Designation: B1023 – 22

Standard Test Method for Abrasion Resistance of Hard Anodic Coatings by a Taber-Type Abraser[1]

This standard is issued under the fixed designation B1023; 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 quantifies the abrasion resistance of electrolytically formed hard anodic oxidation coatings on a plane, rigid surface of aluminum or aluminum alloy.

1.2 This test uses a Taber-type abraser,[2] which generates a combination of rolling and rubbing to cause wear to the coating surface. Wear is quantified as cumulative mass loss or loss in mass per thousand cycles of abrasion.

1.3 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—The procedure described in Method A is similar to MIL-PRF-8625 (paragraph 4.5.5) and SAE AMS 2469 (paragraph 3.3.4). The procedure described in Method B includes a break-in period of 1000 cycles and is similar to ISO 10074 Annex B. When no procedure is specified, Method A shall be the default procedure. Although the procedures described in this method may be similar, they are not equivalent to Specification B893 or Test Method D4060.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

B374 Terminology Relating to Electroplating

B893 Specification for Hard-Coat Anodizing of Magnesium for Engineering Applications

D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

G195 Guide for Conducting Wear Tests Using a Rotary Platform Abraser

2.2 *ISO Standard:*[4]

ISO 10074 Specification for Hard Anodic Oxidation Coatings on Aluminium and Its Alloys

2.3 *SAE Standard:*[5]

SAE AMS 2469 Hard Anodic Coating Treatment of Aluminum and Aluminum Alloys – Processing and Performance Requirements

2.4 *Other Standard:*[6]

MIL-PRF-8625 Anodic Coatings for Aluminum and Aluminum Alloys

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology B374.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abraser, n*—a wear testing instrument that is designed to determine the resistance of surfaces to composite rolling and rubbing action, also referred to as an abrader.

3.2.2 *abrasion cycle, n—in abrasion testing*, one or more movements of the abradant across a material surface, or the material surface across the abradant, that permits a return to its starting position; *in the case of a Taber-type abraser test method*, it consists of one complete rotation of the specimen turntable platform.

[1] This test method is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.10 on Test Methods.

Current edition approved Aug. 1, 2022. Published September 2022. DOI: 10.1520/B1023-22.

[2] Taber is a registered trademark of Taber Industries.

[3] 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.

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[6] Available from IHS Markit, https://global.ihs.com/.

3.2.3 *resurface, v*—the procedure of cleaning and refreshing the running surface of an abrasive wheel prior to use or during testing.

3.2.4 *wear index, n*—the average mass loss in milligrams per thousand cycles of abrasion.

3.3 *Acronyms:*

3.3.1 *CAMI*—Coated Abrasives Manufacturers Institute

4. Summary of Test Method

4.1 A specimen 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 abrasive wheels. The wheels are mounted in such a way that when they are in contact with the rotating test specimen, they rotate in opposing directions. One wheel rubs the specimen outward toward the periphery and the other, inward toward the center while a vacuum suction system removes wear debris generated during the test. The resulting abrasion marks form a pattern of crossed arcs in a circular wear path that covers an area of approximately 30 cm^2.

4.2 This test method uses a Taber-type abraser with CS-17 abrasive wheels and a load of 1000 g applied per wheel.

4.3 A wear index may be used to measure the resistance to abrasive wear, in which the lower the wear index, the better the abrasion resistance quality of the material.

5. Significance and Use

5.1 Hard anodic oxidation coatings are often used to obtain improved resistance to abrasion, and have been used in such applications as valves, sliding parts, hinge mechanisms, cams, gears, swivel joints, pistons, insulation plates, blast shields, etc.

5.2 This abrasion resistance test method may be useful for acceptance testing of a hard anodic coating, and it can be used to evaluate the effects of processing variables such as substrate preparation before coating, surface texture, coating technique variables, and post coating treatments.

5.3 Results may be used for process control, comparative ranking, or to correlate with end-use performance. The resistance of material surfaces to abrasion, as measured on a testing machine in the laboratory, is generally only one of several factors contributing to wear performance as experienced in the actual use of the material. Other factors may need to be considered in any calculation of predicted life from specific abrasion data.

5.4 The properties and characteristics of hard anodic oxidation coatings are significantly affected by both the alloy and the method of production.

