Designation: D 4966 – 98

Standard Test Method for Abrasion Resistance of Textile Fabrics (Martindale Abrasion Tester Method)[1]

This standard is issued under the fixed designation D 4966; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the abrasion resistance of textile fabrics using the Martindale abrasion tester. Fabrics of all types may be tested by this method but difficulties may arise with fabrics with a pile depth greater than 0.08 in. (2 mm).

1.2 The values stated in inch-pound units are to be regarded as standard; the values in SI units are provided as information only.

1.3 *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.*

NOTE 1—For other current test methods of testing the abrasion resistance of textiles refer to Test Methods D 3884, D 3885, D 3886, D 4157, D 4158, and AATCC Test Method 93.

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

D 1776 Practice for Conditioning Textiles for Testing[2]

D 3884 Test Method for Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method)[3]

D 3885 Test Method for Abrasion Resistance of Textile Fabrics (Flexing and Abrasion Method)[3]

D 3886 Test Method for Abrasion Resistance of Textile Fabrics (Inflated Diaphragm Method)[3]

D 4157 Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)[3]

D 4158 Test Method for Abrasion Resistance of Textile Fabrics (Uniform Abrasion Method)[3]

2.2 *AATCC Methods and Procedures:*

Evaluation Procedure 1 Gray Scale for Color Change[3]

Test Method 93 Abrasion Resistance of Fabrics: Accelerator Method[4]

3. Terminology

3.1 *Definitions*—For definitions of other textile terms used in this test method, refer to Terminology D 123.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abrasion, n*—the wearing away of any part of a material by rubbing against another surface.

3.2.2 *abrasion cycle, n*—total number of movements required to complete a geometric shape in a Martindale abrasion tester.

3.2.3 *cycle, n*—16 movements required for the completion of one Lissajous figure on a Martindale tester.

3.2.4 *lissajous figure, n*—a geometric figure that starts as a straight line, then becomes a widening ellipse and narrows to again become a straight line. There are 16 movements in one Lissajous figure.

3.2.5 *movement, n*—one rotation of the two outer gearing of the Martindale tester.

3.2.6 *standard atmosphere for preconditioning textiles, n*—an atmosphere having a relative humidity of 10 to 25 % and a temperature not over 122°F (50°C).

3.2.7 *standard atmosphere for testing, in textiles, n*—an atmosphere for testing in which the air is maintained at a relative humidity of 65 ± 2 % and at a temperature of 70 ± 2°F (21 ± 1°C).

4. Summary of Test Method

4.1 Abrasion resistance is measured by subjecting the specimen to rubbing motion in the form of a geometric figure, that is, a straight line, which becomes a gradually widening ellipse, until it forms another straight line in the opposite direction and traces the same figure again under known conditions of pressure and abrasive action. Resistance to abrasion is evaluated by various means which are described in Section 11.

5. Significance and Use

5.1 *Acceptance Testing*—this test method is not considered satisfactory for acceptance testing of commercial shipments of fabric. The between-laboratory precision of this test method is

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[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 07.02.

[4] Available from the American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, NC 27709.

