



Designation: D3363 – 20

Standard Test Method for Film Hardness by Pencil Test¹

This standard is issued under the fixed designation D3363; 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 a procedure for rapid, inexpensive determination of the film hardness of an organic coating on a substrate in terms of drawing leads or pencil leads of known hardness.

1.2 This test method is similar in content (but not technically equivalent) to ISO 15184.

NOTE 1—Other procedures are available to measure permanent deformation of organic coatings under the action of a single point (stylus tip) including but not limited to Test Methods D2197, D5178, and G171.

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

1.4 *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.*

1.5 *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

D2197 Test Method for Adhesion of Organic Coatings by Scrape Adhesion

D5178 Test Method for Mar Resistance of Organic Coatings

G171 Test Method for Scratch Hardness of Materials Using a Diamond Stylus

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.

2.2 *Other Standards:*

ISO 15184 Determination of film hardness by pencil test.³

3. Summary of Test Method

3.1 A coated panel is placed on a firm horizontal surface. The pencil is held firmly against the film at a 45° angle (point away from the operator) and pushed away from the operator in a 6.5-mm (1/4-in.) stroke. The process is started with the hardest pencil and continued down the scale of hardness to either of two end points: one, the pencil that will not cut into or gouge the film (pencil hardness), or two, the pencil that will not scratch the film (scratch hardness).

4. Significance and Use

4.1 Pencil hardness measurements have been used by the coatings industry for many years to determine the hardness of clear and pigmented organic coating films. This test method has also been used to determine the cure of these coatings, especially when forced dried using heat.

4.2 This test method is especially useful in developmental work and in production control testing in a single laboratory. It should be recognized that the results obtained may vary between different laboratories when different pencils as well as panels are used. To improve test result reproducibility for a specific group of tests, it is recommended to utilize drawing leads or pencils made by the same manufacturer and from the same batch. If drawing leads or pencils from the same manufacturer and from the same batch are not available at the time of subsequent evaluations, it shall be noted on the test report. For all tests, the manufacturer and lot number of the drawing leads or pencils shall be reported.

NOTE 2—Using leads or pencils made by different manufacturers or from the same manufacturer but different production batches, may result in significant variation for leads within the same pencil hardness scale.

4.3 If this test method is used as a basis for purchase agreement, maximum precision will be achieved if a given set of referee pencils be agreed upon between the purchaser and the seller.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

5. Apparatus

5.1 A set of drawing leads (preferred) or wood pencils (see 4.2). The leads must be nominal 2 mm diameter and meet the following scale of hardness:

$$\frac{6B-5B-4B-3B-2B-B-HB-F-H-2H-3H-4H-5H-6H}{\text{Softer} \qquad \qquad \qquad \text{Harder}} \quad (1)$$

The difference between two adjacent leads shall be considered one unit of hardness.

5.2 *Mechanical Lead Holder*, for drawing leads if used.

5.3 *Mechanical Sharpener*, draftsman-type, is helpful for trimming wood pencils if used.

5.4 *Abrasive Paper*, grit No. 400.

6. Test Specimens and Conditions

6.1 Apply the surface coating by appropriate means to a smooth rigid substrate and cure properly, or use representative panels cut from coated stock. The panels used, the curing conditions, and the age of the coating prior to the test shall be within the limits agreed upon between the purchaser and the seller.

6.2 The film thickness of the coating shall be as specified or as agreed upon between the purchaser and the seller.

6.3 Conduct the test at $23 \pm 2^\circ\text{C}$ ($73.5 \pm 3.5^\circ\text{F}$) and $50 \pm 5\%$ relative humidity.

7. Procedure

7.1 For wood pencils, remove approximately 5 to 6 mm ($\frac{3}{16}$ to $\frac{1}{4}$ in.) of wood from the point of each pencil using a draftsman-type mechanical sharpener, being careful to leave an undisturbed, unmarked, smooth cylinder of lead. Holding the pencil holder (when using drawing leads) at an angle of 90° to the abrasive paper, rub the lead against the paper maintaining an exact angle of 90° to the abrasive paper until a flat, smooth and circular cross section is obtained, free of chips or nicks in the edge of the cross section. For wood pencils, see Fig. 1 for an illustration. For mechanical pencil holders with drawing leads, see Fig. 2 as the illustration. The desired edge may be obtained by cementing the abrasive paper to a flat motor-driven disk. By supporting the pencil at 90° to the rotating disk a uniform flat lead end may be obtained more reproducibly.