NOTE 2—Hard anodizing will usually result in a dimensional increase on each surface equal to about 50 % of the coating thickness. Normal thickness for wear applications tends to be 40 µm to 60 µm; however the thickness of anodized coatings often ranges between 8 µm to 150 µm.

5.5 The resistance of hard anodic coatings to abrasion may be affected by factors including test conditions, type of abradant, pressure between the specimen and abradant, composition of the alloy, thickness of the coating, and the conditions of anodizing or sealing, or both.

NOTE 3—The resistance to abrasion is generally measured on unsealed anodic oxidation coatings. While corrosion resistance is often increased by sealing the coating, it has been observed that sealing or dyeing can reduce the resistance to abrasion by over 50 %.

5.6 The outer surface of the anodic coating may be softer or less dense which may cause a greater mass loss in the first 1000 abrasion cycles than the remaining cycles. Two similar procedures are described in this test method. Method B does not report the first 1000 abrasion cycles, so any surface variation that may exist is reduced and a more representative value for the bulk coating is obtained.

5.7 Abrasion tests utilizing a Taber-type abraser may be subject to variation due to changes in the abradant during the course of specific tests. Depending on abradant type and test specimen, the abrasive wheel surface may become clogged due to the adhesion of wear debris generated during the test to the surface of the wheel. To provide a consistent rate of wear, the abrasive wheels must be resurfaced at defined intervals.

6. Apparatus

6.1 *Abraser,* Taber-type abraser as described in Guide G195 (see Fig. 1 and Fig. X2.1) with the auxiliary weights marked 1000 g. The auxiliary weight reference is per arm (not combined) and includes the load of the pivoted arm and auxiliary weight, but not the load of the abrasive wheel.

6.2 *Abrasive Wheels,* which are attached to the free end of the pivoted arms and able to rotate freely about horizontal spindles.

6.2.1 The abrasive wheels consist of hard particles embedded in a binder material and are manufactured in different grades of abrasive quality. Type CS-17[7] abrasive wheels shall be used, unless otherwise agreed upon by the interested parties. The wheels shall not be used after the expiration date stamped on them.

6.2.2 Each abrasive wheel shall be cylindrically shaped; have a diameter between 52.4 mm and 44.4 mm; a width of 12.7 mm ± 0.3 mm; and include an axial hole 16.0 mm ± 0.1 mm in diameter to allow the wheel to be mounted to the flanged holder on the pivoted arms.

6.3 *Refacing Disk,* for resurfacing resilient abrasive wheels. The refacing disk shall be silicon carbide coated abrasive with an average particle size of 92 µm (150 grit CAMI grade), 102 mm diameter with a 7 mm center hole, such as type S-11[7] or equivalent.

6.4 *Wheel Refacer (Optional),* diamond tool apparatus used for correcting out of round wheels.

6.5 *Soft Bristle Brush,* with non-metallic bristles to remove loose particles from the surface of the specimen after testing.

[7] The sole source of supply of the apparatus known to the committee at this time is Taber Industries, 455 Bryant Street, North Tonawanda, NY 14120. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

