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

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The Executive Director
Uganda National Bureau of Standards
P.O. Box 6329
Kampala
Uganda
Tel: +256 417 333 250/1/2
Fax: + 256 414 286 123
E-mail: info@unbs.go.ug
Web: www.unbs.go.ug

Foreword

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The committee responsible for this document is Technical Committee UNBS/TC5/SC2, Paints, Varnishes and related products.

Wherever the words, “ASTM Standard" appear, they should be replaced by "Uganda Standard."

Designation: D4060 – 14

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

This standard is issued under the fixed designation D4060; 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 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 The values stated in SI units are to be regarded as the standard, with the exception of mils when determining coating thickness.

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

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]

D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

D968 Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

D2240 Test Method for Rubber Property—Durometer Hardness

D3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials

D7091 Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals

G195 Guide for Conducting Wear Tests Using a Rotary Platform Abraser

2.2 *Other Standards:*

ISO 7784–2 Paints and varnishes—Determination of resistance to abrasion—Part 2: Rotating abrasive rubber wheel

[1] This test method is under the jurisdiction of ASTM Committee 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 Dec. 1, 2014. Published January 2015. Originally approved in 1981. Last previous edition approved in 2010 as D4060 – 10. DOI: 10.1520/D4060–14.

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

[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.

method[3]

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:
3.1.2 *wear index, n*—1000 times the loss in weight in milligrams per cycle.
3.1.3 *weight loss, n*—the loss in weight in milligrams, determined at a specified number of cycles.
3.1.4 *wear cycles per mil, n*—the number of cycles of abrasion required to wear a film through to the substrate per mil (0.001 in.) 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 using rotary rubbing action under controlled conditions of pressure and abrasive action. The test specimen, mounted on a turntable platform, turns on a vertical axis, against the sliding rotation of two abrading wheels. One abrading wheel rubs the specimen outward toward the periphery and the other, inward toward the center. The resulting abrasion marks form a pattern of crossed arcs over an area of approximately 30 cm^2.
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.

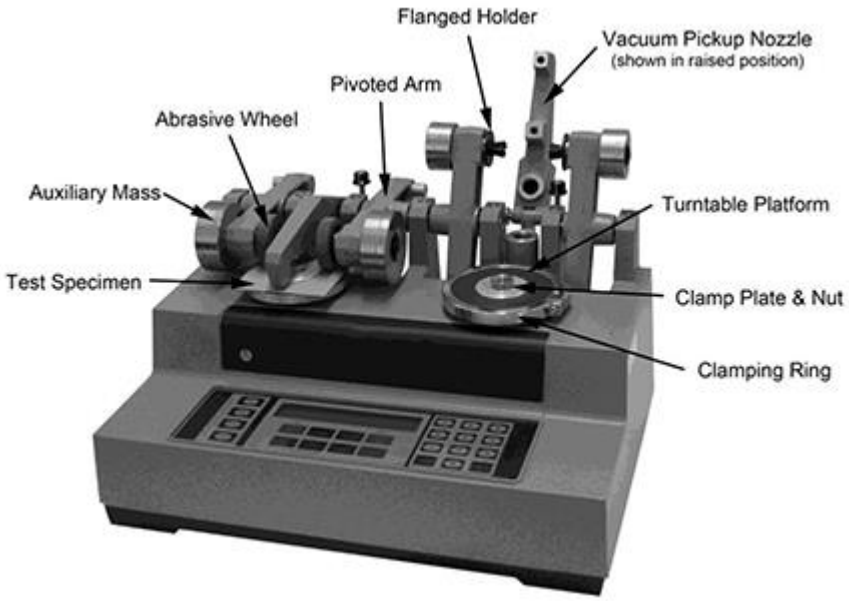
5. Significance and Use

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 coatings. Ratings produced by this test method have correlated well with ratings produced by the falling abrasive values in Test Method D968.
5.2 For some materials, abrasion tests utilizing the Taber Abraser may be subject to variation due to changes in the abrasive characteristics of the wheel during testing. Depending on abradant type and test specimen, the wheel surface may change (that is, become clogged) due to the adhesion of debris generated during the test and must be resurfaced at more frequent intervals as agreed upon by the interested parties. To determine if more frequent resurfacing is required, plot the total weight loss every 50 cycles. If a significant negative change in slope is observed prior to 500 cycles, the point at which the slope changes determines the resurfacing frequency.

