Designation: D5895 – 13

Standard Test Methods for Evaluating Drying or Curing During Film Formation of Organic Coatings Using Mechanical Recorders[1]

This standard is issued under the fixed designation D5895; 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 describe the determination of several stages and the rate of dry-film formation of organic coatings using straight line and circular mechanical drying-time recording devices. The use of mechanical recorders is valuable in comparing the drying behavior of coatings of the same generic type, allowing that one coating may form a gel or resist tearing at a faster rate than another.

1.2 Drying time measured using the mechanical recorders may differ from those found using conventional methods, such as Test Method D1640 or ISO 9117-3 (formerly ISO 1517).

1.3 The values stated in SI are to be regarded as the standard. The values given in parentheses are provided 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D823 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels

D1005 Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

D1640 Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature

D3924 Specification for Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials

D3925 Practice for Sampling Liquid Paints and Related Pigmented Coatings

2.2 *ISO Standard:*

ISO 9117-3 Drying tests—Surface—drying test using ballotini[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *dry-hard time, n*—the dry-hard condition is reached using mechanical recorders when the drying and curing, or both, reactions have proceeded sufficiently that the film is not displaced nor is any noticeable mark left by pinching the panels between the thumb on the film and forefinger with a relatively strong force.

3.1.1.1 *Discussion*—In these test methods, the dry-hard time is reached where the stylus has risen out of the film and rides on the surface, leaving only a mark without disrupting the body of the film (see Fig. 1 and Fig. 2).

3.1.2 *dry-through time, n*—the dry-through condition is reached when the film has solidified so completely that a large, twisting force can be applied without distorting the film.

3.1.2.1 *Discussion*—In these test methods, the dry-through time is reached when the stylus no longer left any visible mark on the film (see Fig. 1 and Fig. 2).

3.1.3 *set-to-touch time, n*—The set-to-touch condition is reached when the film has solidified sufficiently, by solvent evaporation or chemical reaction, or both, that it not longer flows nor sticks to a finger that lightly touches it.

3.1.3.1 *Discussion*—In these test methods, the set-to-touch time is reached where a pear-shaped depression appears in the film when the film stops flowing over the path of the recorder's stylus and leaves a track in the film revealing the glass substrate (see Fig. 1 and Fig. 2).

3.1.4 *tack-free time, n*—the tack-free condition is reached using mechanical recorders when the film surface has dried or cured (see set-to-touch time) so that the film does not adhere to very light objects placed on it.

3.1.4.1 *Discussion*—In these test methods, the tack-free time is reached where the continuous track in the film ceases

[1] These test methods are under the jurisdiction of ASTM Committee D01 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] 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.

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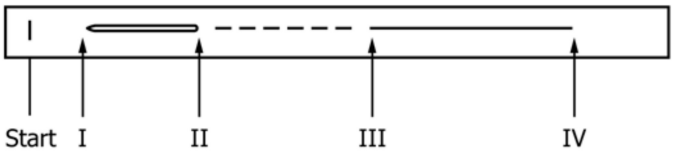
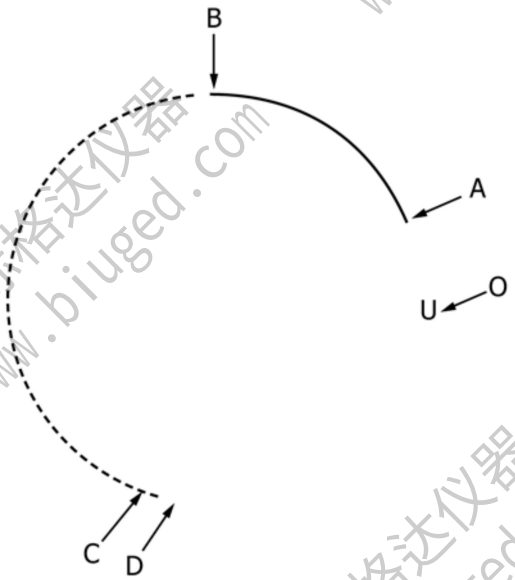


Stage I — Set-to-Touch Time
Stage II — Tack-Free Time
Stage III — Dry-Hard Time
Stage IV — Dry-Through Time

NOTE 1—The above figure represents a typical track of a coating that does not skin over during curing. Any coating which exhibits skinning, such as two pack epoxies or polyurethane coatings, will show a very different track where the stylus tears the surface of the film, leaving diamond or kite-shaped patterns.

