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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Hardness of Organic Coatings by Pendulum Damping Tests[1]

This standard is issued under the fixed designation D 4366; 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 These test methods cover the use of pendulum damping testers in the determination of hardness of organic coatings that have been applied to acceptably plane rigid surfaces, such as a metal or glass panel.

1.2 Two test methods based on different pendulum types are covered as follows:

1.2.1 Test Method A—König Pendulum Hardness Test

1.2.2 Test Method B—Persoz Pendulum Hardness Test

1.3 This standard is similar in content (but not technically equivalent) to ISO 1522.[2]

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 823 Test Methods for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels[3]

D 1005 Test Methods for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers[3]

D 1186 Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Base[3]

D 1400 Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings Applied to a Nonferrous Metal Base[3]

2.2 *Other Standard:*

ISO 1522 Paints and Varnishes Pendulum Damping Test[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *König hardness*—time in seconds for the swing amplitude of the König pendulum to decrease from 6 to 3°.

3.1.2 *Persoz hardness*—time in seconds for the swing amplitude of the Persoz pendulum to decrease from 12 to 4°.

4. Summary of Test Methods

4.1 A pendulum resting on a coating surface is set into oscillation (rocking) and the time for the oscillation amplitude to decrease by a specified amount measured. The shorter the damping time, the lower the hardness.

5. Significance and Use

5.1 The pendulum damping test has been found to have good sensitivity in detecting differences in coating hardness, where hardness is defined as resistance to deformation.

5.2 The two procedures given in these test methods embody the principle that the amplitude of oscillation of a pendulum touching a surface decreases more rapidly the softer the surface. However, these test methods differ in respect to pendulum dimensions, and period and amplitude of oscillation.

5.3 In general, the damping time of the König pendulum is approximately half that of the Persoz pendulum.

5.4 The Persoz pendulum has a greater degree of discrimination than the König for measuring the hardness of soft coatings, but it may not be as suitable for testing hard, slippery films because of its tendency to skid on surfaces with a low coefficient of friction.

5.5 The interaction between the pendulum and the paint film is complex, depending on both elastic and viscoelastic properties, and it may not be possible to establish a precise relationship between the two types of pendulum tests.

TEST METHOD A—KÖNIG PENDULUM HARDNESS TEST

6. Apparatus

6.1 *König Pendulum Tester,*[4] consisting of a stand that supports a pendulum, a test panel, and a pendulum displacement scale. The stand has a stirrup to support the pendulum above the table and a mechanism for shock-free lowering of the pendulum onto the test panel. A typical apparatus is shown in Fig. 1.

NOTE 1—Optional features may be the inclusion of an electronic device

[1] These test methods are under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and are the direct responsibility of Subcommittee D01.23 on Physical Properties of Applied Paint Films.

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[2] Available from American National Standards Institute, 11 W 42nd St., 13th Floor, New York, NY 10036.

[3] *Annual Book of ASTM Standards,* Vol 06.01.

[4] Pendulum hardness testers meeting the apparatus requirements of this test method may be obtained from BYK-Gardner, U.S.A., 2435 Linden Lane, Silver Spring, MD 20910, and Paul N. Gardner Co., Inc., 316 N.E. First Street, P.O. Box 10688, Pompano Beach, FL 33061-6688.

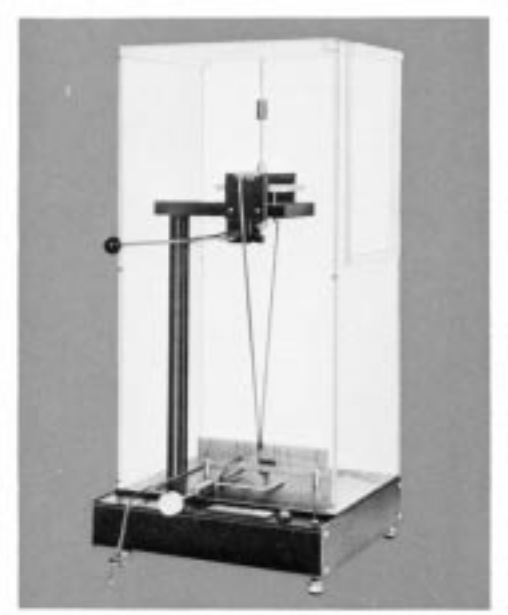

FIG. 1 Apparatus

for automatically timing the oscillation damping and the inclusion of an oscillation counter.

