Designation: D202 – 17

Standard Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation[1]

This standard is issued under the fixed designation D202; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 These test methods cover procedures for sampling and testing untreated paper to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

1.1.1 Untreated papers are thin, fibrous sheets normally laid down from a water suspension of pulped fibers (usually cellulosic) with or without various amounts of nonfibrous ingredients, and which are calendared, if required, to obtain desired thickness and density. Nevertheless, these test methods are applicable, generally although not invariably, to papers formed by other means, to papers modified (during or after formation) by additions, and to papers given subsequent mechanical treatments such as creping.

1.1.2 As an electrical insulating and dielectric material, paper is considered "untreated" until it is subjected to a manufacturing process such as drying, impregnation, or varnish treatment.

1.1.3 The test methods given herein were developed specifically for papers having a thickness of 0.75 mm (0.030 in.) or less. A number of these test methods are also suitable for use on other materials such as pulps or boards. Refer to Test Methods D3376 or D3394 to determine which tests are applicable to pulps or electrical insulating boards. In the paper industry, some products in thicknesses of less than 0.75 mm are termed "paperboard". Such products are included within the scope of these methods.

1.1.4 These test methods are applicable to flexible fibrous-mat materials formed from suspensions of fiber in fluids other than water. Thicknesses of these mats approach 2 mm, and the fibers contained are possibly natural, synthetic, organic, or inorganic; fillers that are natural, synthetic, organic, or inorganic; and flexible polymeric binder materials.

1.2 The procedures appear in the following sections:

Procedure	Sections	ASTM or TAPPI Reference (Modified)
Absorption (Rise of Water)	78 to 83	. . .
Acidity-Alkalinity-pH	45 to 54	E70
Air Resistance	98 to 101	D726
Aqueous Extract Conductivity	55 to 64	. . .
Ash Content	40 to 44	D586
Bursting Strength	102 to 107	D774/D774M
Chlorides (Water-Extractable)	165 to 183	. . .
Conditioning	15	D6054
Conducting Paths	138 to 151	. . .
Density, Apparent	29 to 33	. . .
Dielectric Strength	152 to 157	D149
Dimensions of Sheet, Rolls and Cores	16 to 24	D374
Dissipation Factor and Permittivity	158 to 164	D150
Edge-Tearing Resistance	126 to 130	D827
Fiber Analysis	74 to 77	D1030
Folding Endurance	108 to 110	T 423 and D2176
Grammage	25 to 28	D646
Permittivity	158 to 164	D150
Heat Stability in Air	131 to 137	D827
Impregnation Time	84 to 91	. . .
Internal-Tearing Resistance	121 to 125	D689 or T 414
Moisture Content	34 to 39	D644 and D3277
Particulate Copper	193 to 202	. . .
Particulate Iron	184 to 192	. . .
Reagents	4	D1193
Reports	14	E29
Sampling	6 to 13	D3636
Silver Tarnishing by Paper and Paperboard	203 to 206	T 444
Solvent-Soluble Matter	65 to 73	. . .
Surface Friction	92 to 97	D528 and T 455
Tensile Properties	111 to 120	D76, E4
Thickness (see Dimensions)	16 to 24	D374

1.3 The tests for Holes and Felt Hair Inclusions and the Stain Test for Fine Pores, have been removed from this compilation of test methods. These test methods were specific to grades of capacitor paper formerly covered by Specification D1930, which has been withdrawn.

NOTE 1—This compilation of test methods is closely related to IEC Publication 60554-2. Not all of the individual methods included herein are included in IEC 60554-2, nor are all of the methods in IEC 60554-2 included in this standard. The individual procedures as described in the two standards are in general sufficiently close to each other that it is reasonable to expect that test results obtained by most of the procedures specified in either standard will not differ significantly. However, before assuming that a procedure in these test methods is exactly equivalent to an IEC 60554-2 procedure, the written procedures must be compared closely, and if it seems advisable, test results by the two procedures are compared.

[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 D09.01 on Electrical Insulating Products.

