Designation: D2197 – 16 (Reapproved 2022)

# Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion[1]

This standard is issued under the fixed designation D2197; 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.

*This standard has been approved for use by agencies of the U.S. Department of Defense.*

## 1. Scope

1.1 This test method covers the determination of the adhesion of organic coatings such as paint, varnish, and lacquer when applied to smooth, flat (planar) panel surfaces.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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]

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

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. Summary of Test Method

3.1 The materials under test are applied at uniform thickness to flat panels, usually sheet metal of uniform surface texture. After drying, the adhesion is determined by pushing the panels beneath a rounded stylus or loop that is loaded in increasing amounts until the coating is removed from the substrate surface.

## 4. Significance and Use

4.1 Coatings to perform satisfactorily must adhere to the substrates on which they are applied. This test method has been found useful in differentiating the degree of adhesion of coatings to substrates. It is most useful in providing relative ratings for a series of coated panels exhibiting significant differences in adhesion.

4.2 Studies performed in a laboratory using the loop stylus specified in the previous edition showed meaningful adhesion data were impossible when loads of 10 to 20 kg were required to break the surface of a solvent based coating. The chrome plated loop stylus chattered and skipped across the coating surface when loads of this magnitude were required. Similar meaningless data were obtained when powder coatings were tested that required more than 10 kg to break the surface. Therefore, testing under these conditions is not applicable.

## 5. Apparatus

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

5.2 *Film-Thickness Measuring Apparatus,* as described in Test Method D1005 or Practice D7091.

5.3 *Balanced Beam, Scrape Adhesion Tester* (Figs. 1 and 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 scraping loop. The rod shall be set so that the scraping loop contacts test surfaces directly below the weights. The loop shall be 1.6-mm (1⁄16-in.) diameter rod, bent into a "U" shape with an outside radius of 3.25 ± 0.05 mm (0.128 ± 0.002 in.)

[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.

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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.