6. Apparatus

6.1 *Taber Abraser*[4] *(*Fig. 1*)*, as described in Guide G195 and consisting of the following elements:

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from Taber Industries, 455 Bryant St., North Tonawanda, NY 14120.



Note: Vacuum Suction System not shown.

FIG. 1 Taber Abraser

6.1.1 A horizontal turntable platform; comprised of a rubber pad, clamp plate, and nut to secure the specimen to the turntable. A clamping ring is provided to secure the resurfacing medium

6.1.2 A motor capable of rotating the turntable platform at a speed of either 72 ± 2 r/min for 110v/60Hz or 60 ± 2 r/min for 230v/50Hz,

6.1.3 A pair of pivoted arms, to which the abrasive wheels and auxiliary masses may be attached; loads of 250, 500, or 1000 g on each wheel may be obtained by use of these changeable masses. Counterweight attachments of 125 or 175 g are available to reduce the load against the specimen, and can be used with or without the auxiliary masses.

NOTE 1—Without auxiliary masses or counterweights, each arm will apply a load against the specimen of 250 g per wheel (exclusive of the mass of the wheel itself).

6.1.4 A vacuum suction system and vacuum pick-up nozzle to remove debris and abrasive particles from the specimen surface during testing. The height of the vacuum pickup nozzle shall be adjustable, and the nozzle openings shall be 8 mm in diameter. The vacuum system shall operate when testing commences.

6.1.5 A counter to record the number of cycles (revolutions) made by the turntable platform.

6.2 *Abrasive Wheels*—Resilient Calibrase wheels No. CS-10 or CS-17, as required, shall be used unless otherwise agreed upon by the interested parties. Because of the slow hardening of the bonding material, resilient wheels should not be used after the date marked on them, or one year after their purchase if the wheels are not dated.

6.2.1 The wheels shall be 12.7 ± 0.3 mm thick and have an external diameter of 51.9 ± 0.5 mm when new, and in no case less than 44.4 mm.

NOTE 2—The hardness of the wheels can be checked by Test Method D2240. Measure at least four points equally spaced on the side surface of the wheel. The reading shall be taken 10 s after full application of the pressure, and then averaged. An acceptable hardness for both types of wheels is 81 ± 5 units on Shore Durometer A-2 Scale.

NOTE 3—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.

7. Test Specimens

7.1 Apply a uniform coating of the material to be tested to a rigid panel having both surfaces substantially plane and parallel. Specimens shall be a disk or a square plate with a 6.5 mm hole centrally located on each panel. Typical dimensions for a test panel are 100 mm in diameter or 100 by 100 mm. Thickness of the specimen should be no greater than 6.3 mm unless an S-21 extension nut[4] or arm height extension kit[4] is utilized. Prepare a minimum of two coated panels for the material.

NOTE 4—While the minimum of two coated panels is acceptable, evaluating three or more panels per material will provide greater

confidence in your test results.

NOTE 5—The coatings should be applied in accordance with Practices D823, or as agreed upon between the interested parties.

NOTE 6—The thickness of the dry coatings should be measured in accordance with Test Method D1005 or Practice D7091.

NOTE 7—For those materials greater than 6.3 mm but less than 12.7 mm thick, the S-21 extension nut may be used to affix the specimen to the turntable. This requires a 9.5 mm center hole in the specimen. Alternatively, an arm height extension kit will permit testing of specimens up to 40 mm thick and requires the center hole to be 14.5 mm.

8. Calibration

8.1 Verify calibration of the Taber Abraser as directed by the equipment manufacturer (see Appendix X1).

9. Standardization

9.1 To ensure that the abrading function of the wheels is maintained at a constant level, prepare the abrading wheels prior to each test.

9.1.1 Mount the selected abrasive wheels on their respective flange holders, taking care not to handle them by their abrasive surfaces.

9.1.2 A load of 1000 g (per wheel) should be used, unless otherwise agreed upon by the interested parties.

9.1.3 Mount the resurfacing medium (S-11 abrasive disk) on the turntable and secure in place with the clamp plate, nut and clamping ring. 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 3 ± 1.0 mm, or as agreed upon between buyer and seller, above the abrasive disk.

9.1.4 Set the vacuum suction force to 100. The vacuum suction force may be decreased if agreed upon by the interested parties.