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

1.4 The values stated in SI 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.

1.5 *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.* See 43.2.1, 71.1, 143.1, 148.1 and 156.1 for specific hazards.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles

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

D374 Test Methods for Thickness of Solid Electrical Insulation (Metric) D0374_D0374M

D528 Test Method for Machine Direction of Paper and Paperboard (Withdrawn 2010)[3]

D586 Test Method for Ash in Pulp, Paper, and Paper Products (Withdrawn 2009)[3]

D644 Test Method for Moisture Content of Paper and Paperboard by Oven Drying (Withdrawn 2010)[3]

D646 Test Method for Mass Per Unit Area of Paper and Paperboard of Aramid Papers (Basis Weight)

D689 Test Method for Internal Tearing Resistance of Paper (Withdrawn 2009)[3]

D726 Test Method for Resistance of Nonporous Paper to Passage of Air (Withdrawn 2009)[3]

D774/D774M Test Method for Bursting Strength of Paper (Withdrawn 2010)[3]

D827 Method of Test for Edge Tearing Strength of Paper (Withdrawn 1980)[3]

D1030 Test Method for Fiber Analysis of Paper and Paperboard

D1193 Specification for Reagent Water

D1389 Test Method for Proof-Voltage Testing of Thin Solid Electrical Insulating Materials (Withdrawn 2013)[3]

D1711 Terminology Relating to Electrical Insulation

D2176 Test Method for Folding Endurance of Paper and Plastics Film by the M.I.T. Tester

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

D3277 Test Methods for Moisture Content of Oil-Impregnated Cellulosic Insulation (Withdrawn 2010)[3]

D3376 Test Methods of Sampling and Testing Pulps to be Used in the Manufacture of Electrical Insulation

D3394 Test Methods for Sampling and Testing Electrical Insulating Board

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

E4 Practices for Force Verification of Testing Machines

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E70 Test Method for pH of Aqueous Solutions With the Glass Electrode

2.2 *TAPPI Standards:*[4]

T 414 Internal Tearing Resistance of Paper

T 423 Folding Endurance of Paper (Schopper Type Test)

T 444 Silver Tarnishing by Paper and Paperboard

T 455 Identification of Wire Side of Paper

T 460 Air Resistance of Paper (Gurley Method)

T 470 Edge Tearing Resistance of Paper

T 536 Resistance of Paper to Passage of Air (High Pressure Gurley Method)

2.3 *IEC Standard:*

IEC 60554-2 Specification for Cellulosic Papers for Electrical Purposes—Part 2: Methods of Test[5]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions pertaining to sampling refer to Terminology D1711 or to Practice D3636.

3.1.2 For definitions pertaining to dissipation factor and permittivity refer to Terminology D1711 or to Test Methods D150.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *air resistance, of paper, n*—a paper property which quantifies impediment to the transverse passage of air through the paper under specific conditions of test, and reported as either time for a specified volume per area of test or volume for a specified time per area of test.

3.2.1.1 *Discussion*—It is expressed in terms of time (seconds) required for passage of a specified volume of air through a known area of paper, or, as the volume of air passing through the paper in a given length of time.

3.2.2 *ash content of paper, n*—the solid residue remaining after combustion of the paper under specified conditions, expressed as a percentage of the dry mass of the original specimen.

3.2.3 *basis weight of paper*—see *grammage of paper*.

3.2.4 *bursting strength of paper, n*—the hydrostatic pressure required to produce rupture of a circular area of the material under specified test procedures.

3.2.5 *coverage of paper, n*—the reciprocal of grammage (or basis weight).

[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 Technical Association of the Pulp and Paper Industry (TAPPI), 15 Technology Parkway South, Norcross, GA 30092, http://www.tappi.org.

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

3.2.6 *elongation of paper, n*—the maximum tensile strain developed in the test specimen before break in a tension test under prescribed conditions, calculated as the ratio of the increase in length of the test specimen to the original test span, and expressed as a percentage.

3.2.6.1 *Discussion*—It is calculated as the ratio of the increase in length of the test specimen to the original test span, and is expressed as a percentage.

3.2.7 *folding endurance of paper, n*—the resistance to fatigue resulting from repeated folding under specified conditions of test, expressed as the number of double folds required to rupture a specimen, or as the logarithm of that number.

