Designation: D5178 – 16

Standard Test Method for Mar Resistance of Organic Coatings[1]

This standard is issued under the fixed designation D5178; 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 the determination of the mar resistance on smooth, flat surfaces. Results are expressed in terms of force-to-mar films of organic coatings such as paint, varnish, and lacquer when applied to smooth, flat planar panel surfaces.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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]

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

D1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base (Withdrawn 2006)[3]

D1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base (Withdrawn 2006)[3]

D2691 Method for Microscopical Measurement of Dry Film Thickness of Coatings on Wood Products (Withdrawn 1992)[3]

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:*

3.1.1 *mar resistance, n*—the ability of a coating to resist damage caused by light abrasion. As just defined, it is a resistance of the surface of the coating to permanent deformation, resulting from the application of a dynamic mechanical force.

4. Summary of Test Method

4.1 The materials under test are applied at uniform thickness to flat panels of uniform surface texture. After drying/curing, the mar resistance is determined by pushing the panels beneath a rounded stylus or loop that is loaded in increasing amounts until the coating is marred.

5. Significance and Use

5.1 In some situations, marring of coatings applied to substrates under typical use conditions is unacceptable. This test method has been found useful in differentiating the degree of marring of coatings on substrates. It is most useful in providing relative ratings for a series of coated panels exhibiting significant differences in marring.

5.2 In a limited laboratory study, meaningful mar results were impossible when powder coatings were tested. The mar marking, that is, scratches, became less perceptible with time. Therefore, powder coatings may not be applicable coatings for this test method.

6. Apparatus

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

6.2 *Film-Thickness Measuring Apparatus,* as described in Test Methods D1005, D1186, D1400, or D2691.

6.3 *Balanced Beam Scrape Adhesion and Mar Tester* (Fig. 1 and Fig. 2), consisting of a balanced beam to which is secured a platform for supporting weights, and a rod at an angle of 45°

[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, 2016. Published January 2017. Originally approved in 1991. Last previous edition approved in 2013 as D5178 – 13. DOI: 10.1520/D5178-16.

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

FIG. 1 Balanced Beam Scrape Adhesion and Mar Tester

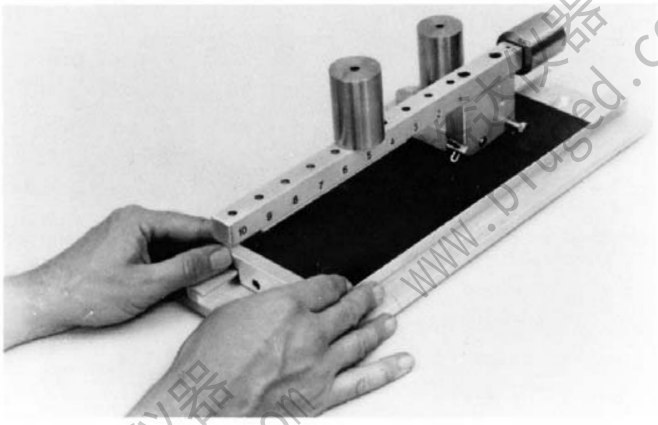

FIG. 2 Balanced Beam Scrape Adhesion and Mar Tester

that holds the scraping loop. The rod shall be set so that the scraping loop contacts test surfaces directly below the weights. The loop shall be 1⁄16-in. (1.6 mm) diameter rod, bent into a "U" shape with an outside radius of 0.128 ± 0.002 in. (3.25 ± 0.05 mm) and hardened to Rockwell HRC 56 to 58, and shall be a smooth finish. The loop can be either chromium plated, nickel plated, or heat treated polished steel as agreed upon between the purchaser and the supplier. These testers are adjustable to accommodate flat, metallic, and nonmetallic specimens to 0.5-in. (12-mm) thick and 4 to 16 in. (100 to 400 mm) wide and long; the specimen should be at least ½-in. (12-mm) wide.

7. Preparation of Specimens

7.1 Apply the materials under test to panels of the composition and surface condition on which it is desired to determine mar resistance of the coating. The panel material (7.1.1), surface preparation, thickness, and number of coats shall be specified or agreed upon between the seller and the purchaser. Apply coatings and air dry or bake under conditions of humidity and temperature mutually agreeable to the seller and the purchaser.

7.1.1 The surface of the coating must be hard enough to resist damage by the scraping loop at a load agreed upon between the producer and the user. If no panel material is specified, use 0.032-in. (0.8-mm) cold-rolled carbon steel prepared in accordance with Methods B or C of Practice D609.