9.1.5 Resurface the wheels by running them 50 cycles against the resurfacing medium. Each S-11 resurfacing disk is good for one resurfacing operation, after which it shall be discarded. **Warning—**Do not brush or touch the surface of the wheels after they are resurfaced.

NOTE 8—The wheels shall be resurfaced in this manner before testing each specimen and after every 500 cycles.

10. Conditioning

10.1 Cure the coated panel under conditions of humidity and temperature as agreed upon between the interested parties. For additional information, reference Specification D3924.

10.2 Unless otherwise agreed upon between the interested parties, 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.

11. Procedure

11.1 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.

11.2 When wear cycles per mil is required, measure the coating thickness of the test specimen on four points along the path to be abraded and take the average of the readings.

11.3 Mount the test specimen on the abraser turntable platform with the side to be abraded facing up. Secure using the clamp plate and nut. Place the abrading heads on the test specimen and the vacuum pick-up nozzle in position as outlined in 9.1.3. Affix the auxiliary masses as outlined in 9.1.2. Set the vacuum suction as outlined in 9.1.4.

NOTE 9—To generate a uniform wear pattern, specimen surfaces must be plane and parallel. If a sample is slightly warped, the model E140-14 Rimmed Specimen Holder with Ring Clamp[4] or similar may be used. This holder clamps the sample against a flat rigid plate about the perimeter of the sample.

NOTE 10—If using a dual table abraser and the second table is not in use, mount a sample to the table and set the vacuum nozzle height as stated in 9.1.3.

11.4 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.

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

11.6 Repeat 11.1 – 11.5 on at least one additional test specimen of the material under test. (See Note 4.)

12. Calculation

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

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

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 11—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.

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

$$L = A - B \qquad (2)$$

where:

A = weight of test specimen before abrasion, mg, and

B = weight of test specimen after abrasion, mg.

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

$$W = D/T \qquad (3)$$

where:

D = number of cycles of abrasion required to wear coating through to substrate and

T = thickness of coating, mils.

NOTE 12—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 the substrate.

13. Report

13.1 Report the following information for each test material:
13.1.1 Temperature and humidity during conditioning and at the time of testing,
13.1.2 Thickness of coating when wear cycles are specified,
13.1.3 Type of abrasive wheels used and frequency of resurfacing if different then Note 8,
13.1.4 Load applied to the abrasive wheels (per arm),
13.1.5 Vacuum nozzle height,
13.1.6 Vacuum suction setting,
13.1.7 Number of wear cycles recorded for each test specimen,
13.1.8 Wear index, weight loss, or wear cycles per mil for each test specimen, and
13.1.9 Mean and range of the abrasion resistance values of the replicate coated panels.

14. Precision and Bias[5]

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1135. Contact ASTM Customer Service at service@astm.org.

14.1 The precision of this test method is based on an interlaboratory study of Test Method D4060 - 01, conducted in 2006. Seven laboratories tested five materials. Each "test result" represented an individual determination. Every laboratory obtained five replicate samples for each material.[5]

14.1.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material given in Table 1; "*r*" is the interval representing the critical difference between two test results for the same material, obtained by the same operator, using the same equipment, in the same laboratory, on the same day.

TABLE 1 Precision of Taber Abrasion Values[A]

Coating	Average	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
		sr	sR	r	R
Polyamide/Epoxy Coating A	129.6	3.1	15.3	8.7	43.0
Polyamide/Epoxy Coating B	109.1	14.6	19.1	40.9	53.6
Polyurethane Coating	49.5	3.0	6.1	8.3	17.2
Polyester/Epoxy Powder Coating	61.3	2.6	6.8	7.1	19.1
Nylon Powder Coating	7.7	1.6	3.2	4.4	8.9

[A] Weight loss (milligrams).

14.1.2 *Reproducibility*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material given in Table 1; "*R*" is the interval representing the difference between two test results for the same material, obtained by different operators, using different equipment, in different laboratories.

14.1.3 Any judgment in accordance with these two statements has approximately a 95 % probability of being correct.

14.1.4 The precision statement was determined through statistical analysis of 173 results, from seven laboratories, on five materials.

NOTE 13—Versions of this test method issued before 2001 specified a vacuum nozzle height of 1 mm above the specimen surface. This was not the intent of the equipment manufacturer, as it could cause variation in the vacuum pick-up efficiency across the radius of the abrasion track. The data summarized in Table 1 utilized a vacuum nozzle height of 6.5 mm above the specimen surface and a vacuum setting of 100.

