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Standard Test Method for Air Permeability of Textile Fabrics[1]

This standard is issued under the fixed designation D737; 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 This test method covers the measurement of the air permeability of textile fabrics.

1.2 This test method applies to most fabrics including woven fabrics, nonwoven fabrics, air bag fabrics, blankets, napped fabrics, knitted fabrics, layered fabrics, and pile fabrics. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated.

1.3 The values stated in SI units are to be regarded as the standard. The values stated in inch-pound units may be approximate.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D123 Terminology Relating to Textiles

D1776 Practice for Conditioning and Testing Textiles

D2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data (Withdrawn 2008)[3]

D2906 Practice for Statements on Precision and Bias for Textiles (Withdrawn 2008)[3]

D4850 Terminology Relating to Fabrics and Fabric Test Methods

F778 Methods for Gas Flow Resistance Testing of Filtration Media

3. Terminology

3.1 For definition of textile terms used in this test method: air permeability, and fabric, refer to Terminology D4850.

3.2 For definitions of cross-machine direction; machine direction and other textile terms used in this test method, refer to Terminology D123.

4. Summary of Test Method

4.1 The rate of air flow passing perpendicularly through a known area of fabric is adjusted to obtain a prescribed air pressure differential between the two fabric surfaces. From this rate of air flow, the air permeability of the fabric is determined.

5. Significance and Use

5.1 This test method is considered satisfactory for acceptance testing of commercial shipments since current estimates of between-laboratory precision are acceptable, and this test method is used extensively in the trade for acceptance testing.

5.1.1 If there are differences of practical significance between reported test results for two laboratories (or more), comparative tests should be performed to determine if there is a statistical bias between them, using competent statistical assistance. As a minimum, ensure the test samples to be used are as homogeneous as possible, are drawn from the material from which the disparate test results were obtained, and are randomly assigned in equal number to each laboratory for testing. The test results from the two laboratories should be compared using a statistical test for unpaired data, at a probability level chosen prior to the testing series. If bias is found, either its cause must be found and corrected, or future test results for that material must be adjusted in consideration of the known bias.

5.2 Air permeability is an important factor in the performance of such textile materials as gas filters, fabrics for air bags, clothing, mosquito netting, parachutes, sails, tentage, and vacuum cleaners. In filtration, for example, efficiency is directly related to air permeability. Air permeability also can be used to provide an indication of the breathability of weather-resistant and rainproof fabrics, or of coated fabrics in general, and to detect changes during the manufacturing process.

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.59 on Fabric Test Methods, General.

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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.

5.3 Performance specifications, both industrial and military, have been prepared on the basis of air permeability and are used in the purchase of fabrics where permeability is of interest.

5.4 Construction factors and finishing techniques can have an appreciable effect upon air permeability by causing a change in the length of airflow paths through a fabric. Hot calendaring can be used to flatten fabric components, thus reducing air permeability. Fabrics with different surface textures on either side can have a different air permeability depending upon the direction of air flow.

5.4.1 For woven fabric, yarn twist also is important. As twist increases, the circularity and density of the yarn increases, thus reducing the yarn diameter and the cover factor and increasing the air permeability. Yarn crimp and weave influence the shape and area of the interstices between yarns and may permit yarns to extend easily. Such yarn extension would open up the fabric, increase the free area, and increase the air permeability.

5.4.2 Increasing yarn twist also may allow the more circular, high-density yarns to be packed closely together in a tightly woven structure with reduced air permeability. For example, a worsted gabardine fabric may have lower air permeability than a woolen hopsacking fabric.

6. Apparatus

6.1 *Air Permeability Testing Apparatus*[4] consisting of the following:

6.1.1 *Test Head* that provides a circular test area of 38.3 cm^2 (5.93 $in.^2$) ± 0.3 %.

NOTE 1—Alternate test areas may be used, such as 5 cm^2 (0.75 $in.^2$), 6.45 cm^2 (1.0 $in.^2$), and 100 cm^2 (15.5 $in.^2$).

6.1.2 *Clamping System to Secure Test Specimens,* of different thicknesses under a force of at least 50 ± 5 N (11 ± 1 lbf) to the test head without distortion and minimal edge leakage underneath the test specimen.

6.1.2.1 A suitable means to minimize edge leakage is to use a 55 Type A durometer hardness polychloroprene (neoprene) clamping ring 20 mm (0.75 in.) wide and 3 mm (0.125 in.) thick around the test area above and underneath the test specimen.

