrical insulating board.

### 7. Terminology

#### 7.1 Definitions of Terms Specific to This Standard:

7.1.1 The descriptions of terms used in this test method, with the exception of the definition of "unit of product," are in accordance with Practice **D3636**.

7.1.2 *unit of product—product, n*—an entity of electrical insulating board on which one or more quality characteristics ~~may be~~ is determined. A unit of product ~~may be~~ is a sheet, pallet, box, carton, case, package, or bundle. The unit of product is established by the customer and ~~may is~~ is or ~~may is~~ is not be the same as the unit of purchase, supply, production, or shipment.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from Technical Association of the Pulp and Paper Industry (TAPPI), 15 Technology Parkway South, Norcross, GA 30092, <http://www.tappi.org>.

## 8. Establishing Acceptable Quality Levels (AQLs)

8.1 Acceptable quality levels (AQLs) for each major and minor property (as defined in Practice **D3636**) shall be as mutually agreed upon between the purchaser and the seller. In addition, ~~if group AQLs may be~~ are established for given groups of properties and these too shall be mutually agreed upon between the purchaser and the seller.

## 9. Selection of Sample and Identification of Lot Sample

9.1 Samples shall be in accordance with Practice **D3636**, with the exception of those paragraphs pertaining specifically to rolls, pads, or bobbins.

9.2 Mark each unit of the sample so that it ~~may be identified~~ is identifiable at any time by the seller and the purchaser.

## REPORTS

### 10. Report

10.1 At the completion of all tests record the results in a test report that includes the following:

10.1.1 Identification (of the board sampled and tested) by lot number, type, grade, etc., and so forth,

10.1.2 Dates of testing,

10.1.3 Location of the testing laboratory and the name of the person responsible for testing,

10.1.4 Remarks indicating the method used and any deviation from the standard,

10.1.5 Test results as specified in the individual method, and

10.1.6 Specification limits for each property measured for the board being tested.

10.2 Report the results as calculated or observed values rounded to the nearest unit in the last right-hand place of figures used in the material specification to express the limiting value (see Practice **E29**).

## CONDITIONING

### 11. Conditioning

11.1 Condition samples and specimens cut from the samples (with the exception of samples taken for moisture determination or as otherwise specified) in a circulating-air atmosphere maintained at  $50 \pm 2$  % relative humidity and a temperature of  $23 \pm 2$  °C, using procedures as specified in ~~Method~~ Practice **D685**.

11.2 For referee purposes, the conditioning specified in **11.1** will give most consistent results. However, for routine testing under factory or other non-standard atmospheric conditions, if the board has a moisture content within the range from 5 to 7 % as determined in Sections **31 – 34**, there will be only slight variations from properties as determined after conditioning specified above.

<https://standards.iteh.ai/catalog/standards/sist/04caa589-87fb-4cc0-885c-8c8f05a27d7b/astm-d3394-16>

## DIMENSIONS OF SHEETS

### 12. Apparatus

12.1 *Scale*—A scale of suitable length graduated such that lengths, widths, and diagonals can be directly read to within half of the allowable tolerance for these dimensions. The scale shall be properly calibrated in accordance with Practice **D2865**.

12.2 *Thickness-Measuring Device*—Machinist micrometer with ratchet as specified in Test Methods **D374**.

### 13. Sampling

13.1 Sample in accordance with Sections **6 – 9**.

### 14. Test Specimens

14.1 Specimens for determination of length, width, and squareness of sheets shall be whole sheets. For thickness determinations, use a whole sheet ~~may be used~~ or, if desired, a portion of a whole sheet will serve as a specimen. If a portion is selected as a specimen for thickness determination, that portion shall be representative of the full width (cross-grain direction) of the sheet.

14.2 Determine the dimensions as received, provided the moisture content is in the specification range for the material being tested (see **11.2**).

### 15. Procedure

15.1 Measure the length and the width of each specimen to the nearest appropriate unit. Make at least two measurements in each direction.

15.2 Measure each of the two diagonals of each specimen.

15.3 Measure the thickness in accordance with Test Methods **D374**, Method A. Make at least five thickness determinations across the sheet.

NOTE 2—Points of measurement ~~should be~~ are selected to include the areas most likely to be the extremes.