3.2.7.1 *Discussion*—The level is expressed as the number of double folds required to rupture a specimen. Sometimes the level is expressed as the logarithm of the number.

3.2.8 *grammage of paper, n*—the mass per unit area of paper, expressed as grams per square metre.

3.2.8.1 *Discussion*—Grammage is sometimes called weight or basis weight of paper. These terms are most frequently used when non-metric units are used, and the area is that of the paper in one of the several standard reams of papers defined within the paper industry.

3.2.9 *impregnation time of paper, n*—the time in seconds required for a liquid of specified composition and viscosity to penetrate completely from one face of a sheet of paper to the other under certain prescribed conditions.

3.2.10 *internal tearing resistance of paper, n*—the force required to continue a previously-initiated tear across a specified distance in a single thickness of paper, expressed as the average force per sheet to tear one or more sheets together.

3.2.10.1 *Discussion*—It is indicated on the specified apparatus and reported as the average force per sheet to tear one or more sheets together across a specified distance.

3.2.11 *kinetic surface friction of paper, n*— the ratio of the force parallel to the surfaces of two pieces of paper in contact with each other to the force normal to the surfaces required to continue previously-initiated movement relative to each other at constant speed.

3.2.11.1 *Discussion*—One possible test configuration uses a paper-covered block on a paper-covered inclined plane, in which case the result is expressed in degrees of angle of inclination of the plane which will cause the block to continue an initiated movement.

3.2.12 *loss on ignition of inorganic fiber paper, n*—the volatile and combustible fraction of a paper, expressed as a percentage of the original dry mass lost upon ignition, using a specified procedure.

3.2.12.1 *Discussion*—It is expressed as a percentage of the original dry weight lost upon ignition, and is usually used instead of ash content when dealing with papers which are principally composed of inorganic fibers.

3.2.13 *solvent-soluble material in paper, n*— the mass of material that can be extracted from a dry specimen by a specified solvent under prescribed conditions, expressed as a percentage of the original dry mass.

3.2.14 *tensile energy absorption of paper (TEA), n*—the work performed when a paper specimen is stressed to break in tension under prescribed conditions, as measured by the integral of the tensile stress over the range of tensile strain from zero to the strain corresponding to maximum stress, expressed as energy (work) per unit of original surface area of the test specimen.

3.2.14.1 *Discussion*—The TEA is expressed as energy (work) per unit of original surface area (length × width) of the test specimen.

3.2.15 *tensile strength of paper, n*—the maximum tensile stress developed in a test specimen in a tension test carried to break under prescribed conditions, expressed for thin papers as force per unit original width of the test specimen.

3.2.15.1 *Discussion*—Tensile stress is the force per unit of original cross-sectional area, but in thin materials such as paper it is commonly expressed in terms of force per unit of original width.

3.2.16 *thickness of an electrical insulating material, n*—the perpendicular distance between the two surfaces of interest, determined in accordance with a standard method.

3.2.16.1 *Discussion*—The thickness of papers under 0.05 mm (0.002 in.) in thickness, is often defined as one tenth that of a stack of ten sheets in certain paper specifications.

3.2.17 *water extract conductivity of paper, n*—the apparent volume conductivity at 60 Hz of a specimen of water that has been used to dissolve water-soluble impurities from a specimen of paper under prescribed conditions.

4. Reagents

4.1 *Purity of Reagents*—Use reagent grade chemicals in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[6] Other grades are acceptable, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

4.2 *Purity of Water*—Except where otherwise indicated, use reagent water, Type III, of Specification D1193.

5. Precision and Bias

5.1 For individual test methods that follow, where no precision and bias section is included and where the procedure is contained in another standard to which reference is made, refer to that standard for information relative to precision and bias for that test method.

SAMPLING

6. Scope

6.1 This test method covers the procedure for judging lot acceptability of electrical insulating papers. It is designed for

[6] "Reagent Chemicals, American Chemical Society PO Box 182426, Columbus, OH 43218-2426." For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, NY, and the "United States Pharmacopeia."