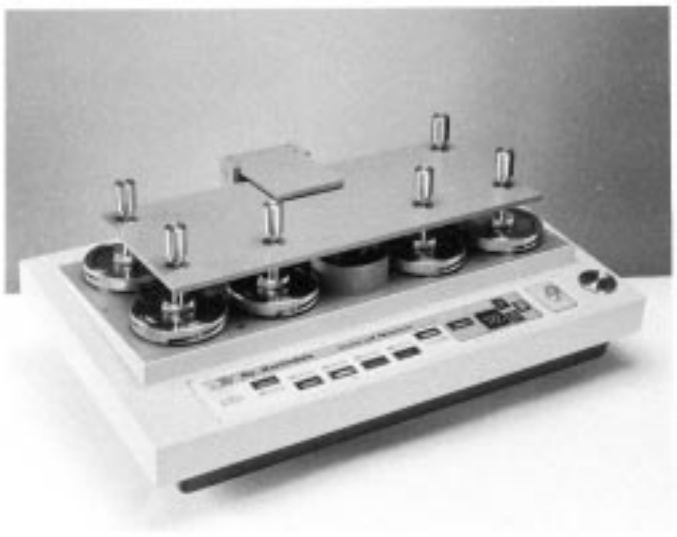

FIG. 1 Martindale Abrasion Tester

poor and, because of the nature of abrasion testing itself, technicians frequently fail to obtain results in agreement on the same type of testing instrument, both within and between laboratories. Although this test method is not recommended for acceptance testing, it is useful because it is used widely, especially outside the United States.

5.1.1 In case of a dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should conduct comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens that are as homogeneous as possible and that are from a lot of material of the type in question. The test specimens then should be assigned randomly in equal numbers to each laboratory for testing. The average results from the two laboratories should be compared using Students t-test for unpaired data and an acceptable probability level chosen by the two parties before the testing is begun. If a bias is found, either its cause must be found and corrected or the purchaser and the supplier must agree to interpret future test results in light of the known bias.

5.2 The resistance to abrasion also is affected greatly by the conditions of the tests, such as the nature of abradant; variable action of the abradant over the area of specimen abraded, the tension on the specimen, the pressure between the specimen and abradant, and the dimensional changes in the specimen.

5.3 Abrasion tests are all subject to variation due to changes in the abradant during specific tests. The abradant must be changed accordingly at frequent intervals or checked periodically against a standard. With disposable abradants, the abradant is used only once or changed after limited use. With permanent abradants that use hardened metal or equivalent surfaces, it is assumed that the abradant will not change appreciably in a specific series of tests, but obviously similar abradants used in different laboratories will not likely change at the same rate due to differences in usage. Permanent abradants also may change due to pick up of finishing or other material from test fabrics and must accordingly be cleaned at frequent intervals. The measurement of the relative amount of abrasion also may be affected by the method of evaluation and may be influenced by the judgment of the operator.

5.4 The resistance of textile materials to abrasion as measured on a testing machine in the laboratory is generally only one of several factors contributing to wear performance or durability as experienced in the actual use of the material. While “abrasion resistance” (often stated in terms of the number of cycles on a specified machine, using a specified technique to produce a specified degree or amount of abrasion) and “durability” (defined as the ability to withstand deterioration or wearing out in use, including the effects of abrasion) frequently are related, the relationship varies with different end uses, and different factors may be necessary in any calculation of predicted durability from specific abrasion data.

5.4.1 Laboratory tests may be reliable as an indication of relative end-use performance in cases where the difference in abrasion resistance of various materials is large, but they should not be relied upon where differences in laboratory test findings are small. In general, they should not be relied upon for prediction of actual wear-life in specific-end uses unless there are data showing the specific relationship between laboratory abrasion tests and actual wear in the intended end-use.

5.5 These general observations apply to all types of fabrics, including woven, nonwoven, and knit apparel fabrics, household fabrics, industrial fabrics, and floor coverings. It is not surprising, therefore, to find that there are many different types of abrasion testing machines, abradants, testing conditions, testing procedures, methods of evaluation of abrasion resistance, and interpretation of results.

5.6 All the test methods and instruments so far developed for abrasion resistance may show a high degree of variability in results obtained by different operators and in different laboratories; however, they represent the methods now most widely in use.

5.7 Since there is a definite need for measuring the relative resistance to abrasion, standardized test methods are desirable and useful and may clarify the problem and lessen the confusion.

6. Apparatus and Materials

6.1 *Martindale Abrasion Tester,*[5] (Fig. 1) with the following replaceable items:

6.1.1 *Standard Abradant Fabric*,[5] a plain weave, crossbred, worsted wool fabric described in the finished state as in Table 1.

6.1.2 *Standard Felt,*[5] of mass 22 ± 1.5 oz/yd^2 (750 ± 50 g/m^2) and 0.12 ± 0.01 in. (3 ± 0.3 mm) thick.

