



Standard Test Methods for Dry Abrasion Mar Resistance of High Gloss Coatings¹

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.

^{ε1} NOTE—Reference to research report was added editorially to Test Method B in August 2013.

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 contains a rotating specimen holder and two abrasive wheels. Test Method B uses a device that contains a reciprocating specimen holder and a single wheel that has been fitted with abrasive paper. 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.

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

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, Varnish, and Related Products on Test Panels

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

D3924 Specification for 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. These test methods measure resistance to visible damage caused by mild abrasion.

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.

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

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.

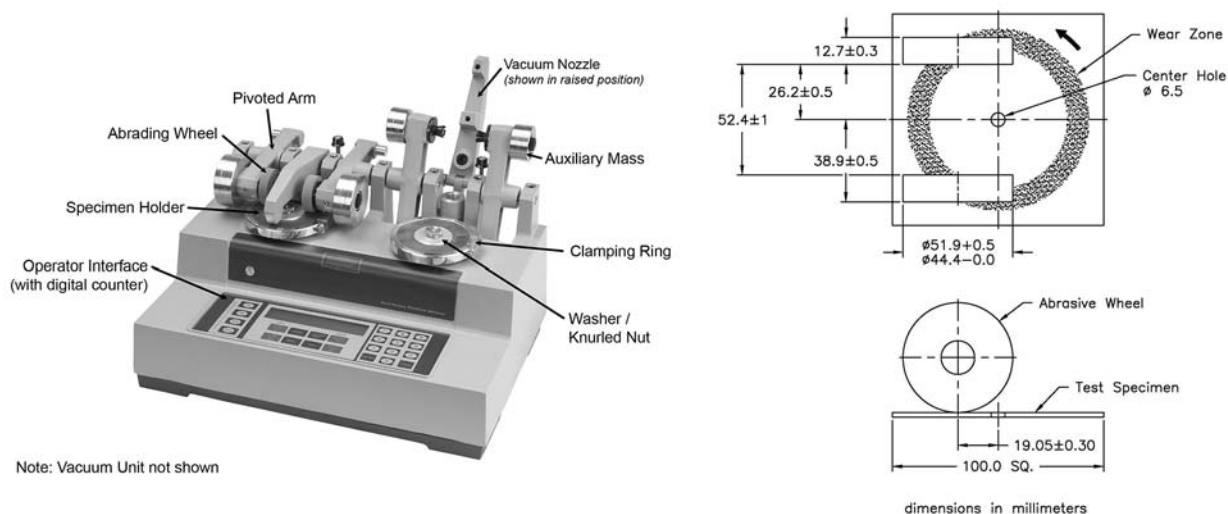


FIG. 1 Abrader for Method A

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.

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 S-11 refacing disc³ for resurfacing the abrasive wheels. The load selected is the same as the test load.

6.5 *Abrasive Wheels*—“Calibrase” wheels CS-10,³ unless otherwise specified or agreed. Wheels that have worn to the diameter of the wheel label should not be used. Prior to testing, ensure the expiration date has not passed.

NOTE 2—The abrasive quality of a Calibrase wheel may change with hardness. Hardness can change with time and storage conditions. However, abrasive quality can’t be inferred from hardness measurements alone. Many other factors can also affect abrasive quality.

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.

6.6 *Glossmeter*, with 20° geometry complying with Test Method D523 but with an opening no larger than 25 by 75 mm to accommodate 100 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.

NOTE 4—Subjective evaluations may be made visually by comparing abraded panels with a measured abraded standard using one of the procedures in Test Method D4449.

7. Preparation of Specimens

7.1 Prepare a minimum of two 100 by 100-mm panels for each coating that is being tested. Prepare and coat panels in accordance with Practices D609 and D823.

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

7.1.2 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 5—It is important that the panels be planar for reproducible results. Cutting and drilling of painted panels has not been satisfactory.

NOTE 6—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.

