Designation: D3363 – 22

Standard Test Method for Film Hardness by Pencil Test[1]

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 metal or similarly hard 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

2.2 *Other Standards:*

ISO 15184 Determination of film hardness by pencil test[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *gouge hardness, n*—the hardest pencil lead that will leave the film uncut for a stroke length of at least 3 mm (⅛ in.); also referred to as pencil hardness.

3.1.2 *scratch hardness, n*—the hardest pencil lead that will not rupture or scratch the film.

4. Summary of Test Method

4.1 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 for a minimum of 6.5 mm (¼-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).

NOTE 2—A result in which the film coating is removed, revealing the substrate or previous coating layer if two or more coatings are present is considered a cut or gouge. A result in which the lead leaves a blemish or defacement of the film coating, but does not reveal the substrate is considered a scratch. A result in which the lead is transferred to the film coating, but does not result in any damage is a pencil mark. See Fig. 1 and Fig. 2.

5. Significance and Use

5.1 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 using forced dried heat.

5.2 This test method is convenient 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 manufacturer's pencils as well as when different substrates are used. To

[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.

[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

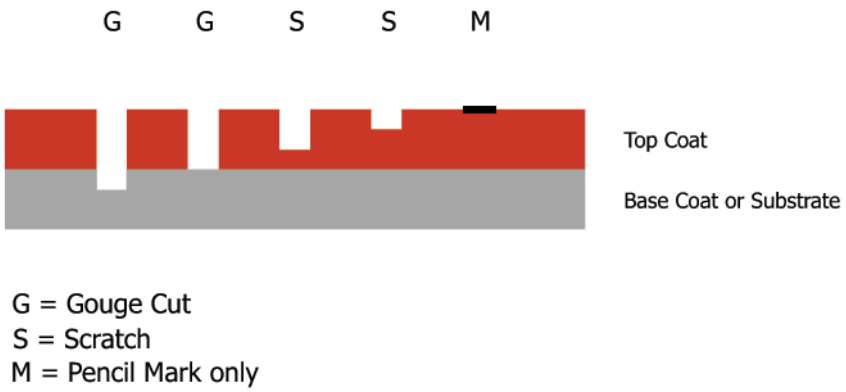

FIG. 1 Representation of Gouge vs. Scratch

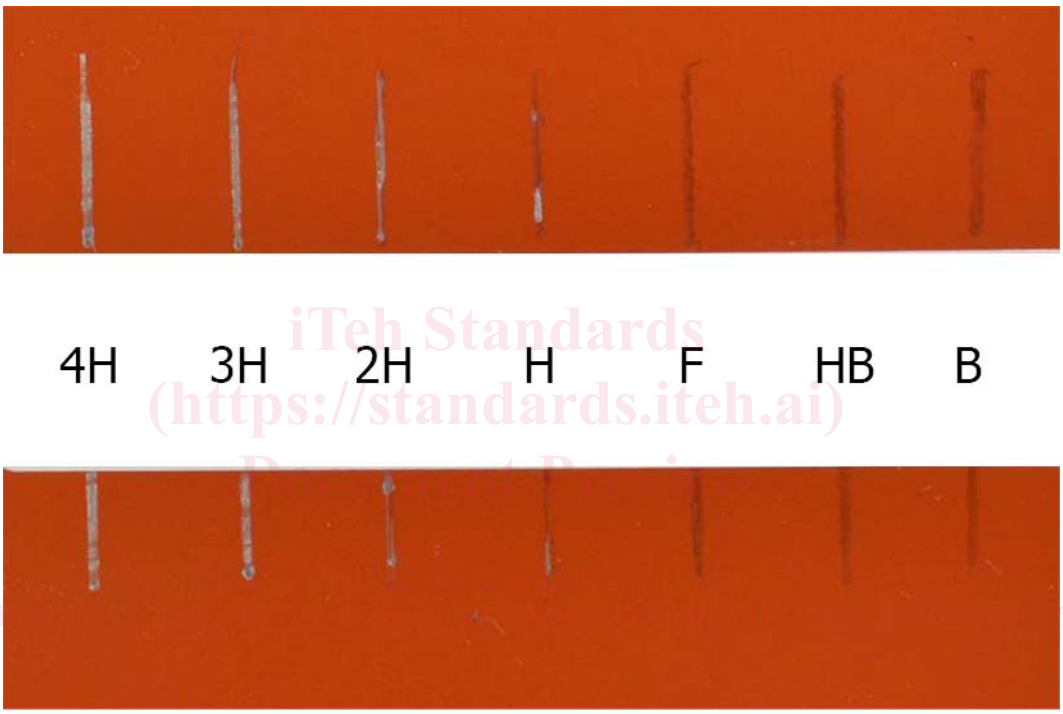

FIG. 2 Typical Example of Pencil Test

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.