NOTE 2—Since air leakage may affect test results, precautions must be taken, especially with very heavy or lofty fabrics, to prevent leakage. The use of a weighted ring and rubber gaskets on the clamp surfaces has been found to be helpful. Methods F778 describes a series of usable clamping adaptions to eliminate edge leakage. Gaskets should be used with caution because in some cases, and with repeated-use gaskets may deform resulting in a small change in test area. A weighted ring can be used with fabrics, such as knits or those that readily conform to the test head. The weighted ring is not recommended for lofty or stiff fabric.

6.1.3 Means for drawing a steady flow of air perpendicularly through the test area and for adjusting the airflow rate that preferably provides pressure differentials of between 100 and 2500 Pa (10 and 250 mm or 0.4 and 10 in. of water) between the two surfaces of the fabric being tested. At a minimum, the test apparatus must provide a pressure drop of 125 Pa (12.7 mm or 0.5 in. of water) across the specimen.

6.1.4 *Pressure Gage or Manometer,* connected to the test head underneath the test specimen to measure the pressure drop across the test specimen in pascals (millimetres or inches of water) with an accuracy of ±2 %.

6.1.5 *Flowmeter,* volumetric counter or measuring aperture to measure air velocity through the test area in $cm^3/s/cm^2$ ($ft^3/min/ft^2$) with an accuracy of ±2 %.

6.1.6 *Calibration Plate,* or other means, with a known air permeability at the prescribed test pressure differential to verify the apparatus.

6.1.7 Means of calculating and displaying the required results, such as scales, digital display, and computer-driven systems.

6.2 *Cutting Dies or Templates,* to cut specimens having dimensions at least equal to the area of the clamping surfaces of the test apparatus (optional).

7. Sampling and Test Specimens

7.1 *Lot Sample*—As a lot sample for acceptance testing, randomly select the number of rolls or pieces of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider the rolls or pieces of fabric to be the primary sampling units. In the absence of such an agreement, take the number of fabric rolls or pieces specified in Table 1.

NOTE 3—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls or pieces of fabric and between specimens from a swatch from a roll or piece of fabric to provide a sampling plan with a meaningful producer's risk, consumer's risk, acceptable quality level, and limiting quality level.

7.2 *Laboratory Sample*—For acceptance testing, take a swatch extending the width of the fabric and approximately 1 m (1 yd) along the lengthwise direction from each roll or piece in the lot sample. For rolls of fabric, take a sample that will exclude fabric from the outer wrap of the roll or the inner wrap around the core of the roll of fabric.

7.3 *Test Specimens*—From each laboratory sampling unit, take ten specimens unless otherwise agreed upon between purchaser and supplier. Use the cutting die or template described in 6.2, or if practical, make air permeability tests of a textile fabric without cutting.

7.3.1 *Cutting Test Specimens*—When cutting specimens, cut having dimensions at least equal to the area of the clamping mechanism. Label to maintain specimen identity.

7.3.1.1 Take specimens or position test areas representing a broad distribution across the length and width, preferably along the diagonal of the laboratory sample, and no nearer the edge

TABLE 1 Number of Rolls or Pieces of Fabric in the Lot Sample

Number of Rolls or Pieces in Lot, Inclusive	Number of Rolls or Pieces in Lot Sample
1 to 3	all
4 to 24	4
25 to 50	5
over 50	10 % to a maximum of 10 rolls or pieces

[4] For additional information on obtaining apparatus, equipment, or supplies that may be suitable for use in this standard, please visit the ASTM Manufacturers' Equipment Directory at www.astm.org.

than one tenth its width unless otherwise agreed upon between the purchaser and supplier. Ensure specimens are free of folds, creases, or wrinkles. Avoid getting oil, water, grease, and so forth, on the specimens when handling.

8. Preparation of Test Apparatus and Calibration

8.1 Set-up procedures for machines from different manufacturers may vary. Prepare and verify calibration of the air permeability tester as directed in the manufacturer's instructions.

8.2 When using microprocessor automatic data gathering systems, set the appropriate parameters as specified in the manufacturer's instructions.

8.3 For best results, level the test instrument.

8.4 Verify calibration for the range and required water pressure differential that is expected for the material to be tested.

9. Conditioning

9.1 Precondition the specimens by bringing them to approximate moisture equilibrium in the standard atmosphere for preconditioning textiles as specified in Practice D1776.

9.2 After preconditioning, bring the test specimens to moisture equilibrium for testing in the standard atmosphere for testing textiles as specified in Practice D1776 or, if applicable, in the specified atmosphere in which the testing is to be performed.

9.3 When it is known that the material to be tested is not affected by heat or moisture, preconditioning and conditioning is not required when agreed upon in a material specification or contract order.