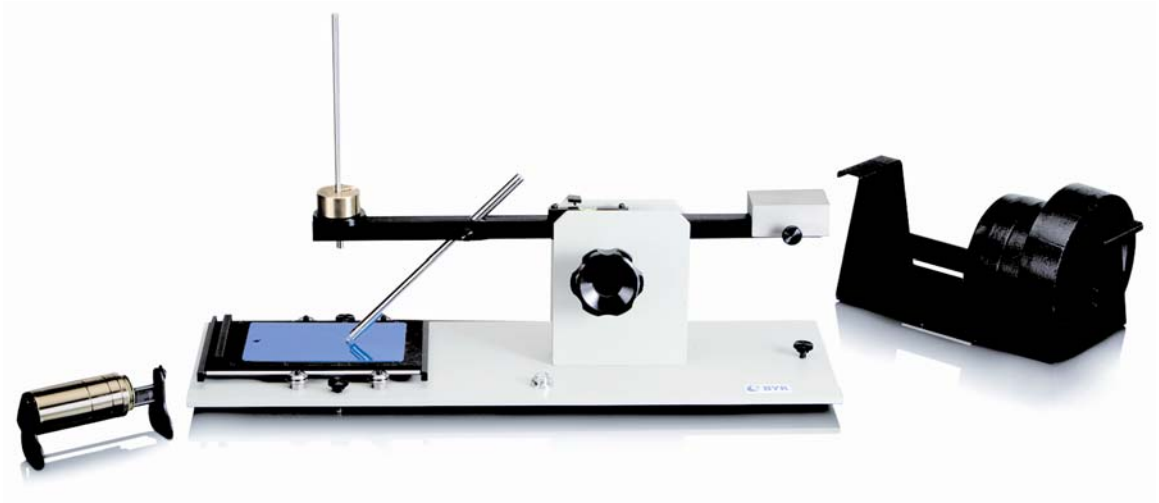

FIG. 1 Balanced-Beam Scrape-Adhesion Tester

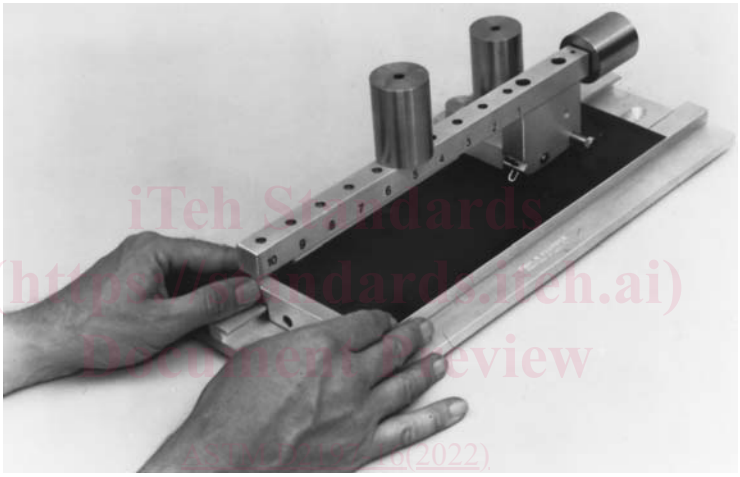

FIG. 2 Balanced Beam Scrape Adhesion and Mar Tester



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 12-mm (0.5-in.) thick and 100 to 400 mm (4 to 16 in.) wide and long; the specimen should be at least 12-mm (½-in.) wide.

## 6. Preparation of Specimens

6.1 Apply the materials under test to panels of the composition and surface condition on which it is desired to determine adhesion. The panel material (6.1.1), surface preparation, thickness, and number of coats shall be specified or agreed upon by the seller and the purchaser. Apply uniform coatings and air dry or bake under conditions of humidity and temperature mutually agreeable to the seller and purchaser. Either mask the panel or remove material after application, so that 13 mm (½ in.) at one end of the panel is uncoated.

6.1.1 The surface of the panel must be hard enough that it will not be damaged by the scraping loop. If no panel material is specified, use 0.8-mm (0.032-in.) cold-rolled carbon steel prepared in accordance with Methods B or C of Practice D609.

## 7. Conditioning and Number of Tests

7.1 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 by the seller and the purchaser. Test at least two replicate specimens of each material.

## 8. Procedure

8.1 When using the instrument shown in Fig. 1, level the base plate of the apparatus 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). Adjust the main bearing support so that the beam is balanced in the horizontal plane when the loop is just touching the specimen surface.

8.2 Raise the beam and lock it. Wipe the loop with clean cloth or chamois. Place a test panel on the sliding platform so that it may be moved away from the operator and the uncoated portion is toward the main beam support. Place weights on the

**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 A and C | 52.1 | 4.2 | 4.6 | 11.7 | 12.8 |
| Panel Set B and H | 123.7 | 6.8 | 17.4 | 19.0 | 48.7 |
| Panel Set D and G[B] | 35.8 | 7.3 | 23.7 | 20.4 | 66.3 |

[A] The average of the laboratories' averages.
[B] Only five laboratories reported.

**TABLE 2 Load (kg)**

| Material | Average[A] $\bar{X}$ | Repeatability Standard Deviation $s_r$ | Reproducibility Standard Deviation $S_R$ | Repeatability Limit r | Reproducibility Limit R |
|---|---|---|---|---|---|
| Panel Set A and C | 2.30 | 0.30 | 1.14 | 0.83 | 3.18 |
| Panel Set B and H[B] | 6.39 | 0.42 | 2.67 | 1.17 | 7.47 |
| Panel Set D and G[C] | 2.54 | 0.59 | 1.07 | 1.65 | 2.99 |

[A] The average of the laboratories' averages.
[B] Only five laboratories reported.
[C] Only four laboratories reported.

weight support using an initial amount that is estimated to be appropriate for the particular coating. Carefully lower the beam until the loop rests on the uncoated portion of the test specimen and the full load is applied, then slowly (1 to 2 s/in.) push the sliding platform away from the operator for a distance of at least 75 mm (3 in.). If the coating is removed, continue the testing, using successively smaller loads (0.5-kg increments) until the coating is not removed. If the coating is not removed by the initial scrape, continue the testing, using successively larger loads (0.5-kg increments) until the coating is removed 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.

8.3 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.

8.3.1 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.

8.4 For each applied load, tabulate the number of times the coating was removed or adhered. The load where the scrape results change from mainly adhering to mainly removed, ignoring the first 13 mm (½ in.) of the scratch if the coating was removed, is the adhesion failure end point.

## 9. Report

9.1 Report the following information:
9.1.1 Load in kilograms at the adhesion failure end point,
9.1.2 Panel material and surface preparation,
9.1.3 "U" shape loop surface finish,
9.1.4 Dry-film thickness, and
9.1.5 Any deviation from the specified procedure.

## 10. Precision and Bias

10.1 The precision of this test method is based on an interlaboratory study of D2197, Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion, 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:D01-1181.[3]

10.1.1 *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.

10.1.1.1 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.

10.1.1.2 Repeatability limits are listed in Table 1 and Table 2.

10.1.2 *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.

10.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1181. Contact ASTM Customer Service at service@astm.org.