NOTE 3—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.

5.3 This test method has been found to be useful in providing relative rankings for a series of coatings that exhibit significant differences in film hardness. Caution should be used when attempting to compare coatings of similar film hardness.

5.4 This test method may not be appropriate for coatings applied to a wood or other softer substrate in which results may be more a function of substrate deformation than coating hardness.

5.5 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 interested parties.

6. Apparatus

6.1 A set of drawing leads or wood pencils (see 5.2). The leads must be nominal 2 mm diameter and meet the following scale of hardness:

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

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

NOTE 4—Drawing leads or wood pencils in the range of 9B to 9H are acceptable to use.

6.1.1 A device, with two wheels, that holds the pencil at a 45° angle and allows the tip of the pencil to exert a consistent force during the test may be used if agreed upon by the interested parties. This device shall not be used for softer leads, if the edge of the lead crumbles under the weight of the device. The device may need additional applied pressure to crumble hard leads.

6.2 *Mechanical Lead Holder,* for drawing leads if used (see Fig. 4).

6.3 *Mechanical Sharpener,* modified draftsman-type which will remove the wood only, leaving the cylindrical pencil lead intact, is helpful for trimming wood pencils if used.

6.4 *Abrasive Paper,* grit No. 400.

7. Test Specimens and Conditions

7.1 Apply the surface coating by appropriate means to a smooth rigid metal or similarly hard 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 interested parties.

7.2 The film thickness of the coating shall be as specified or as agreed upon between the interested parties.

7.3 Conduct the test at 23 ± 2 °C (73.5 ± 3.5 °F) and 50 ± 5 % relative humidity.

8. Procedure

8.1 For wood pencils, remove approximately 5 to 6 mm (3⁄16 to ¼ in.) of wood from the point of each pencil using a modified 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. 3 for an illustration. For mechanical pencil holders with drawing leads, see Fig. 4 as an illustration. The desired edge may be obtained by cementing the abrasive paper

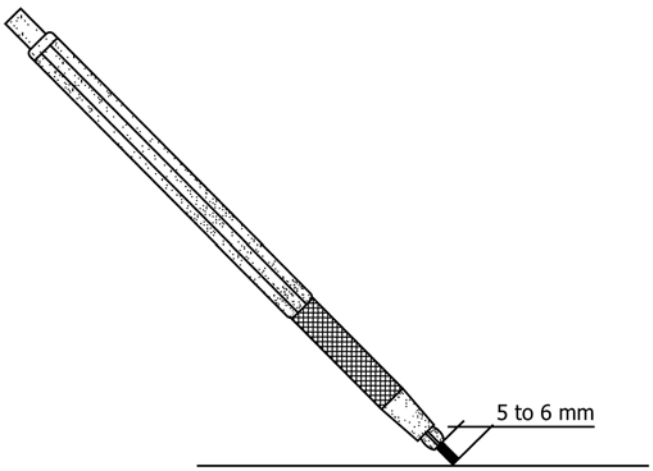

FIG. 4 View of Mechanical Holder with Drawing Lead

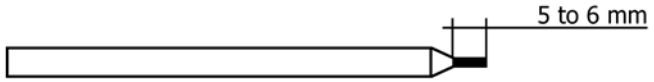

FIG. 3 View of Wood Pencil

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.

8.2 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 a minimum of 6.5 mm (¼ in.).

NOTE 5—ISO 15184 states the tip of the pencil exerts a force of 7.35 ± 0.1 N on the paint surface.

8.3 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 (⅛ in.) (see definition of gouge hardness in Section 3).

NOTE 6—Monitor closely for cutting into or scratching the film by visual inspection or by fingernail feel, or both. Some finishes contain compounds that may tend to lubricate the film.

NOTE 7—If the sharp edge of the lead is slightly chipped or crumbled, rub the lead against the abrasive paper until a flat, smooth, and circular cross-section is obtained (see 8.1).

8.4 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.

NOTE 8—With some films, the two end points will be identical.

8.5 Make a minimum of two determinations for gouge hardness (8.3) and scratch hardness (8.4) for each pencil or lead.

9. Report

9.1 Report the following information:

9.1.1 The two end points as follows:

9.1.1.1 *Gouge Hardness*, and

9.1.1.2 *Scratch Hardness*.

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

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

10. Precision and Bias

10.1 *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 following criteria should be used for judging the acceptability of results at a 95 % confidence level: