Designation: ~~D6037 – 18~~ D6037 – 21

Standard Test Methods for Dry Abrasion Mar Resistance of High Gloss Coatings[1]

This standard is issued under the fixed designation D6037; 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 procedures for evaluating the relative mar resistance of high gloss coatings. Two test methods are included. Test Method A uses a device that rotates the test specimen on a vertical axis, against the sliding rotation of two abrading wheels. Test Method B uses a device that reciprocates a specimen in a horizontal plane over a stationary wheel that has been fitted with abrasive paper and is advanced after each double stroke. Either method can be used to evaluate the dry abrasion mar resistance of coatings applied to planar, rigid surfaces. Each test method provides good discrimination between highly mar resistant coatings.

NOTE 1—The mar resistance values obtained by these test methods have no absolute significance. They should only be used to derive relative performance rankings for test panels that have been prepared from the series of coatings that are currently being evaluated. If mar resistance values are quoted between laboratories, it is essential that a common standard be measured and that the values be compared to that standard. Even then, the values should be used with caution.

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1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

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

1.4 *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:*[2]

D523 Test Method for Specular Gloss

D609 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products

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

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

[1] These test methods are under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

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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.

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

D3924 Specification for Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials
D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
D4449 Test Method for Visual Evaluation of Gloss Differences Between Surfaces of Similar Appearance
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
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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *mar resistance, n*—the ability of a coating to resist permanent deformation or fracture, resulting from the application of a dynamic mechanical force.

4. Summary of Test Method

4.1 The coatings that are being evaluated are applied at uniform dry film thickness to planar panels of uniform surface texture. After drying or curing, or both, the panels are marred. Mar resistance is assessed by measuring the coating's gloss within the abraded and unabraded areas of test panels. Mar resistance is directly related to the coating's ability to retain gloss in abraded areas.

NOTE 2—Subjective evaluations may be made visually by comparing abraded panels with a measured abraded standard using one of the procedures in Test Method D4449.

5. Significance and Use

5.1 Coatings, particularly the high gloss coatings used on automobiles, boats, toys, etc., are subject to a wide variety of conditions (for example, wiping, cleaning, and exposure) that can mar their surface. The ability of these coatings to maintain their appearance is an important product attribute. These test methods provide a way to estimate the ability of high gloss coatings to resist mar damage.

5.2 These test methods do not provide fundamental values. However they are suitable for estimating the ability of high gloss coatings to resist mar.

5.3 Since the susceptibility of coatings to marring varies widely, the number of cycles that are needed to cause "relevant" mar damage also varies. Usually, 2 to 50 cycles are sufficient.