10. Procedure

10.1 Test the conditioned specimens in the standard atmosphere for testing textiles, which is 21 ± 1°C (70 ± 2°F) and 65 ± 2 % relative humidity, unless otherwise specified in a material specification or contract order.

10.2 Handle the test specimens carefully to avoid altering the natural state of the material.

10.3 Place each test specimen onto the test head of the test instrument, and perform the test as specified in the manufacturer's operating instructions.

10.3.1 Place coated test specimens with the coated side down (towards low pressure side) to minimize edge leakage.

10.4 Make tests at the water pressure differential specified in a material specification or contract order. In the absence of a material specification or contract order, use a water pressure differential of 125 Pa (12.7 mm or 0.5 in. of water).

10.5 Read and record the individual test results in SI units as $cm^3/s/cm^2$ and in inch-pound units as $ft^3/min/ft^2$ rounded to three significant digits.

10.5.1 For special applications, the total edge leakage underneath and through the test specimen may be measured in a separate test, with the test specimen covered by an airtight cover, and subtracted from the original test result to obtain the effective air permeability.

10.6 Remove the tested specimen and continue as directed in 10.3 – 10.5 until ten specimens have been tested for each laboratory sampling unit.

10.6.1 When a 95 % confidence level for results has been agreed upon in a material specification or contract order, fewer test specimens may be sufficient. In any event, the number of tests should be at least four.

11. Calculation

11.1 *Air Permeability, Individual Specimens*—Calculate the air permeability of individual specimens using values read directly from the test instrument in SI units as $cm^3/s/cm^2$ and in inch-pound units as $ft^3/min/ft^2$, rounded to three significant digits. When calculating air permeability results, follow the manufacturer's instructions as applicable.

NOTE 4—For air permeability results obtained 600 m (2000 ft) above sea level, correction factors may be required.

11.2 *Air Permeability, Average*—Calculate the average air permeability for each laboratory sampling unit and for the lot.

11.3 *Standard Deviation, Coefficient of Variation*—Calculate when requested.

11.4 *Computer-Processed Data*—When data are automatically computer-processed, calculations are generally contained in the associated software. It is recommended that computer-processed data be verified against known property values and its software described in the report.

12. Report

12.1 Report that the air permeability was determined in accordance with Test Method D737. Describe the material or product sampled and the method of sampling used.

12.2 Report the following information for each laboratory sampling unit and for the lot as applicable to a material specification or contract order:

12.2.1 Air permeability.

12.2.2 When calculated, the standard deviation or the coefficient of variation.

12.2.3 Pressure differential between the fabric surfaces.

12.2.4 For computer-processed data, identify the program (software) used.

12.2.5 Manufacturer and model of test instrument.

12.2.6 Any modification of this test method or equipment including changing or adding gaskets.

13. Precision and Bias[5]

13.1 *Summary*—In comparing two averages, the differences should not exceed the single-operator precision values shown in Table 2 for the respective number of tests, and for fabrics having averages similar to those shown in Table 3, in 95 out of 100 cases when all the observations are taken by the same well-trained operator using the same piece of equipment and specimens randomly drawn from the sample of fabrics. Larger differences are likely to occur under all other circumstances.

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting RR:D13-1109.

TABLE 2 Air Permeability, $ft^3/min/ft^2$, Critical Differences[A] for the Conditions Noted

Materials	Number of Observations in Each Average	Single-Operator Precision	Within-Laboratory Precision	Between-Laboratory Precision
Woven Fabrics				
Plain, Oxford spun yarns, Material 5	1	28.8	34.1	59.3
	2	20.3	27.4	55.7
	5	12.9	22.4	53.4
	10	9.1	20.5	52.6
Plain, spun yarns, Material 6	1	9.7	13.0	30.4
	2	6.9	11.0	29.6
	5	4.3	9.6	29.1
	10	3.1	9.1	29.0
Plain, continous filament yarns, Material 7	1	2.8	2.8	4.4
	2	2.0	2.0	3.8
	5	1.3	1.3	3.5
	10	0.9	0.9	3.4
Nonwoven Fabrics				
Hydroentangled	1	27.6	33.9	52.0
	2	19.5	27.7	48.2
	5	12.3	23.3	45.8
	10	8.7	21.6	45.0
Dry-laid	1	51.3	55.6	73.4
	2	36.3	42.1	63.8
	5	23.0	31.3	57.2
	10	16.2	26.8	54.9
Meltblown	1	8.8	9.3	21.5
	2	6.2	6.9	20.6
	5	4.0	4.9	20.0
	10	2.8	4.0	19.8
Needlepunch	1	100.7	112.4	113.4
	2	71.2	87.0	88.2
	5	45.0	67.3	68.8
	10	31.8	59.2	61.0
Resin-bonded	1	162.7	179.8	189.2
	2	115.1	138.1	150.1
	5	72.8	105.4	120.8
	10	51.5	92.0	109.3
Spun-bonded	1	234.6	234.6	251.2
	2	165.9	165.9	188.7
	5	104.9	104.9	138.1
	10	74.2	74.2	116.5
Thermal	1	206.2	232.3	232.2
	2	145.8	180.8	180.8
	5	92.2	141.2	141.2
	10	65.2	125.2	125.2
Wet-laid	1	1.34	2.80	3.24
	2	0.95	2.63	3.10
	5	0.60	2.52	3.01
	10	0.43	2.49	2.98