6.2 *König Pendulum*, consisting of an open framework connected by a cross-bar, to the underface of which are two balls, 5 ± 0.005 mm in diameter of hardness 63 ± 3 HRC, inset to serve as the fulcrum. The lower end of the framework is formed into a pointer. A weight sliding on a vertical rod attached to the cross-bar is used to counterpoise the pendulum. The total weight of the pendulum shall be 200 ± 0.2 g.

6.3 *Stop Watch*, or other timing device for timing the oscillation damping of the pendulum.

6.4 *Polished Plate (Float) Glass Panel*, for calibrating the pendulum.

7. Calibration

7.1 Check the alignment of the pendulum and panel table as follows.

7.1.1 Place the polished glass panel on the panel table and gently bring the pendulum to rest on the surface of the glass. Be sure the pendulum oscillates freely.

7.1.2 Place a spirit level on the glass panel surface. Level the glass panel by means of the adjusting screws at the base of the instrument.

7.1.3 Clean the glass panel by wiping with a soft, lintless cloth wetted with the solvent mixture specified in Practice D 3891.

7.1.4 Clean the fulcrum balls by wiping with a soft tissue wetted with solvent. Leave the pendulum in ambient conditions and then bring it to rest on the glass panel.

7.1.5 Check the position of the scale relative to the pendulum pointer. With the pendulum at rest, its pointer should indicate zero on the scale. If the pointer does not indicate zero, move the scale to obtain the correct zero setting.

7.2 Check the duration of the pendulum swing on the glass panel.

7.2.1 Deflect the pendulum through 6°, release it and simultaneously start a stopwatch or other timing device.

7.2.2 Determine whether the time for 100 swings of the pendulum falls within 140 ± 2 s.

7.2.3 If the measured time is less than specified, move the weight on the pendulum rod upward. If the measured time is more than specified, move the weight downward. Continue adjustments until the specified time is obtained. If the time cannot be obtained, the instrument should be judged faulty and be repaired.

7.3 Check the duration of damping of the pendulum on the glass panel as follows:

7.3.1 Deflect the pendulum through 6°, release it and simultaneously start the stopwatch or other timing device.

7.3.2 Determine whether the time for the amplitude of swing to decrease from 6 to 3° falls within 250 ± 10 s (corresponding to 172 to 185 pendulum swings).

8. Test Panel Preparation and Conditioning

8.1 Apply uniform coatings of the material to be tested to plane, rigid surfaces, such as metal or glass panels, by one of the procedures given in Test Methods D 823.

8.2 Cure the coated panels under the conditions of humidity and temperature, as agreed upon between the purchaser and seller.

8.3 Measure the thickness of the dry coating in accordance with Test Methods D 1005, D 1186, or D 1400.

NOTE 2—Coating thickness must be controlled closely because the pendulum test results can be affected by thickness variations. A minimum thickness of 25 µm is required to minimize substrate effects.

9. Procedure

9.1 Unless otherwise specified, make the hardness determination at 23± 2°C and 50 ± 5 % relative humidity, after holding the test panels under these conditions for at least 16 h.

9.2 Place the test panel on the panel table and gently bring the pendulum onto the panel surface.

9.3 Deflect the pendulum through 6°, release it and simultaneously start the stopwatch or other timing device.

9.4 Determine the time for the amplitude of swing to decrease from 6 to 3°. This is the König hardness.

9.5 Repeat steps 9.2-9.4 on at least two other areas of the test panel.

10. Report

10.1 Report the following information:

10.1.1 Mean and range of the König hardness values in seconds obtained for the test panel,

10.1.2 Manufacturer and model of the hardness tester used,

10.1.3 Mean and range of the thickness values obtained for the coating on the test panel, and the method used for determining the thickness,

10.1.4 Temperature and relative humidity during the test, and

10.1.5 Test panel preparation and conditioning techniques used.

11. Precision and Bias [5]

11.1 *Method A—König Pendulum Test*—On the basis of an

[5] Supporting data are available from ASTM Headquarters. Request RR: D01-1050.

interlaboratory test of this test method in which operators in four laboratories made three hardness measurements on each of six coated panels covering a wide range of hardness on two days, the within-laboratory coefficient of variation was found to be 3 % with 24 df and the between-laboratories coefficient of variation 8 % with 18 df. Based on these coefficients, the following criteria should be used for judging the acceptability of results at the 95 % confidence level.