6.1.3 *Polyurethane Foam Backing*,[5] 0.12 ± 0.04 in. (3 ± 0.01 mm) thick, 1.94 lbf/ft^3 (29 to 31 kg/m^3) density, and 38.23 to 47.22 lbf (170 to 210 N) hardness.

6.1.4 *Fabric Punches or Press Cutters,*[6] 1.5 in. (38 mm) and 5.5 in. (140 mm) in diameter.

[5] Commercially available from Ahiba, 2175 Hawkins St., Charlotte, NC 28203.

[6] Available from Testing Machines, Inc., 400 Bayview Ave., Amityville, NY 11701.

TABLE 1 Specifications for Standard Wool Abrasion Fabric

	Warp	Weft
Yarn linear density	R63, Tex/2	R74, Tex/2
Threads per unit length	(43/in.) 17/cm	(30/in.) 12/cm
Single twist	540 ± 20 tpm 'Z'	500 ± 20 tpm' Z'
Twofold twist	450 ± 20 tpm 'S'	350 ± 20 tpm 'S'
Fiber diameter	27.5 ± 20 µm	29 ± 20 µm
Mass per unit area of fabric, min	5.8 oz/yd^2(195 g/m^2)	

6.1.5 *AATCC Gray Scale for Color Change.*[4]

7. Sampling

7.1 *Lot Sample*—As a lot sample for acceptance testing, take at random the number of rolls of fabric directed in an applicable material specification or other agreement between the purchaser and the supplier. Consider rolls of fabric to be the primary sampling unit.

NOTE 2—An adequate specification or other agreement between the purchaser and the supplier requires taking into account the variability between rolls, bolts, or pieces of fabric and among specimens from a swatch from a roll of fabric from a roll, bolt, or piece, or among cartons of garments and among garments within a carton, 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 of garments, take one garment from each carton (see Note 2).

7.3 *Test Specimens*—Cut three circular specimens from each swatch in the laboratory sample with each specimen being 1.5 in. (38 mm) in diameter.

8. Preparation of Apparatus

8.1 For the assembly, maintenance, and verification of the apparatus, refer to the manufacturer's instructions.

8.2 See the testing notes given in A1.1.

9. Conditioning

9.1 Precondition and condition specimens as directed in Practice D 1776 by bringing them to approximate moisture equilibrium for testing in the standard atmosphere for testing. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighings made at intervals of not less than 2 h does not exceed 0.1 % of the mass of the specimen.

9.2 Place the conditioned specimens in the standard atmosphere for testing textiles, which is 70 ± 2°F (21 ± 1°C) and 65 ± 2 % relative humidity for at least 4 h before testing.

10. Procedure

10.1 Make all tests in the standard atmosphere for testing.

10.2 On each testing table place a piece of felt, approximately 5.5 in. (140 mm), followed by a piece of the standard fabric of the same size. Place the mounting weight (supplied with the machine) on the table to flatten the fabric/felt pieces. Secure the fabric/felt to the table with the mounting weight in place then remove the weight and inspect for tucks or ridges. If necessary, repeat the mounting process.

10.3 Option 3 (see 11.3) is to be used to interpret the results, weigh a specimen to the nearest milligram.

10.4 Assemble the holder by placing the specimen face down into the specimen holder. For fabric having a mass/unit area less than 14.7 yd^2 (500 g/m^2) place a 1¼-in. (38-mm) disk of polyurethane foam between the specimen and the metal insert. Assemble the holder according to manufacturer's instructions.

10.5 Place the assembled holder on the machine above the table with the fabric/felt pieces and add the required weight to give a pressure on each specimen of 1.31 ± 0.03 psi (9 ± 0.2 kPa) for apparel fabrics and 1.74 ± 0.04 psi (12 ± 0.3 kPa) for upholstery fabrics.