[A] The critical differences were calculated using $t = 1.960$, which is based on infinite degrees of freedom.

13.2 *Woven Fabrics, Interlaboratory Test Data*—An interlaboratory test was run in 1994 through 1995 in which randomly drawn samples of three fabrics were tested in each of eight laboratories. Two operators in each laboratory each tested eight specimens of each fabric using this test method. Four of the eight specimens were tested on one day, and four specimens were tested on a second day. Analysis of the data was conducted using Practices D2904 and D2906. The components of variance for air permeability expressed as standard deviations were calculated to be the values listed in Table 3. The three woven fabric types were:

TABLE 3 Air Permeability, $ft^3/min/ft^2$

Materials	Grand Average	Components of Variance Expressed as Standard Deviations[A]		
		Single-Operator Component	Within-Laboratory Component	Between-Laboratory Component
Woven Fabrics				
Plain, Oxford spun yarns Mat 5	217.0	10.4	6.6	17.5
Plain, spun yarns Mat 6	90.0	3.5	3.1	9.9
Plain, continous filament yarns Mat 7	8.3	1.0	0.0	1.2
Nonwoven Fabrics				
Hydroentangled	220.0	9.9	7.1	14.2
Dry-laid	402.0	18.5	7.7	17.3
Meltblown	72.7	3.2	1.0	7.0
Needlepunch	278.0	36.0	18.0	5.3
Resin-bonded	948.0	58.7	27.5	21.3
Spun-bonded	474.0	84.6	0.0	32.4
Thermal	564.0	74.4	38.6	0.0
Wet-laid	17.2	0.5	0.9	0.6

[A] The square roots of the components of variance are being reported to express the variability in the appropriate units of measure rather than as the squares of those units of measure.

Material 5—S/2438, Plain Weave, Oxford, Spun Yarns
Material 6—S/0002H, Plain Weave, Spun Yarns
Material 7—S/28305, Plain Weave, Continuous Filament Yarns

13.3 *Nonwoven Fabrics, Interlaboratory Test Data*—An interlaboratory test was run in 1994 in which randomly drawn samples of eight fabrics were tested in each participating laboratory. Two operators in each laboratory each tested eight specimens of each fabric using this test method. Four of the eight specimens were tested on one day and four specimens were tested on a second day. Analysis of the data was conducted using Practices D2904 and D2906. The components of variance for air permeability of nonwoven fabrics expressed as standard deviations were calculated to be the values listed in Table 3. The eight fabric types and number of participating laboratories were as follows:

Nonwoven Material	Number of Participating Laboratories
Hydroentangled	5
Dry-Laid	5
Meltblown	5
Needlepunched	5
Resin-Bonded	2
Spun-Bonded	4
Thermal	4
Wet-Laid	5

13.4 *Precision*—For the components of variance reported in Table 3, two averages of observed values should be considered significantly different at the 95 % probability level if the difference equals or exceeds the critical differences listed in Table 2. There were sufficient differences related to the fabric type and structure to warrant listing the components of variance and the critical differences separately. Consequently, no multi-fabric comparisons were made.

NOTE 5—The tabulated values of the critical differences should be considered to be a general statement, particularly with respect to between-laboratory precision. Before a meaningful statement can be made about two specific laboratories, the amount of statistical bias, if any, beteween them must be established with each comparison being based on recent data obtained on specimens taken from a lot of fabric to the type being

evaluated so as to be as nearly homogeneous as possible, and then randomly assigned in equal numbers to each of the laboratories.

NOTE 6—Since the interlaboratory test for resin-bonded nonwoven fabric included only two laboratories and the spun-bonded and thermal nonwoven fabrics included only four laboratories, estimates of between laboratory precision may be either underestimated or overestimated to a considerable extent and should be used with special caution.

13.5 *Bias*—The value of air permeability only can be defined in terms of a test method. Within this limitation, this test method has no known bias.

14. Keywords

14.1 air permeability; fabric