7.2 Place the coated panel on a level, firm, horizontal surface. Starting with the hardest lead, hold the pencil or lead holder firmly with the lead against the film at a 45° angle (point away from the operator) and push away from the operator. Exert sufficient uniform pressure downward and forward either to cut or scratch the film or to crumble the edge of the lead. It is suggested that the length of the stroke be 6.5 mm ($\frac{1}{4}$ in.).

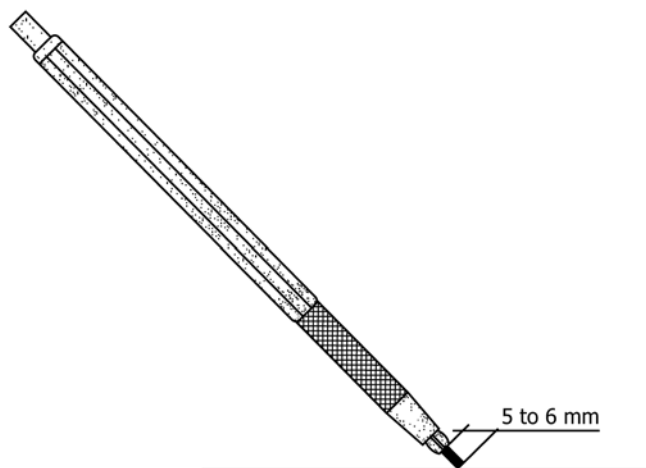


FIG. 2 View of Mechanical Holder with Sharpened Drawing Lead

7.3 Repeat the process down the hardness scale until a pencil is found that will not cut through the film to the substrate (either metal or a previous coat) for a distance of at least 3 mm ($\frac{1}{8}$ in.) (see 8.1.1).

NOTE 3—The operator must watch closely for cutting into or scratching the film. Some finishes contain compounds that may tend to lubricate the film. Checks should be made by close visual inspection and by fingernail feel.

NOTE 4—In conducting the test, if the sharp edge of the lead is slightly chipped or crumbled, the lead must be resharpened.

7.4 Continue the process until a pencil is found that will neither cut through nor scratch the surface of the film. Any defacement of the film other than a cut (gouge) is considered a scratch. Record each end point (if applicable) for gouge and scratch hardness (see 8.1).

NOTE 5—With some films, the two end points will be identical.

7.5 Make a minimum of two determinations for gouge hardness (7.3) and scratch hardness (7.4) for each pencil or lead.

8. Report

8.1 Report the following information:

8.1.1 The two end points as follows:

8.1.1.1 *Gouge Hardness*—The hardest pencil that will leave the film uncut for a stroke length of at least 3 mm ($\frac{1}{8}$ in.).

8.1.1.2 *Scratch Hardness*—The hardest pencil that will not rupture or scratch the film.

8.1.2 The manufacturer, lot or batch number, and grade of lead or pencil used, and

8.1.3 Any deviation from standard conditions, including roughness in the finish.

9. Precision and Bias

9.1 *Precision*—In an interlaboratory test of this test method with three different films on panels, ten laboratories and operators, and repeated by switching leads and panels between laboratories, the within-laboratory standard deviation was found to be 0.52 and the between-laboratory standard deviation was found to be 0.61. Based on these standard deviations, the

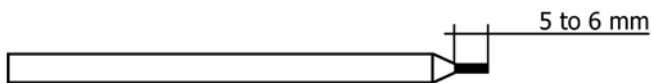


FIG. 1 View of Wood Pencil after Sharpening