



Designation: D5178 – 21

# Standard Test Method for Mar Resistance of Organic Coatings<sup>1</sup>

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 ( $\epsilon$ ) 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 *Units*—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, 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:<sup>2</sup>

[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](#)

[D2691 Method for Microscopical Measurement of Dry Film](#)

<sup>1</sup> 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.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[Thickness of Coatings on Wood Products \(Withdrawn 1992\)](#)<sup>3</sup>

[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:

3.1.1 *mar resistance, n*—the ability of a coating to resist damage caused by light abrasion; 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 loop stylus at a constant normal load. Increasing (decreasing) loads are applied to the stylus until the coating is marred (not 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](#).

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

6.2 *Film-Thickness Measuring Apparatus*, as described in Test Methods D1005, D2691, or D7091.

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° that holds the loop stylus. The rod shall be set so that the loop stylus contacts test surfaces directly below the weights. The weights shall be in increments of 0.5 kg up to a maximum load of 10 kg.

6.3.1 *Loop Stylus*, the loop shall be 1/16 in. (1.6 mm) diameter rod, bent into a “U” shape with an outside radius of 0.128 in. ± 0.002 in. (3.25 mm ± 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 interested parties.

## 7. Preparation of Specimens

7.1 Panels shall be flat, and either metallic or nonmetallic panels as agreed upon by the interested parties. 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.

7.1.1 Typical panel dimensions are 4 in. (100 mm) wide by 6 in. (150 mm) or 8 in. (200 mm) long and a thickness of 0.5 in. (12 mm) or less. Other panel dimensions are acceptable, provided they accommodate sufficient tests as specified in 9.3 – 9.5.

7.2 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 surface preparation, thickness, and number of coats shall be specified or agreed upon between the interested parties. Apply coatings and air dry or bake under conditions of humidity and temperature mutually agreeable to the interested parties.

## 8. Conditioning and Number of Tests

8.1 Condition the test panels for at least 48 h at 23°C ± 2°C (73.5°F ± 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 interested parties. 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 to allow the operator freedom to manually move the test specimen under the weighted scraping element (loop). Insert the loop into the holder and tighten the clamping screw. Adjust the main bearing support so that the beam is 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.

9.1.1 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.

9.2 Raise the beam and lock it in the raised position. Wipe the loop with a clean cloth or chamois. Position 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 1/2 in. (12 mm) wide on the specimen 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.

9.3 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 1/4 in. (6 mm)/s for a distance of at least 3 in. (75 mm).

9.3.1 If the coating is marred by the initial scrape, continue the testing using successively smaller loads (0.5 kg increments) until the coating is not marred. If the coating is not marred, 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.

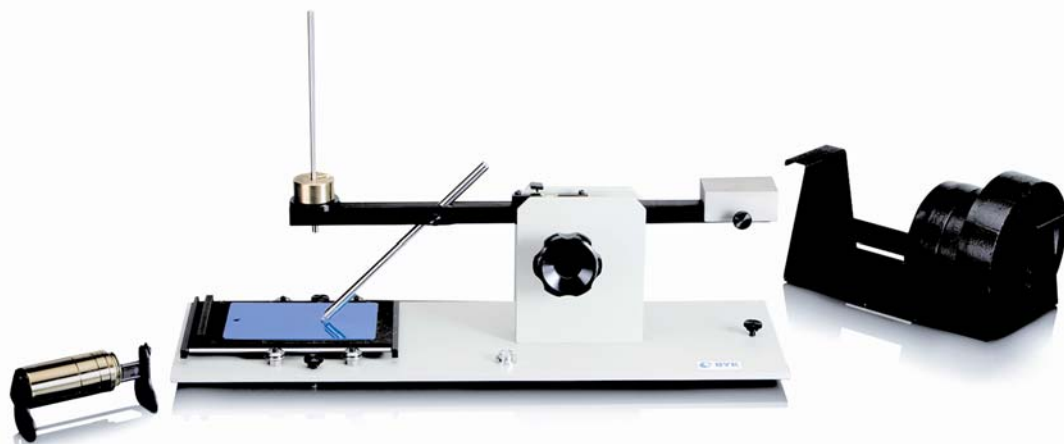


FIG. 1 Balanced Beam Scrape Adhesion and Mar Tester

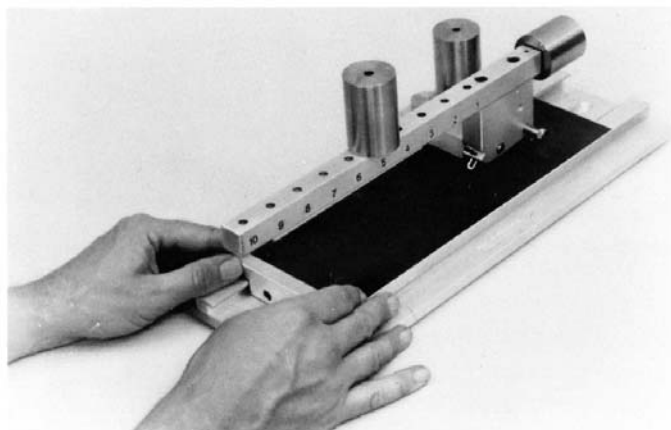


FIG. 2 Balanced Beam Scrape Adhesion and Mar Tester

TABLE 1 Film Thickness (microns)

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

<sup>A</sup> The average of the laboratories' averages.

<sup>B</sup> Five laboratories reported results.

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

| Material                       | Average <sup>A</sup><br>$\bar{X}$ | Repeatability<br>Standard<br>Deviation<br>$s_r$ | Reproducibility<br>Standard<br>Deviation<br>$S_R$ | Repeatability<br>Limit<br>$r$ | Reproducibility<br>Limit<br>$R$ |
|--------------------------------|-----------------------------------|---|---|-------------------------------|---------------------------------|
| Panel Set E and R <sup>B</sup> | 7.05                              | 0.88  | 1.98  | 2.46                          | 5.55                            |
| Panel Set B and H <sup>B</sup> | 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                            |

<sup>A</sup> The average of the laboratories' averages.

<sup>B</sup> Five laboratories reported results.

9.4 When the critical load has been determined, repeat the test five times at each of the following three loadings: 0.5 kg above, 0.5 kg below and at the load determined in 9.3.1. Use the replicate specimen to apply these three loads in random fashion so the same load is not made in succession.

9.5 To confirm the critical load determined in 9.4 was correct, tabulate the number of times the coating was marred for each applied load. If it is determined the critical load was too excessive (insufficient), repeat the test five times 0.5 kg below (above) the loading identified in 9.4 until the mar failure point is identified.

## 10. Report

10.1 Report the following information:

- 10.1.1 Load in kilograms at the mar failure 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.<sup>4</sup>

11.1.1 *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 following values only in one case in 20.

<sup>4</sup> 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.