Designation: D 4060 – ~~95~~01

Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser[1]

This standard is issued under the fixed designation D 4060; 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 Department of Defense.

1. Scope

1.1 This test method covers the determination of the resistance of organic coatings to abrasion produced by the Taber Abraser on coatings applied to a plane, rigid surface, such as a metal panel.

1.2 Because of the poor reproducibility of this test method, it should be restricted to testing in only one laboratory when numerical abrasion resistance values are to be used. Interlaboratory agreement is improved significantly when rankings of coatings are used in place of numerical values.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 This standard is similar in content (but not technically equivalent) to ISO 7784–2.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*

---

[1] This test method is under the jurisdiction of ASTM Committee ~~D-1~~ D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

Current edition approved ~~Feb. 15, 1995.~~ Dec. 10, 2001. Published ~~April 1995.~~ February 2002. Originally published as D 4060 – 81. Last previous edition D 4060 – 9~~0.~~5

D 823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[2]
D 968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive[2]
D 1005 Test Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[2]
D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[2]
D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[2]
D 2240 Test Method for Rubber Property—Durometer Hardness[3]

2.2 *Other Standards:*
ISO 7784–2 Paints and varnishes—Determination of resistance to abrasion—Part 2: Rotating abrasive rubber wheel method[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*
3.1.1 Abrasion resistance can be expressed as one or more of the following terms:
3.1.1.1 *wear index*—1000 times the loss in weight in milligrams per cycle.
3.1.1.2 *weight loss*—the loss in weight in milligrams, determined at a specified number of cycles.
3.1.2 *wear cycles per mil*—the number of cycles of abrasion required to wear a film through to the substrate per mil of film thickness.

4. Summary of Test Method

4.1 The organic coating is applied at uniform thickness to a plane, rigid panel and, after curing, the surface is abraded by rotating the panel under weighted abrasive wheels.
4.2 Abrasion resistance is calculated as loss in weight at a specified number of abrasion cycles, as loss in weight per cycle, or as number of cycles required to remove a unit amount of coating thickness.

5. Significance and Use

5.1 Coating on substrates can be damaged by abrasion during manufacturing and service. This test method has been useful in evaluating the abrasion resistance of attached coatings. Ratings produced by this test method have correlated well with ratings produced by the falling abrasive values in Test Methods D 968.

6. Apparatus

6.1 *Taber Abraser.*[5]
6.2 *Abrasive Wheels*—Resilient calibrase wheels No. CS-10 or CS-17, as required, shall be used. Because of the slow hardening of the rubber bonding material in this type of wheel, the wheels should not be used after the date marked on them, or one year after their purchase if the wheels are not dated.

NOTE 1—The hardness of the wheels can be checked by Test Method D 2240. An acceptable hardness for both types of wheels is 81 ± 5 units on Shore Durometer A-2 Scale.
NOTE 2—The CS-17 wheels produce a harsher abrasion than the CS-10 wheels.

6.3 *Resurfacing Medium*, an S-11 abrasive disk, used for resurfacing the abrasion wheels.
6.4 *Vacuum Pick-Up Assembly*, consisting of a vacuum unit, a variable transformer suction regulator, a nozzle with bracket attachment, and a connecting hose with adaptor.

7. Test Specimens

7.1 Apply a uniform coating of the material to be tested to a plane, rigid panel. Specimens shall be a disk 4 in. (100 mm) in diameter or a plate 4–in. (100–mm) square with rounded corners and with a ¼-in. (6.3-mm) hole centrally located on each panel. Prepare a minimum of two coated panels for the material.

NOTE 3—The coatings should be applied in accordance with Practices D 823, or as agreed upon between the purchaser and the seller.
NOTE 4—The thickness of the dry coatings should be measured in accordance with Test Methods D 1005, D 1186, or D 1400.

8. Standardization

8.1 Mount the selected abrasive wheels on their respective flange holders, taking care not to handle them by their abrasive surfaces. Adjust the load on the wheels to 35.27 oz (1000 g).

---

[2] *Annual Book of ASTM Standards*, Vol 06.01.
[3] *Annual Book of ASTM Standards*, Vol 09.01.
[4] Available from ~~T. Taber Industries, 455 Bryant St., P.O. Box 164, North Tonawanda,~~ American National Standards Institute, 25 West 43rd St. 4th Floor, New York, NY ~~14120-9911.~~ 10036.
[5] ~~Supporting data are available~~
Available from ~~ASTM Headquarters. Request RR: D01-1037.~~ T. Taber Industries, 455 Bryant St., P.O. Box 164, North Tonawanda, NY 14120-9911.

8.2 Mount the ~~resurfacing~~ surface medium (S-11 abrasive disk) on the turntable. Lower the abrading heads carefully until the wheels rest squarely on the abrasive disk. Place the vacuum pick–up nozzle in position and adjust it to a distance of ~~1/32 in. (1 mm)~~ 4 mm (¼ in.), or as agreed upon between buyer and seller, above the abrasive disk.

8.3 Set the counter to "zero" and set the suction regulator to approximately 50 points on the dial. The setting may be increased to 90 if more effective removal of the abradings appears necessary.

8.4 Start the vacuum pick-up and then the turntable of the abrader. Resurface the wheels by running them 50 cycles against the resurfacing medium.

NOTE 5—The wheels should be resurfaced in this manner before testing each specimen and after every 500 cycles.