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. Conditioning

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

8.2 Unless otherwise agreed upon between the purchaser and the seller, condition the coated panels for at least 24 h at $23^{\circ} \pm 2^{\circ}\text{C}$ and $50 \pm 5\%$ relative humidity in accordance with Specification **D3924**. Conduct the test in the same environment or immediately after removal therefrom.

9. Procedure

9.1 Using a glossmeter that is calibrated and verified for accuracy, measure the 20° gloss 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 7—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.

9.2 Mount the pair of Calibrase wheels to be used on their respective flange holders, taking care not to handle them by their abrasive surfaces. Select the same load to be used in the test and affix it to the abraser. Mount an S-11 refacing disc on the turntable. Reface the wheels for 25 cycles before abrading each specimen. In each case lightly brush the residue from the resurfacing operation off each wheel. Discard the S-11 refacing disc after each use.

9.3 Mount the test panel on the turntable and subject it to abrasion for a selected number of cycles. An abrasion of 10 cycles and 500 g-load are typically used, unless otherwise agreed upon. Use a soft camel’s hair brush or compressed air to remove residue from the specimen after abrasion.

9.4 Repeating 9.1, 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.”

9.4.1 If the panel was marked for measurement of unabraded gloss, it can be easily placed in the correct position for measuring abraded gloss. However, to compensate for any abrasion unevenness, it is desirable to make minor adjustments to panel position to get the four lowest gloss readings within the abraded area (see Note 4).

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

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

9.6 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.

10. Report

10.1 Report the following information:

10.1.1 The percent gloss retention values that were obtained for each coating in the series.

10.1.2 The number of panels that were tested for each of the coatings evaluated.

10.1.3 The abrasive wheel, load, and number of cycles used.

10.1.4 A plot of percent gloss retention versus number of abrasion cycles, if more than one number of abrasion cycles was used.

10.1.5 Any deviation from the test procedure.

11. Precision and Bias⁵

11.1 *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.

11.1.1 *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.

11.1.1.1 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.

11.1.1.2 Repeatability limits are listed in **Tables 1 and 2**.

11.1.2 *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.

11.1.2.1 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.

11.1.2.2 Reproducibility limits are listed in **Tables 1 and 2**.

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

11.1.4 Any judgment in accordance with statements **11.1.1** and **11.1.2** would have an approximate 95 % probability of being correct.

11.2 *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.

11.3 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)

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 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.

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.

B: Acrylic industrial polyurethane topcoat on steel substrate (black)

C: Aromatic aerospace polyurethane topcoat on steel substrate (dark blue)

D: Aromatic aerospace polyurethane topcoat on steel substrate (black)

E: Melamine formaldehyde resin laminate panel (white)

F: Melamine formaldehyde resin laminate panel (yellow)

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

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

TEST METHOD B

12. Apparatus

12.1 *Application Equipment*, see 6.1.

12.2 *Film Thickness Measuring Apparatus*, see 6.2.