## 16. Report

16.1 The report shall conform to Section **10** and shall include the following:

16.1.1 Sheet size, reported as the average of the measurements in each direction.

16.1.2 Squareness of the sheet, reported as the quotient of the shorter diagonal divided by the longer diagonal (for convenience, squareness is expressed as a percent).

NOTE 3—This method of calculating squareness assumes that the sheet closely approximates a parallelogram in shape. If measurements of width or length vary at different points, it is possible that a high squareness value ~~may be~~ is calculated from measurements on a sheet that differs significantly from being rectangular.

16.1.3 Average thickness, and

16.1.4 Variation in thickness, reported as the difference between the highest and the lowest thickness value obtained in **15.3**.

## 17. Precision and Bias

17.1 The precision and bias of this test method are not known.

### APPARENT DENSITY

## 18. Scope

18.1 This test method ~~may be~~ is used for determination of apparent density of insulating board, using measurements of dimensions and weight made after appropriate conditioning.

18.2 Procedures are given for determining either the “wet-wet” or the “dry-dry” density.

## 19. Significance and Use

19.1 Apparent density affects the dielectric and physical characteristics of insulating board and is a factor in the economics of its use in apparatus. This test is useful for specification, design, and quality control purposes.

## 20. Apparatus

20.1 *Scale or Calipers*, graduated in units of length, with the smallest graduation equal to, or less than, 0.25 % of the smallest dimension to be measured, calibrated in accordance with Practice **D2865**.

20.2 *Balance*, graduated in units of weight, with the smallest graduation equal to, or less than, 0.25 % of the specimen weight, calibrated in accordance with Recommended Practice **D2865**.

20.3 *Thickness-Measuring Device*, conforming to the requirements of Test Methods **D374**, Method A.

20.4 *Oven*, conforming to the requirements of Test Method **D644**.

## 21. Procedure

21.1 From each unit of product in the sample obtained in accordance with Sections 6 through 9, prepare at least two rectangular specimens having an area of at least 75 in.<sup>2</sup> (0.05 m<sup>2</sup>) each.

21.2 *Procedure A: Wet-Wet Density*—Condition the specimens in accordance with Section **11**.

21.3 *Procedure B: Dry-Dry Density*—Dry the specimens to constant weight in an oven at 105 ± 3°C, in accordance with Test Method **D644**. Cool to room temperature, using a desiccator or other means to prevent reabsorption of moisture. Exposure to the open air while making the measurements specified in **21.4** shall be sufficiently brief that there will not be a weight increase of more than 0.1 % of the oven-dry weight of the specimens.

21.4 Measure the width, length, and thickness in accordance with Section **15** to determine the weight of each specimen.

21.5 From the dimensions and weight of each specimen, calculate the apparent density and report the results in units of grams per cubic centimetre, calculated as follows:

$$\text{Apparent density, g/cm}^3 = \frac{\text{weight} \times \text{factor}}{\text{volume}} \quad (1)$$

Weight Units	Volume Units	Factor
g	cm <sup>3</sup>	1
g	in. <sup>3</sup>	0.0610
lb	in. <sup>3</sup>	27.68

## 22. Report

22.1 The report shall be in accordance with Section 10, and include the individual results for the apparent density of each specimen.

## 23. Precision and Bias

23.1 The precision and bias of this test method are not known.

### SHRINKAGE

## 24. Significance and Use

24.1 The dimensions of electrical insulating boards will change as a function of moisture content, which varies with changes in the ambient relative humidity or as a result of heat or vacuum used in drying operations. The suitability of a board for some particular applications ~~may be~~ is affected by the magnitude and direction of these dimensional changes.

24.2 The dimensional changes resulting from oven drying of specimens that have been conditioned under specified humidity conditions are used in this method as a measure of the shrinkage characteristics. This method is useful for design purposes, for specifications, and for some special control purposes.

## 25. Test Specimens

25.1 Cut square or rectangular pieces having dimensions of at least 3 in. (76 mm) in the plane of the sheet. The dimensions in the plane of the sheet ~~may be~~ are determined by measuring either the overall distances between smoothly finished edges, or the distances between benchmarks on one face of the specimen. The optimum size of the test specimen will be determined by the method used for measuring the dimensions, and by the size of the conditioning chamber available.

## 26. Conditioning

26.1 Unless otherwise specified, condition the specimens to equilibrium with a standard atmosphere as specified in Section 11.