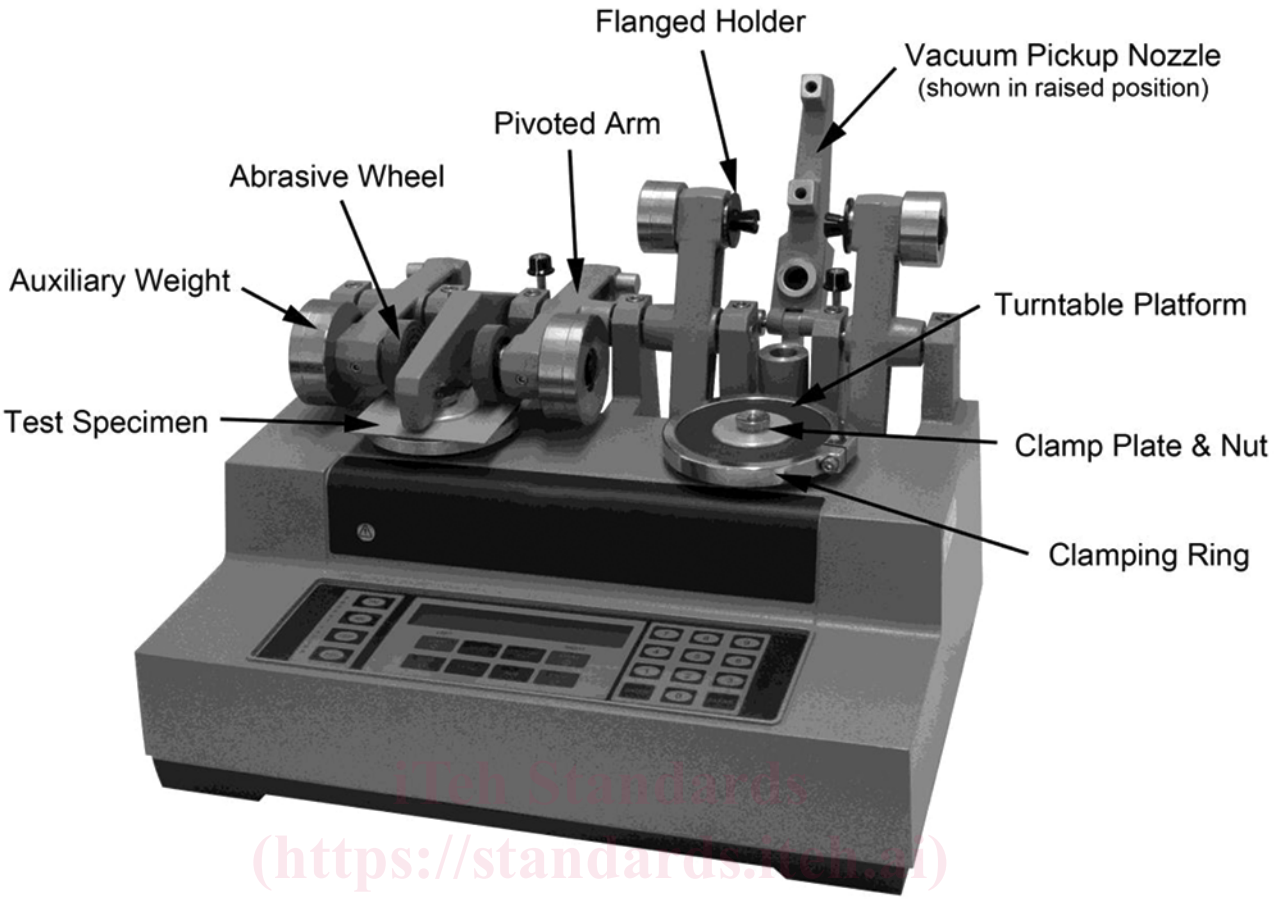

FIG. 1 Taber-Type Abraser

6.6 *Analytical Balance,* capable of weighing specimens to the nearest 0.1 mg.

6.7 *Desiccator (Optional),* containing a drying agent and of sufficient size to contain specimens to be tested.

7. Specimen Preparation

7.1 Specimen preparation shall be in accordance with the specified aluminum anodize processing specification. If no specification is indicated, then:

7.1.1 A minimum of two replicate specimens shall comprise a test result, unless otherwise agreed upon by the interested parties.

7.1.2 Each specimen shall be a rigid panel having both surfaces plane and parallel. Typical dimensions are 100 mm x 100 mm with a 6.5 mm hole centrally located on each panel. Specimen panels shall have a minimum nominal thickness of 1.6 mm and not greater than 6.5 mm, unless otherwise agreed upon by the interested parties.

NOTE 4—For other information on specimen preparation, see Appendix X3.

8. Standardization of Abrasive Wheels

8.1 To ensure the abrading function of the CS-17 abrasive wheels is maintained, resurface the wheels prior to testing each specimen. If Method B is followed, resurface the wheels prior to and after the initial break-in of 1000 abrasion cycles.

8.1.1 Mount the abrasive wheels on their respective flange holders. A load of 1000 g shall be applied per wheel.

8.1.2 Mount a new refacing disk on the turntable platform, and secure in place with the clamp plate and nut. Place the clamping ring on the turntable platform to prevent the vacuum suction system from lifting the refacing disk as it passes under the vacuum pickup nozzle.

8.1.3 Adjust the vacuum pickup nozzle to a distance of 3 mm ± 1 mm above the refacing disk. Adjust the vacuum suction force to 100 % or the maximum setting.