9. Conditioning

9.1 Cure the coated panel under conditions of humidity and temperature as agreed upon between purchaser and seller.

9.2 Unless otherwise agreed upon between purchaser and seller, condition the coated panel for at least 24 h at 23 ± 2°C and 50 ± 5 % relative humidity. Conduct the test in the same environment or immediately on removal therefrom.

10. Procedure

10.1 Weigh the test specimen to the nearest 0.1 mg and record this weight, if either the wear index or the weight loss is to be reported.

10.2 Measure the coating thickness of the test specimen in several locations along the path to be abraded.

10.3 Mount the test specimen on the turntable. Place the abrading heads on the test film and the vacuum pick-up nozzle in position as outlined in 8.2. Set the counter and suction regulator as outlined in 8.3.

10.4 Start the vacuum pick-up and then the turntable of the abrader. Subject the test specimen to abrasion for the specified number of cycles or until wear through of the coating is observed. In determining the point of wear through, stop the instrument at intervals for examination of the test specimen.

10.5 Remove any loose abradings remaining on the test specimen by light brushing. Reweigh the test specimen.

10.6 Repeat 10.1-10.5 on at least one additional test specimen of the material under test.

11. Calculation

11.1 *Wear Index*—Compute the wear index, *I*, of a test specimen as follows:

$$I = \frac{(A - B)\,1000}{C} \tag{1}$$

where:
A = weight of test specimen before abrasion, mg,
B = weight of test specimen after abrasion, mg, and
C = number of cycles of abrasion recorded.

NOTE 6—In calculating wear index it may be advisable to discard the last 200 cycles because the results may be affected by abrasion of the exposed substrate.

11.2 *Weight Loss*—Compute weight loss, *L*, of the test specimen as follows:

$$L = A - B \tag{2}$$

where:
A = weight of test specimen before abrasion, mg, and
B = weight of test specimen after abrasion, mg.

11.3 *Wear Cycles Per Mil*—Compute the wear cycles per mil, *W*, of the test specimen as follows:

$$W = D/T \tag{3}$$

where:
D = number of cycles of abrasion required to wear coating through to substrate and
T = thickness of coating, mils (0.001 in.) (to one decimal place).

NOTE 7—In calculating the wear cycles, it is advisable to discard the first and last readings because the first may be affected by an uneven surface and the last by abrasion of parts of the substrate.

12. Report

12.1 Report the following information for each test material:

12.1.1 Temperature and humidity during conditioning and at the time of testing,

12.1.2 Thickness of coating when wear cycles are specified,

12.1.3 Kind of calibrase abrasive wheels used,

12.1.4 Load applied to the abrasive wheels,
12.1.5 Number of wear cycles recorded for each test specimen,
12.1.6 Wear index, weight loss, or wear cycles per mil for each test specimen, and

TABLE 1 Precision of Taber Abrasion Values

	Within-Laboratory		Between-Laboratories	
Std. Dev.	Coefficient of Variation, %	Maximum Allowable Difference, %	Coefficient of Variation, %	Maximum Allowable Difference, %
Weight loss at 500 cycles	12	48	36	105
Weight loss at 500 cycles	12	48	36	105
Weight loss at 1000 cycles	10	46	30	90
0.00185	60	0.008	0.00197	90
Wear index at 500 cycles	13	52	36	106
Wear index at 500 cycles6	13	52	36	10.0065
Wear index at 1000 cycles	10	46	30	92
0.0059	63	0.025	0.0048	92
Cycles per mil	13	44	31	92
Cycles per mil6	0.013	44	31	9266

12.1.7 Mean and range of the abrasion resistance values of the replicate coated panels.

13. Precision and Bias

13.1 On the basis of[6]

13.1 In an interlaboratory test study of this test method, one operator in which operators in five each of three laboratories tested four eight panels of six coatings having covering a broad wide range of abrasion resistance, shown by the within-laboratory coefficients of variation and between-laboratories coefficients of variation were found to be those 99 % significant difference in Table 1. Based upon these coefficients, the following criteria should be used a preliminary, but complete, ANOVA for judging the acceptability of results obtained in one laboratory for all six materials. The statistical analysis of values obtained at 1000 cycles resulted in the 95 % confidence level: division of material standard deviation into two groups because the materials with high abrasion resistance, that is, low weight loss, had lower interlaboratory deviations and, generally, interlaboratory deviations. These are presented in Table 1.

13.1.1 *Repeatability*—Two results—Results from eight panels obtained by the same operator should be considered suspect if they differ by more than the maximum allowable difference values shown acceptable differences (MAD) given in Table 1.

13.1.2 *Reproducibility*—Two results, each the mean of eight repeat panels, obtained by operators in different laboratories should be considered suspect if they differ by more than the maximum allowable difference values shown differences given in Table 1.

NOTE 8—When 8— All previous revisions of this test method is used to rank a series of coatings by magnitude of abrasion resistance, specified 1 mm which was not the precision is significantly better than shown in Table 1. In the interlaboratory study for evaluating precision, all laboratories ranked the coatings in the same order intent of abrasion resistance. the equipment manufacturer.

13.2 *Bias*—Bias cannot be determined as—Since there is no accepted reference material suitable for determining the value bias for abrasion resistance is defined in terms of the procedure in this test method, bias cannot be determined.

14. Keywords

14.1 abrasion resistance; wear index; Taber Abraser tester

[6] During the analysis, results from two panels obtained by one laboratory on one of the materials and one panel of another material were rejected because they differed from the other panels of the same materials and the results obtained by the other laboratories for those materials.