10.6 Using the manufacturer's directions, set the counter system to record the desired movements and start the abrasion machine. If Options 1 or 2 (see 10.1 and 10.2) are to be used, examine the specimen to assess the progress toward the endpoint. As the endpoint is approached, reduce the number of movements between examinations. Cut off with sharp scissors any pills that form. If Option 3 (see 11.3) is to be used to interpret the results, the specimen must be weighed to the nearest milligram after the required movements.

11. Evaluation

11.1 *Option 1*—The end point is reached on a woven fabric when two or more yarns have broken, or on a knitted fabric when a hole appears.

11.2 *Option 2*—The end point is reached when there is a change in shade or appearance that is sufficient to cause a customer to complain.

11.2.1 Changes of shade can arise from a variety of causes, for example, loss of raised finish from a fabric or of boucle loops or effects from fancy yarns. Where different types of fibers are dyed differently in an intimate blend, differential loss of yarn or fiber can cause pronounced changes in shade or appearance. In this case the end point is assessed against the AATCC gray scale for color change.

11.2.2 The end point is reached when the shade change is assessed as the AATCC gray scale rating of 3 or lower.

11.3 *Option 3*—Determine the mass loss as the difference between the masses before and after abrasion. This loss may be expressed as a percentage of the before abrasion mass.

12. Report

12.1 State that the specimens were tested as directed in Test Method D 4966. Describe the material or product sampled and the method of sampling used.

12.2 Depending on the test option used, report the following information:

12.2.1 Type of abradant and the mass of the weights used.

12.2.2 For Option 1, the average number of movements required to rupture two or more yarns in a woven fabric or develop a hole on a knitted fabric.

12.2.3 For Option 2, the effect of abrasion on luster, color, napping, pilling, etc. at a given number of movements, recorded by qualitative or comparative ranking.

12.2.4 For Option 2, the average number of movements required to reach a gray scale rating of three or lower.

12.2.5 If any other means of evaluating the effect of abrasion is used, describe the particular method employed.

12.2.6 For Option 3, the mass loss difference before and

after abrasion is reported as weight loss in milligrams or as a percentage calculated by the formula:

$$((A - B)/A) \times 100 \quad (1)$$

where:
A = before weight, and
B = after weight.

13. Precision and Bias

13.1 *Precision*—Four measurements were made using Option 3 on two types of Martindale abrasion units on two days. Each set of four were run for 25 000 movements and the weight loss measured. The results are reported in groups of four:

	Day 1		
	Machine A		Machine B
	1.1 mg		1.0 mg
	1.1 mg		0.6 mg
	2.0 mg		0.2 mg
	1.2 mg		0.7 mg
Average	1.35mg	Average	0.63mg
Std. Dev.	0.38mg	Std. Dev.	0.29mg

	Day 2		
	Machine A		Machine B
	1.6 mg		1.9 mg
	1.8 mg		2.0 mg
	1.1 mg		1.1 mg
	1.6 mg		1.8 mg
Average	1.53mg	Average	1.70mg
Std. Dev.	0.26mg	Std. Dev.	0.35mg

13.2 *Bias*—The value for abrasion resistance of fabrics and garments is defined only in terms of this test method. Within this limitation, Test Method D 4966 has no bias.

14. Keywords

14.1 abrasion; knit fabric; woven fabric

ANNEX

(Mandatory Information)

A1. TESTING NOTES

A1.1 Reject any abradant fabric containing knots, very thick or thin yarns.

A1.2 Change the abradant fabric for every new specimen and at 50 000 movements if breakdown has not been reached.

A1.3 Make sure that the abradant is held in place firmly and that there are no tucks or ridges present.

A1.4 Examine the test specimens before mounting as they should be circular and not elliptical. If they are elliptical, it is possible that the specimens will be tested under the wrong conditions, or they may be pulled out of the holders during testing.

A1.5 Do not allow any oil or grease to come in contact with the specimens or abradant.

A1.6 Every time a specimen holder is taken from the machine to test the specimen or endpoint, make sure that it is tightened properly before it is replaced onto the machine.