8.1.4 Lower the abrading heads until the abrasive wheels rest on the refacing disk. Resurface the wheels by running them 50 cycles against the refacing disk. Each refacing disk is good for one resurfacing operation, after which it shall be discarded. Do not brush or touch the surface of the wheels after they are resurfaced.

NOTE 5—If resurfacing did not refresh the wheels sufficiently, it may be necessary to resurface the wheels a second time using a new refacing disk.

NOTE 6—A thin film of rubber may form on the left hand edge of abrasive wheels as the main body of the wheel wears down. Should it extend greater than 1.5 mm beyond the wheel surface, it can be removed by gently rubbing the edge. Do not rub excessively so as to round the edge of the wheel.

NOTE 7—A wheel refacer may be used to correct out of round conditions with the abrasive wheels. This condition is typically evidenced by an up-and-down movement of one or both of the pivoted arms. After correcting this condition, the abrasive wheels should be resurfaced according to 8.1.1 – 8.1.4.

9. Conditioning

9.1 *Conditioning*—Unless otherwise agreed upon between the interested parties, condition the specimens at 23 °C ± 5 °C and no greater than 60 % relative humidity for a minimum of 24 h. Conduct the test in the same environment or immediately on removal therefrom. Specimens may be placed in a desiccator prior to and following the test.

NOTE 8—The friction between the abrasive wheels and specimen during the test causes an increase in specimen temperature. As a result, it is not critical to test or condition the specimen in a tightly controlled environment.

9.1.1 If required by the interested parties, record temperature and humidity during conditioning or testing, or both.

10. Procedure – Method A

10.1 Condition the specimen according to 9.1.

10.2 Just prior to testing, determine the mass of the test specimen to the nearest 0.1 mg and record this as W_0.

10.3 Mount the test specimen on the turntable platform with the side to be abraded facing up. Secure the specimen to the turntable platform using the clamp plate and nut.

10.4 Ensure the auxiliary weights marked 1000 g are affixed to the weight mounts of the pivoted arms; and the vacuum suction and distance between the vacuum pickup nozzle and the specimen surface are adjusted as outlined in 8.1.3.

NOTE 9—If using a dual table abraser and the second table is not in use, mount a "dummy" test specimen to the unused turntable platform and set the vacuum nozzle height as stated in 8.1.3.

10.5 Ensure the CS-17 abrasive wheels are affixed to the pivoted arm wheel flange holders, and were resurfaced using the procedure outlined in 8.1.1 – 8.1.4.

10.6 Lower the abrading heads (with auxiliary weights and abrasive wheels attached) and subject the test specimen to 10 000 abrasion cycles.

10.7 After the test is complete, remove the specimen from the turntable platform and use a soft bristle brush or clean dry compressed air, or both, to remove any loose debris remaining on the test specimen. If the coating is breached to the base metal, the test is considered a failure and shall be discarded.

10.8 Determine the mass of the test specimen to the nearest 0.1 mg and record this as W_2.

NOTE 10—It has been observed that freshly exposed anodic oxidation coatings can gain mass by absorbing water vapor. Hence, tests may be subject to errors depending upon variations in atmospheric humidity or if there is any significant delay with measuring mass after testing is completed. To reduce this variation, specimens may be placed in a desiccator or conditioned in the test environment for a minimum of 1 h or as agreed upon by the interested parties prior to measuring specimen mass after abrasion.

10.9 Unless otherwise agreed upon by the interested parties or if quantity is indicated by the process specification, perform a minimum of one additional replicate test following 10.1 – 10.8.

11. Calculation of Results – Method A

11.1 Compute the mass loss, L_A (change in mass caused by abrasion, in mg), as follows:

$$L_A = (W_0 - W_2) \tag{1}$$

where:

W_0 = mass of test specimen before abrasion, mg, and
W_2 = mass of test specimen after abrasion, mg.

11.2 Compute the wear index, I_A (average mass loss per thousand cycles, in mg), of a test specimen as follows:

$$I_A = \frac{(W_0 - W_2)\ 1000}{C} \tag{2}$$

where:

W_0 = mass of test specimen before abrasion, mg,
W_2 = mass of test specimen after abrasion, mg, and
C = number of abrasion cycles recorded.

12. Procedure – Method B

12.1 Condition the specimen according to 9.1.

12.2 Follow the procedure outlined in 10.3 – 10.5.

12.3 Lower the abrading heads and subject the test specimen to an initial break-in of 1000 abrasion cycles. Remove the specimen from the turntable platform and use a soft bristle brush or clean dry compressed air, or both, to remove any loose debris and abraded material.