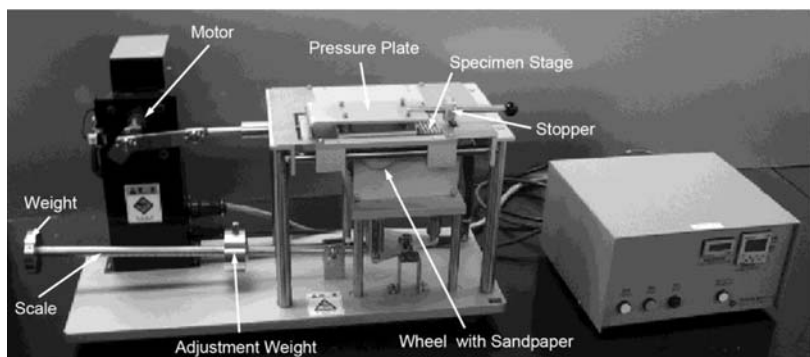


FIG. 2 Abrader for Method B

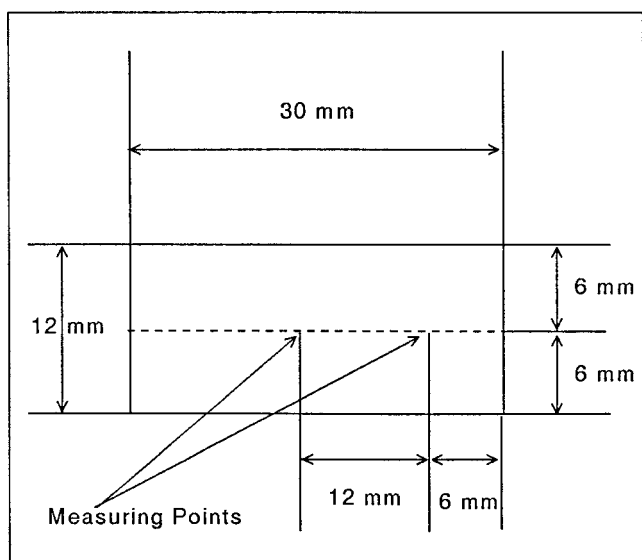
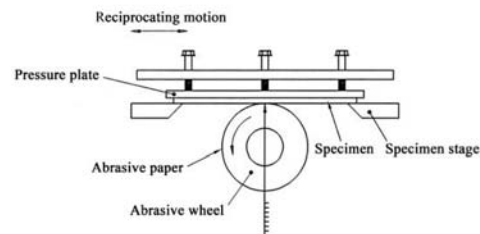


FIG. 3 Plan-to-abrade area 30 x 12 mm

12.3 *Abrader* (Fig. 2)⁶, consisting of a pressure plate for holding the test specimen level and rigid, and a stationary wheel to which abrasive paper is adhered to the outer circumference. The force between the wheel and the test specimen shall be capable of being varied from 100 to 3000 g. The test specimen shall slide back and forth in a horizontal plane in parallel contact with the test surface of the wheel. After each double stroke (complete reciprocal movement), the wheel is advanced through an angle of 0.9° to bring an unused portion of abrasive paper into contact with the surface before making the next double stroke. The angle of rotation is such that after 400 double strokes the wheel will have made one complete revolution. At the completion of one revolution the abrasive paper shall be renewed. The relative speed of movement is 40 ± 2 double strokes per minute. The abraded area is about 12 by 30 mm.

12.4 *Abrasive Wheel*⁶—50-mm diameter by 12-mm wide.

⁶ The sole source of supply of the apparatus known to the committee at this time is Suga Test Instruments Co., Ltd., 5-4-14, Shinjuku, Shinjuku-ku, Tokyo, 160-0022, Japan. 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.

12.5 *Abrasive Paper*⁶—The abrasive paper is coated with 3 μm (4000 mesh) grade aluminum oxide. It shall be used by cutting 12 by 157-mm strips to cover the circumference of the wheel without overlapping, and shall be bonded into position.

NOTE 8—Other grades of abrasive paper may be used by mutual agreement among the interested parties.

12.6 *Glossmeter*, see 6.6, but the glossmeter opening should be no larger than 12 by 12 mm.

13. Preparation of Specimens

13.1 Prepare a minimum of two panels (between 30 by 50 mm and 70 by 300 mm for each coating that is being tested. Prepare and coat the panels in accordance with Practices D609 and D823 (see Note 5 and Note 6).

14. Conditioning

14.1 See 8.1 and 8.2.

15. Procedure

15.1 Using a glossmeter with 20° geometry, complying with Test Method D523, that is calibrated and verified for accuracy, measure the gloss at two positions within the test area that will be abraded (see Fig. 3). Record the mean of these two readings as “Unabraded Gloss.”