8. Conditioning and Number of Tests

8.1 Condition the test panels for at least 48 h at 23 ± 2°C (73.5 ± 3.5°F) and 50 ± 5 % relative humidity, and test in the same environment, or immediately on removal therefrom, unless otherwise specified or agreed upon by the seller and the purchaser. Test at least two replicate specimens of each material.

9. Procedure

9.1 In preparation for using the apparatus, ensure that it is reasonably level and place it so that the weight holder is toward the operator. This places the beam release on the operator's right and allows freedom to move the test specimen manually under the weighted scraping element (loop). Insert the loop into the holder as far as it will go and tighten the clamping screw. Adjust the main bearing support so that the beam is

TABLE 1 Film Thickness (microns)

Material	Average[A] $\bar{X}$	Repeatability Standard Deviation s_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Panel Set E and R[B]	109.9	32.2	37.5	90.2	105.0
Panel Set B and H[B]	93.3	10.9	10.9	30.4	30.6
Panel Set D and G[B]	74.0	25.2	25.2	70.4	70.4

[A] The average of the laboratories' averages.
[B] Five laboratories reported results.

TABLE 2 Load at the Mar Failure End Point (kg)

Material	Average[A] $\bar{X}$	Repeatability Standard Deviation s_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Panel Set E and R[B]	7.05	0.88	1.98	2.46	5.55
Panel Set B and H[B]	1.52	1.34	1.34	3.75	3.75
Panel Set D and G	1.25	0.93	0.93	2.60	2.60

[A] The average of the laboratories' averages.
[B] Five laboratories reported results.

balanced in the horizontal plane when the loop is just touching the specimen surface. The alignment of the beam should be such that the end of the loop is over the midline of the movable table.

9.2 Raise the beam and lock it in the raised position. Wipe the loop with a clean cloth or chamois. Locate the specimen on the sliding platform against the stop so that the specimen can be moved away from the operator and there is an area at least 3 in. (75 mm) long by ½ in. (12 mm) wide on the sample parallel to the horizontal plane through the beam. Place weights on the weight support using an initial amount that is estimated to be appropriate for the particular coating. Release the beam and carefully lower it until the loop rests on the coated test specimen and the full load is applied, then slowly push the sliding platform away from the operator at a rate of ¼ in. (6 mm)/s for a distance of at least 3 in. (75 mm). If the coating is marred, continue the testing using successively smaller loads (0.5-kg increments) until the coating is not marred. If the coating is not marred by the initial scrape, continue the test using successively larger loads (0.5-kg increments) until the coating is marred or until the maximum load of 10 kg has been applied. Use a new area of the test surface each time a scrape is made.

9.3 When the critical load has been approximately located, repeat the test five times at each of three loadings: above, below, and at the load determined in the first trial. Use the replicate specimen to apply different loads in random fashion so the same load is not made in succession.

9.3.1 Periodically examine the loop to ensure that the original smooth surface is intact. If the contacting surface is worn, reverse the loop. When both sides are worn, replace with a new loop.

9.4 For each applied load, tabulate the number of times the coating was marred.

10. Report

10.1 Report the following information:
10.1.1 Load in kilograms at the mar failure end point,
10.1.2 Panel material and surface preparation,
10.1.3 "U" shape loop surface finish,
10.1.4 Dry-film thickness, and
10.1.5 Any deviation from the specified procedure.

11. Precision and Bias

11.1 The precision of this test method is based on an interlaboratory study of D5178, Standard Test Method for Mar Resistance of Organic Coatings, conducted in 2015. Six laboratories tested three panel pairings. Every "test result" represents an individual determination. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No: RR:D01-1182.[4]

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 Table 1 and Table 2.

11.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1182. Contact ASTM Customer Service at service@astm.org.

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 Table 1 and Table 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 62 test results, from a total of 6 laboratories, on 3 pairings of materials. The materials used were described as the following:

Panel set B: Polyurethane Coating
Panel set D: Epoxy Coating
Panel set E: Polysiloxane Coating
Panel set G: Epoxy Coating
Panel set H: Polyurethane Coating
Panel set R: Polysiloxane Coating

11.4 To judge the equivalency of two test results, it is recommended to choose the panel set type closest in characteristics to the test panels.

12. Keywords

12.1 balanced beam scrape adhesion and mar tester; balanced beam tester; coatings; mar or organic mar resistance