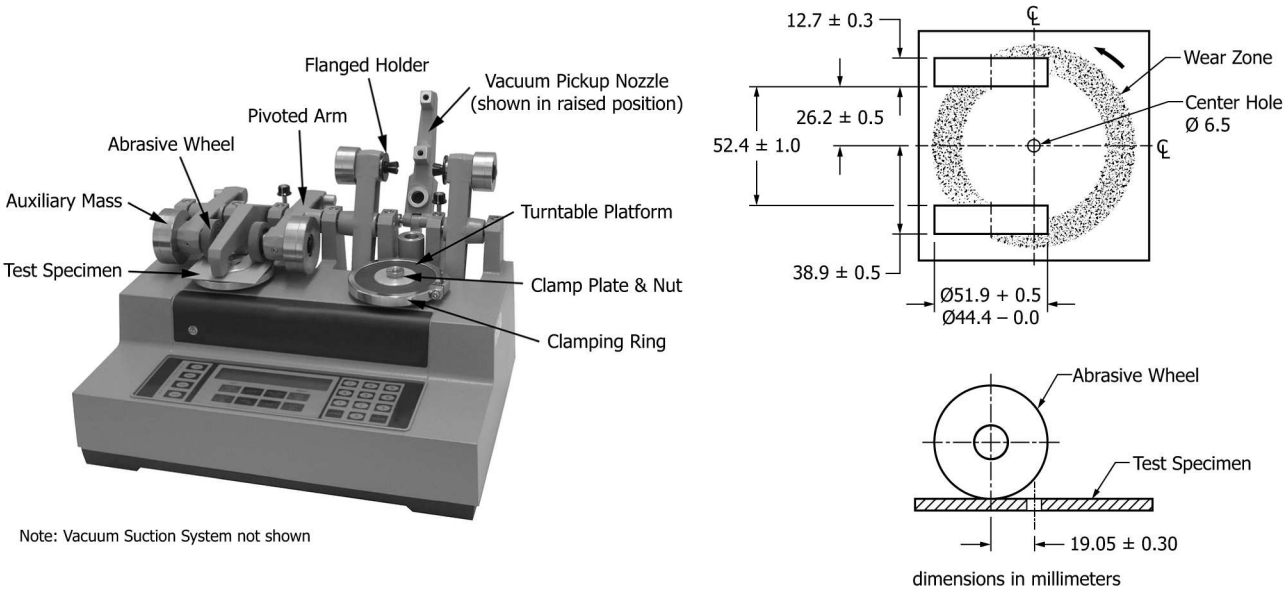

FIG. 1 Abrader for Method A

TEST METHOD A

6. Apparatus

6.1 *Application Equipment,* as described in Practices D609 and D823.

6.2 *Film Thickness Measuring Apparatus,* as described in Test Methods D1005 or D7091.

6.3 *Abrader (*Fig. 1*)*[3]—An abrasion tester as described in Test Method D4060 shall be used. In this method only the 500 g load per wheel is used unless otherwise specified.

6.4 *Refacing Disc*—~~an~~An S-11 refacing disc[3] for resurfacing the abrasive wheels.

6.5 *Abrasive Wheels*—"Calibrase" wheels CS-10,[3] unless otherwise specified or agreed upon by the interested parties. Wheels that have worn to the diameter of the wheel label must not be used. Prior to testing, ensure the expiration date has not passed.

6.6 *Glossmeter,* with 20° geometry ~~complying with Test Method~~and a maximum width ~~D523 but with an opening no larger than 25 mm~~of the measurement area of 10 mm; complying with Test Method D523~~by 75 mm to accommodate 100 mm by 100 mm test panels.~~. In addition, geometry that places the panel with the test surface facing upwards tends to minimize the chance of stray light affecting the measurement when complete coverage of the opening is not attained.

NOTE 3—For coatings that are semi- to high-gloss, a glossmeter with a 60° geometry may be better suited.

7. Preparation of Specimens

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

7.2 Prepare and coat panels in accordance with Practices D609 and D823.

7.2.1 Panels,[4] that is, metal panels with a 6.5 mm hole drilled in the center to accommodate the mounting spindle, are available.

7.2.2 If it is not convenient to apply test coatings to panels,[4] other planar, distortion-free substrates can be used by substituting a "Drive Pin Type" specimen holder for the standard panel holder.

NOTE 4—It is important that the panels be planar for reproducible results. Cutting and drilling of painted panels is not recommended.

NOTE 5—Measurements are color dependent. Dark colors give lower values of gloss retention. To standardize, it is recommended that testing be done using a black coating. Clearcoats are applied over a black basecoat. For other colors a black panel should be included as a control.

8. Standardization

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

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

[3] 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.

[4] The sole source of supply of primed Taber panels known to the committee at this time is ACT Test Panels, LLC, 273 Industrial Drive, Hillsdale, MI. 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.

8.1.2 A load of 500 g (per wheel) shall be used, unless otherwise agreed upon by the interested parties.

8.1.3 Mount an S-11 abrasive disc 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 disc. Place the vacuum pick-up nozzle in position and adjust it to a distance of 3 mm ±1 mm above the S-11 refacing disc.