14.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining bias for this test method, therefore no statement on bias is being made.

15. Keywords

15.1 abrasion resistance; wear index; Taber Abraser tester

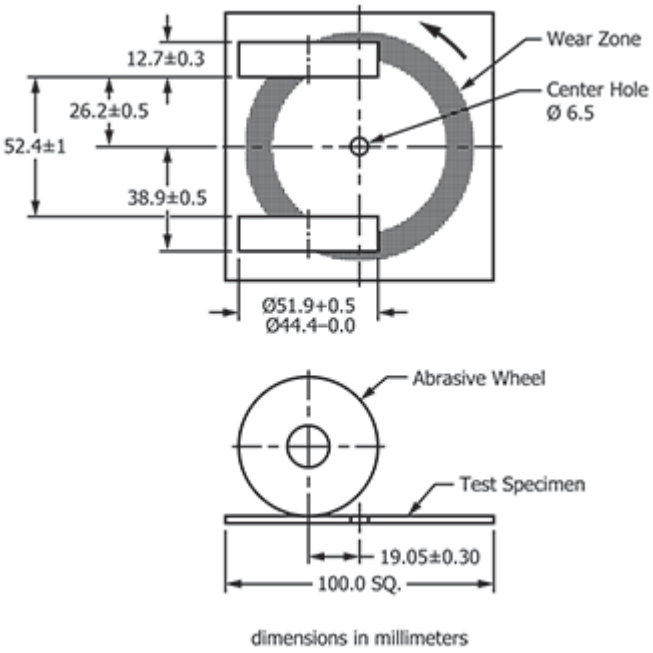
APPENDIX

(Nonmandatory Information)

X1. CALIBRATION VERIFICATION

X1.1 To facilitate the verification of calibration of the Taber Abraser, a kit is available[4] that provides a fast reliable system check. This kit is not meant as a substitute for regular instrument calibration. Procedures in the kit allow the user to verify:

X1.1.1 *Wheel Alignment and Tracking*—The wheels should be spaced equally on both sides from the wheel-mounting flange to the center of the specimen holder. When resting on the specimen, the wheels will have a peripheral engagement with the surface of the specimen, the direction of travel of the periphery of the wheels and of the specimen at the contacting portions being at acute angles, and the angles of travel of one wheel periphery being opposite to that of the other. Wheel internal faces shall be 52.4 ± 1.0 mm apart and the hypothetical line through the two spindles shall be 19.05 ± 0.3 mm away from the central axis of the turntable (Fig. X1.1).



This schematic shows the proper wheel position in relation to the turntable platform.

FIG. X1.1 Diagrammatic Arrangement of Taber Abraser Test Set-up

X1.1.2 *Wheel Bearings Condition*—The Taber Abraser wheel bearings should be able to rotate freely about their horizontal spindles and not stick when the wheels are caused to spin rapidly by a quick driving motion of the forefinger.

X1.1.3 *Vacuum Suction Force*—Air pressure in the suction device must not be lower than 137 millibar, as measured by a suction gage.

NOTE X1.1—Vacuum suction force may be influenced by the condition of the collection bag, which must be emptied or replaced on a regular basis. Any connection or seal leaks will also influence suction force.

X1.1.4 *Turntable Platform Position*—The vertical distance from the center of the pivot point of the Taber Abraser arms to the top of the turntable platform should be approximately 25 mm. The turntable platform shall rotate substantially in a plane with a deviation at a distance of 1.6 mm from its periphery of not greater than 0.10 mm.

X1.1.5 *Turntable Speed*—The turntable should rotate at the speed stated in 6.1.2.

X1.1.6 *Load*—The accessory mass marked 500 g shall weigh 250 ± 1 g and the accessory mass marked 1000 g shall weigh 750 ± 1 g.

SUMMARY OF CHANGES

Committee D01 has identified the location of selected changes to this standard since the last issue (D4060–10) that may impact the use of this standard. (Approved December 1, 2014.)

(1) Removed inch-pound units of measurement.
(2) Specified how to secure the refacing medium to the turntable and changed the vacuum nozzle gap to 3 ± 1.00 mm in paragraph 9.1.3.
(3) Added statement about use life of refacing disc to paragraph 9.15.
(4) Eliminated the statement “to one decimal place” when measuring the thickness of coating mils (paragraph 12.3).

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