## 27. Procedure

27.1 Measure the dimensions of the specimens in the grain direction, the cross direction, and the thickness, in accordance with Sections 12 – 16. Make the measurements in the atmosphere in which conditioning was performed, or within 3 min of removal from that atmosphere.

27.2 Dry the specimens to constant weight at 105°C, and cool to room temperature in accordance with Test Method D644.

27.3 Measure the dimensions of the specimens in accordance with 27.1.

## 28. Calculation

28.1 From the average dimensions before and after drying in each of the three directions, calculate the linear shrinkage in each of the three directions as a percentage of the respective initial dimensions.

## 29. Report

29.1 The report shall be in accordance with Section 10, and shall include the average shrinkage for each specimen in the grain direction, the cross direction, and the thickness.

## 30. Precision and Bias

30.1 The precision and bias of this test method are not known.

### MOISTURE CONTENT

## 31. Significance and Use

31.1 Moisture content of electrical insulating board is important for economic and technical reasons. Many physical and dimensional characteristics of board are affected by moisture content and moisture content history. This test is useful for specification and quality control use. (For a more complete treatise on the significance of moisture content, see STP 60 B Paper and Paperboard—Characteristics, Nomenclature, and Significance of Tests.<sup>5</sup>)

## 32. Procedure

32.1 From a sample obtained in accordance with Sections 6 – 9 take carefully protected specimens and determine the moisture content in accordance with Test Method D644. Take specimens from the test units and place immediately in a moisture-proof container, transport to a laboratory, and weigh immediately prior to oven drying.

<sup>5</sup> Available from ASTM Headquarters, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428–2959.

### 33. Calculation

33.1 Calculate the moisture content of the board as follows:

$$\begin{aligned} & \text{Moisture content, \%} && (2) \\ & = (\text{weight loss on drying} \times 100 / \text{original weight}) \end{aligned}$$

### 34. Report

34.1 The report shall be in accordance with Section 10, and shall include the high, low, and average moisture content of the lot of board.

### 35. Precision and Bias

35.1 The precision and bias of this test method are not known.

## AQUEOUS EXTRACT CHARACTERISTICS

### 36. Summary of Test Method

36.1 Procedures are specified for the preparation of aqueous extracts and for determination of their characteristics, including conductivity, pH, free acidity and alkalinity, and soluble chloride content.

### 37. Significance and Use

37.1 ~~Water-soluble~~ It is possible that water-soluble extractives, such as ionizable acids, bases, salts, or combinations thereof may will degrade insulating qualities of board. ~~Excessive quantities may~~ It is possible excessive quantities will lower the insulation resistance and may cause corrosion or degradation of the board under electric stress. Many of these impurities can be detected and their amounts estimated from measurements of conductivity, pH, free acidity or alkalinity, and chloride content of aqueous extracts of the board.

### 38. Apparatus

38.1 The apparatus shall be as specified in Test Methods D202 for the corresponding tests.

### 39. Test Specimens

39.1 In preparing specimens for the tests in 40.1 – 40.3, cut the board into pieces as small as possible, consistent with minimal handling and exposure. In the case of specimens from thick, high-density boards, extend the maceration time to 10 min if needed to pulp the specimen completely.

### 40. Procedure

40.1 *Acidity-Alkalinity-pH*—Test in accordance with Test Methods D202.

40.2 *Conductivity*—Test in accordance with Test Methods D202.

40.3 *Chloride Content*—Test in accordance with Method A of Test Methods D202, except before refluxing, macerate the specimen for 5 min, using the same apparatus and procedure used to prepare aqueous extracts for pH measurements (40.1).

### 41. Report

41.1 The report shall be in accordance with Section 10 and shall include the following:

41.1.1 Test procedure used, and

41.1.2 Results of each test, including results of tests on blanks.

### 42. Precision and Bias

42.1 The precision and bias of the test for acidity-alkalinity-pH, and of conductivity are not known.

42.2 For the precision of the test for chlorides see Test Methods D202. No statement can be made as to the bias of the chloride test, since a standard reference sample does not exist.

## ASH CONTENT

### 43. Significance and Use

43.1 The presence of fillers, pigments, and mineral or metallic contaminants may affect the properties and performance of boards used for electrical insulation. This test provides a rapid means for determination of the amount of material present that is incombustible and nonvolatile under the conditions of test.