8.1.4 Set the vacuum suction force to 100.

8.1.5 Resurface the wheels by running them 25 cycles. In each case lightly brush the residue from the resurfacing operation off each wheel. Each S-11 resurfacing disk is good for one resurfacing operation, after which it shall be discarded.

9. Conditioning

9.1 Cure the coated panels under conditions of temperature and humidity as agreed upon between the interested parties.

9.2 Unless otherwise agreed upon, condition the coated panels for at least 24 h at 23°C ± 2°C and 50 % ± 5 % relative humidity in accordance with Specification D3924. Conduct the test in the same environment or immediately after removal therefrom.

10. Procedure

10.1 Using a glossmeter that is calibrated and verified for accuracy, measure the 20° gloss (see Note 3) at four positions within the test area that will be abraded, approximately 38 mm from the center of the specimen and 90° apart. Record the mean of these four readings as "Unabraded Gloss."

NOTE 6—It is recommended that the panel be marked, or a template be created, to ensure that measurements are taken in the area that will be abraded.

10.2 Mount the test panel on the turntable with the side to be abraded facing up. Lower the abrasive wheels, adjust the vacuum pick-up nozzle as outlined in 8.1.3, and set the vacuum suction as outlined in 8.1.4. Affix the auxiliary masses marked 500 g to each pivoted arm and subject the test panel to abrasion for a selected number of cycles. An abrasion of 10 cycles is typically used, unless otherwise agreed upon (see 5.3). Use a soft bristle brush or compressed air to remove residue from the specimen after abrasion.

10.3 Repeating 10.1, measure the gloss at four positions within the abraded area immediately following the abrasion test unless otherwise agreed upon by the interested parties. Record the mean of these four readings as "Abraded Gloss."

10.3.1 If the panel was marked for measurement of unabraded gloss, the glossmeter can be easily placed in the correct position for measuring abraded gloss. However, to compensate for any abrasion unevenness, it may be desirable to make minor adjustments to panel position to get the four lowest gloss readings within the abraded area.

10.4 Calculate the percent gloss retention for each panel from the following equation:

$$\text{percent gloss retention} = 100 \times (\text{abraded gloss/unabraded gloss}) \quad (1)$$

10.5 Repeat 10.1 – 10.4 on at least one additional test specimen of the material under test.

NOTE 7—While the minimum of two coated panels is acceptable, evaluating three or more panels per material will provide greater confidence in your test results.

10.6 Calculate the grand mean from the means obtained for each of the panels used to test a particular coating and report as the percent gloss retention for that coating.

11. Report

11.1 Report the following information:

11.1.1 The percent gloss retention values that were obtained for each coating in the ~~series.~~series;

11.1.2 The number of panels that were tested for each of the coatings ~~evaluated.~~evaluated;

11.1.3 The abrasive wheel, load, and number of cycles ~~used.~~used;

11.1.4 A plot of percent gloss retention versus number of abrasion cycles, if more than one number of abrasion cycles was ~~used.~~used; and

11.1.5 Any deviation from the test procedure.

12. Precision and Bias[5]

12.1 *Precision*—The precision of this test method is based on an interlaboratory study of ASTM D6037, Test Methods for Dry Abrasion Mar Resistance of High Gloss Coatings — Method A, conducted in 2012. Each of eight laboratories tested three or four different materials. Every "test result" represents an individual determination, and all participants were asked to report five test results. Unabraded and abraded gloss were measured and reported with both 20° and 60° geometry for all samples. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report RR:D01-1170.

12.1.1 *Repeatability (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 following values only in one case in 20.

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

12.1.1.2 Repeatability limits are listed in Tables 1 and 2.

12.1.2 *Reproducibility (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 one case in 20.

TABLE 1 Mar Resistance (measured with 20 degree geometry)

Material	Number of Abrasion Cycles	Average[A] $\bar{x}$	Repeatability Standard Deviation s_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
A	10	40.500	3.773	9.523	10.565	26.665
A	50	10.729	0.694	3.132	1.942	8.770
A	100	7.100	0.626	2.204	1.752	6.171
B	10	30.492	2.494	8.108	6.982	22.703
B	50	5.267	0.674	1.668	1.887	4.672
B	100	2.292	0.369	1.226	1.032	3.432
C	10	24.950	2.199	7.113	6.156	19.915
C	50	4.965	0.828	1.698	2.317	4.754
C	100	3.230	0.490	1.131	1.371	3.168
D	10	30.745	4.893	5.332	13.701	14.930
D	50	8.460	1.655	2.383	4.635	6.673
D	100	5.945	1.948	2.744	5.455	7.684
E	20	80.057	16.100	16.950	45.081	47.459
E	40	75.315	1.087	2.006	3.045	5.618
E	60	72.550	1.090	1.842	3.053	5.159
F	20	80.927	16.529	17.243	46.280	48.279
F	40	78.125	2.917	3.554	8.167	9.951
F	60	76.055	2.836	4.011	7.940	11.231
G	20	63.473	4.836	9.615	13.541	26.923
G	40	51.073	4.138	11.022	11.586	30.861
G	60	42.653	5.415	11.758	15.161	32.921

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

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1170. Contact ASTM Customer Service at service@astm.org.

TABLE 2 Mar Resistance (measured with 60 degree geometry)

Material	Number of Abrasion Cycles	Average[A] $\bar{X}$	Repeatability Standard Deviation s_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
A	10	67.683	1.429	5.139	4.001	14.389
A	50	43.158	1.288	4.371	3.607	12.238
A	100	35.433	1.180	3.848	3.304	10.774
B	10	59.096	1.429	5.888	4.000	16.485
B	50	29.121	2.471	5.848	6.920	16.374
B	100	15.683	2.101	5.592	5.884	15.657
C	10	54.915	2.449	6.011	6.857	16.831
C	50	29.080	2.421	5.487	6.780	15.363
C	100	23.310	1.425	4.893	3.989	13.699
D	10	60.520	3.845	3.892	10.766	10.897
D	50	38.775	2.662	8.515	7.453	23.842
D	100	34.020	4.301	7.097	12.042	19.872
E	20	89.113	1.050	1.668	2.940	4.670
E	40	84.108	1.170	1.401	3.275	3.923
E	60	82.021	1.751	2.198	4.903	6.153
F	20	89.233	0.739	1.612	2.069	4.514
F	40	85.188	0.982	1.397	2.749	3.911
F	60	81.808	0.810	3.000	2.268	8.399
G	20	83.480	3.928	3.928	10.998	10.998
G	40	74.108	5.293	5.490	14.820	15.372
G	60	65.009	6.039	6.228	16.909	17.438

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

FIG. 2 Abrader for Method B

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

12.1.2.2 Reproducibility limits are listed in Tables 1 and 2.

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

12.1.4 Any judgment in accordance with statements 12.1.1 and 12.1.2 would have an approximate 95 % probability of being correct.

12.2 *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.

12.3 The precision statement was determined through statistical examination of 971 results, from eight laboratories, on seven different materials described as:

A: Fluorinated aromatic aerospace polyurethane topcoat on steel substrate ~~(black)~~(black);
B: Acrylic industrial polyurethane topcoat on steel substrate ~~(black)~~(black);
C: Aromatic aerospace polyurethane topcoat on steel substrate (dark ~~blue)~~blue);
D: Aromatic aerospace polyurethane topcoat on steel substrate ~~(black)~~(black);
E: Melamine formaldehyde resin laminate panel ~~(white)~~(white);
F: Melamine formaldehyde resin laminate panel ~~(yellow)~~(yellow); and

G: Urethane finish on oak hardwood flooring (clear ~~coat)~~coat).

12.4 To judge the equivalency of two test results, it is recommended to choose the material closest in characteristics to the test material.