12.4 Determine the mass of the test specimen to the nearest 0.1 mg and record this as W_1.

12.5 Resurface the wheels for 50 cycles using the procedure outlined in 8.1.1 – 8.1.4.

12.6 Mount the test specimen on the turntable platform with the abraded side facing up. Secure using the clamp plate and nut.

12.7 Lower the abrading heads (with auxiliary weights and abrasive wheels attached) and subject the test specimen to an additional 10 000 abrasion cycles.

12.8 After the test is complete, remove the specimen from the turntable platform and use a soft bristle brush or clean dry compressed air, or both, to remove any loose debris remaining on the test specimen. If the coating is breached to the base metal, the test is considered a failure and shall be discarded.

12.9 Determine the mass of the test specimen to the nearest 0.1 mg and record this as W_2. See Note 10.

12.10 Unless otherwise agreed upon by the interested parties or if quantity is indicated by the process specification, perform a minimum of one additional replicate test following 12.1 – 12.9.

13. Calculation of Results – Method B

13.1 Compute the mass loss, L_B (change in mass after break-in period caused by abrasion, in mg), as follows:

$$L_B = (W_1 - W_2) \quad (3)$$

where:

W_1 = mass of test specimen after 1000 abrasion cycle break-in period, mg, and
W_2 = mass of test specimen after abrasion, mg.

13.2 Compute the wear index, I_B (average mass loss per thousand cycles after break-in period, in mg), of a test specimen as follows:

$$I_B = \frac{(W_1 - W_2)\ 1000}{C} \quad (4)$$

where:

W_1 = mass of test specimen after 1000 abrasion cycle break-in period, mg,
W_2 = mass of test specimen after abrasion, mg, and
C = number of abrasion cycles recorded.

14. Report

14.1 State that the specimens were tested as directed in Test Method B1023.

14.2 For process control testing, record or report the information required by the process specification or as agreed upon between the interested parties. For all other tests, report the following information:

14.2.1 Identification of the test specimen (including alloy),

14.2.2 Temperature and humidity, if required by the interested parties,

14.2.3 If Method B was followed,

14.2.4 Mass loss or wear index, or both, as calculated for each specimen,

14.2.5 Average mass loss or average wear index, or both, for the test results,

14.2.6 Any deviation from the procedure described in this standard.

15. Precision and Bias

15.1 The precision of this test method is based on an interlaboratory study of Test Method B1023, conducted in 2021. Ten volunteer laboratories were asked to test four different materials. Every "test result" represents an individual determination, and all participants were instructed to report four replicate test results for each material. Practice E691 was followed for the design of study and analysis of the data; the details are given in ASTM Research Report RR:B08-2000.[8]

15.1.1 *Repeatability Limit (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the determined values only in 1 case in 20.

15.1.1.1 Repeatability limit can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

15.1.1.2 Repeatability limits are listed in Tables 1 and 2.

15.1.2 *Reproducibility Limit (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

15.1.2.1 Reproducibility limit can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

15.1.2.2 Reproducibility limits are listed in Tables 1 and 2.

15.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

15.1.4 Any judgment in accordance with statement 15.1.1 would normally have an approximate 95 % probability of being correct; however, the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

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

15.3 The precision statement was determined through statistical examination of 191 results, from 10 laboratories, on 4 materials. The specimens used for this study were anodized by three different companies, and the specimens utilized in Procedure B were not anodized by the same company as those used for Procedure A.

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B08-2000. Contact ASTM Customer Service at service@astm.org.

TABLE 1 Mass Loss (Method A) (mg)

Material	Number of Laboratories	Average[A]	Repeatability Standard Deviation	Reproducibility Standard Deviation	Repeatability Limit	Reproducibility Limit
	n	$\bar{x}$	s_r	s_R	r	R
1100 Alloy – (Anodizer A)	10	8.717	2.325	4.289	6.510	12.010
2024 Alloy – (Anodizer B)	10	14.153	2.038	2.181	5.707	6.106
6061 Alloy – (Anodizer B)	10	7.925	1.346	2.417	3.770	6.767
7075 Alloy – (Anodizer B)	10	12.450	2.544	3.310	7.124	9.268

[A] The average of the laboratories' calculated averages.