11.1.1 *Repeatability*—Two results, each the mean of three determinations on a specimen, obtained by the same operator should be considered suspect if they differ by more than 8 % of their mean value.

11.1.2 *Reproducibility*—Two results, each the mean of three determinations on a specimen, obtained by operators in different laboratories should be considered suspect if they differ by more than 23 % of their mean value.

11.2 *Bias*—No statement can be made on bias as the value of König hardness is defined only in terms of this test method.

TEST METHOD B—PERSOZ PENDULUM HARDNESS TEST

12. Apparatus

12.1 *Persoz Hardness Tester*,[4] consisting of a stand that supports a pendulum, a test panel, and a pendulum displacement scale. The stand has a stirrup to support the pendulum above the table and a mechanism for shock-free lowering of the pendulum onto the test panel. A typical apparatus is similar to that shown in Fig. 1.

12.2 *Persoz Pendulum*, consisting of an open framework with an upper cross-bar with two stainless steel balls, 8.0 ± 0.005 mm in diameter and of hardness 59 ± 1 HRC, inset to form a fulcrum, and with a lower cross-bar that also forms the pointer. The total weight of the pendulum shall be 500 ± 0.1 g., its center of gravity at rest shall be 60 ± 0.1 mm below the fulcrum, and the pointer shall be 400 ± 0.2 mm below the plane of the fulcrum.

13. Calibration

13.1 Check the alignment of the pendulum and panel table.

13.1.1 Follow the procedures outlined in 7.1.1-7.1.4.

13.2 Check the duration of the pendulum swing on the glass panel.

13.2.1 Deflect the pendulum through 12°, release it and simultaneously start the stopwatch or other timing device.

13.2.2 Determine whether the time for 100 swings of the pendulum falls within 100 ± 0.1 s.

13.2.3 If this value cannot be achieved, reclean the glass panel and the bearing balls of the pendulum, recheck the level of the glass panel, and retest. It is not permissible to adjust the instrument scale at this point.

13.3 Check the duration of damping of the pendulum on the glass panel as follows:

13.3.1 Deflect the pendulum through 12°, release it and simultaneously start the stopwatch or other timing device.

13.3.2 Determine whether the time for the amplitude of swing to decrease from 12 to 4° is ≥ 420 s.

13.3.3 If this value cannot be achieved, repeat the glass panel and instrument checks described in 13.2.3.

14. Procedure

14.1 Unless otherwise specified, make the hardness determination at 23± 2°C and 50 ± 5 % relative humidity, after holding the test panels under these conditions for at least 16 h.

14.2 Place the test panel on the panel table and gently bring the pendulum onto the panel surface.

14.3 Deflect the pendulum through 12°, release it, and simultaneously start the stopwatch or other timing device.

14.4 Determine the time for the amplitude of swing to decrease from 12 to 4°. This is the Persoz hardness.

14.5 Repeat steps 14.2-14.4 on at least two other areas of the test panel.

15. Report

15.1 Report the following information:

15.1.1 Mean and range of the Persoz hardness values in seconds obtained for the test panel,

15.1.2 Manufacturer and model of hardness tester used,

15.1.3 Mean and range of the thickness values obtained for the coating on the test panel, and the method used for determining the thickness,

15.1.4 Temperature and relative humidity during the test, and

15.1.5 Test panel preparation and conditioning techniques used.

16. Precision and Bias [5]

16.1 *Method B—Persoz Pendulum Test*—On the basis of an interlaboratory test of this test method in which operators in five laboratories made two or three hardness measurements on each of six coated panels (covering a wide range of hardness), the within-laboratory coefficient of variation was found to be 1 % with 24 df and the between-laboratories coefficient of variation 3 % with 12 df. Based on these coefficients, the following criteria should be used for judging the acceptability of results at the 95 % confidence level.

16.1.1 *Repeatability*—Two results, each the mean of three determinations on a specimen, obtained by the same operator should be considered suspect if they differ by more than 3 % of their mean value.

16.1.2 *Reproducibility*—Two results, each the mean of three determinations on a specimen, obtained by operators in different laboratories should be considered suspect if they differ by more than 8 % of their mean value.

16.2 *Bias*—No statement can be made on bias as the value of Persoz hardness is defined only in terms of this test method.

17. Keywords

17.1 damping hardness tests; König pendulum hardness tester; organic coatings; pendulum hardness tests; Persoz pendulum hardness tester