15.2 Place the test specimen into position on the apparatus.

15.3 Attach a new abrasive paper to the circumference of the wheel.

15.4 Set the apparatus to run for 10 double strokes for a distance of 30 mm using a 500-g load.

15.5 Repeating 15.1, measure the gloss at two positions within the abraded area. Record the mean of these two readings as “Abraded Gloss” (see Note 4).

NOTE 9—A 3-mm length at one end of the abraded area might be subject to extra wear because of the continual wheel rotation that takes place at this point. This end should be ignored when taking the measurements.

15.6 Calculate results as described in 9.5 and 9.6.

16. Report

16.1 Report the following information:

- 16.1.1 The percent gloss retention for each coating.
- 16.1.2 The number of panels tested.

TABLE 3 Precision Statement Based on Six Replicate Observations

Material	Values in Units of Percent Gloss Retention					
	$\bar{X}$	s_x	s_r	S_R	r	R
Acrylic Plastic – Soft	70.972	1.8187	1.4931	2.2728	4.18	6.36
Acrylic Plastic – Hard	96.432	1.7193	1.1580	2.0183	3.24	5.65
Steel Plate with Polyurethane Coating (red)	41.931	1.4108	1.2972	1.8419	3.63	5.16
Steel Plate with Acrylic Urethane Coating (red)	38.672	1.2365	1.0876	1.5858	3.05	4.44
Aluminum Plate with Polyurethane Coating (clear)	40.222	0.8840	1.0963	1.3353	3.07	3.74
Aluminum Plate with Urethane Coating (white)	30.753	0.4415	1.0408	1.0408	2.91	2.91

16.1.3 The abrasive wheel and paper, load, and number of double strokes used.

16.1.4 A plot of percent gloss retention versus the number of abrasion cycles used, if more than one number of abrasion cycles was used.

17. Precision and Bias⁷

17.1 *Precision*—The precision of this test method is based on an interlaboratory study of Test Method D6037 — Method B, conducted in 2011. Six laboratories tested six materials, and subjected each to ten double strokes. Each “test result” represented an individual determination. Every laboratory obtained six replicate samples for each material.

17.1.1 *Repeatability (r)*—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 3**; “*r*” is the interval representing the critical difference between the

two test results for the same material, obtained by the same operator, using the same equipment, in the same laboratory, on the same day.

17.1.2 *Reproducibility (R)*—Two test results shall be judged not equivalent if they differ by more than the “*R*” value for that material given in **Table 3**; “*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.

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

17.1.4 The precision statement was determined through statistical analysis of 216 results, from six laboratories, on six materials.

17.2 *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.

⁷ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1171. Contact ASTM Customer Service at service@astm.org.

18. Keywords

18.1 abraser; abrasion tester; coatings; gloss; mar

SUMMARY OF CHANGES

Committee D01 has identified the location of selected changes to this standard since the last issue (D6037 –96 (2008)) that may impact the use of this standard. (Approved June 1, 2013.)

- (1) Updated scope to include the purpose of the test method (1.1).
- (2) Updated to SI units as the standard, instead of inch-pounds (1.3).
- (3) Corrected referenced documents (2.1). Added Practice D7091 which replaces withdrawn Test Methods D1186 and D1400; removed Test Method D2240 reference because the wheel hardness reference was deleted from 6.5.1; added Practices E117 and E691 which are referenced in Section 11, Precision and Bias.
- (4) Added Figure 1 showing apparatus for Test Method A.
- (5) Included option to use 60 degree geometry for semi- to high-gloss coatings (Note 3).

- (6) Defined area to measure “Unabraded Gloss” (9.1).
- (7) Required gloss measurement to be taken immediately following abrasion unless otherwise specified (9.4).
- (8) Addition of Precision statement for Test Method A (Section 11).
- (9) Added Figure 2 showing apparatus for Test Method B.
- (10) Revised description of apparatus by combining information found in 12.3 and 12.4 (12.3).
- (11) Included dimensional information for abrasive wheel (12.4).
- (12) Addition of Precision statement for Test Method B (Section 17).



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