FIG. 1 Stages of Drying Using Straight Line Drying Time Recorders



Stage A — Set-to-Touch Time
Stage B — Tack-Free Time
Stage C — Dry-Hard Time
Stage D — Dry-Through Time

FIG. 2 Stages of Drying Using Circular Time Drying Recorders

and the stylus starts to tear the film or leave a ragged/sharp-edged grove as it first begins to climb over the film (see Fig. 1 and Fig. 2).

NOTE 1—The above descriptions are typical for coatings that do not skin over during curing. Any coating which exhibits skinning, such as two pack epoxies or polyurethane coatings, will show a very different track where the stylus tears the surface of the film, leaving diamond or kite-shaped patterns.

4. Summary of Test Methods

4.1 In Test Method A (Straight Line Recorder), the coating is applied to glass strips approximately 300 by 25 mm (12 by 1 in.). The drying time recorder is immediately placed on the wet film and the stylus lowered onto the wet coating. The stylus moves across the glass strip at a selected constant speed.

4.2 In Test Method B (Circular Recorder), the coating is applied to glass plates approximately 6 in. by 6 in. (150 by 150 mm). The drying time recorder is immediately placed on the wet film and a stylus is moved in a 360° arc at a selected constant speed.

5. Significance and Use

5.1 The drying times of a coating are significant in determining when a freshly painted room, floor or stair may be put back in use or a coated article handled or packaged. Slow drying may result in dirt pick-up or, on an exterior surface, moisture may cause a nonuniform appearance.

5.2 These test methods are used to determine the various stages of drying or curing in the dry-film formation of organic coatings using mechanical devices for the purpose of comparing types of coatings or ingredient changes, or both. To evaluate the stages of drying in a quantitative manner, use of instrumentation under environmental controlled conditions is strongly recommended. These devices also offer a method of determining drying characteristics of coatings that can not be ascertained within the standard 8-h work day.

5.3 When evaluating drying characteristics of baking systems, the circular drying time devices offer a method to determine quantitatively drying times of coatings at room temperature and elevated conditions. Maximum temperatures would be limited by considerations such as the affect of temperature on the motor lubrication or structural components of the device.

5.4 The straight line drying time devices offer a method to determine quantitatively drying times of coatings tested simultaneously using one recorder.

5.5 This method is useful in comparing the behavior of coatings during drying of the same generic type. Determination of actual drying times should be conducted following procedures outlined in Test Method D1640 or ISO 9117-3.

6. Coatings and Recommend Film Thicknesses

6.1 Whenever tests are to be performed on coatings not listed in Table X1.1, there should be a prior agreement between the purchaser and seller as to the substrate, film thickness, application method, and conditions for testing the specific coating involved.

6.2 Tests should be carried out at a practical viscosity under which the coating can be applied at the proper film thickness with resultant good flow and leveling properties.

6.3 Films to be tested should have practical thicknesses commensurate with those expected under actual usage for the type under test.

7. Test Conditions

7.1 *Air Dry Coatings,* conduct all tests in a well ventilated room, free from direct drafts, dust, laboratory fumes, and under diffused light. Make all measurements at a temperature of 23 ± 2°C and 50 ± 5 % relative humidity in accordance with Specification D3924. For baking systems, conduct all tests in a forced draft oven at controlled temperatures within the limits of the drying time device.

7.2 *Light Conditions*—Illumination of air dry films during the entire drying test period should be about 270 lx (25 fc) from normal laboratory or sky sources, never from direct sunlight or other sources high in nonvisible radiant energy.

8. Preparation of Test Specimens

8.1 All test specimens shall be prepared and tested by one operator properly skilled in the methods to be used. Conduct testing at least in duplicate. Sampling shall be conducted in accordance with procedures outlined in Practice D3925.

8.2 Apply the test materials to clean glass panels or other specific substrates of suitable dimensions agreed upon between the purchaser and the seller.

NOTE 2—Ground-glass plates may be more suitable for certain types of coatings that have a tendency to crawl, such as low-viscosity drying oils. Suitable plates can be prepared by roughening the surface of polished glass by grinding a paste of silicon carbide (grit 1-F) and water between two glass plates.

8.3 Cast the test films preferably with an appropriate film applicator for the recommended dry film thickness as indicated in Table X1.1. When a suitable applicator is not available or it has been agreed to apply the film in some other manner, the various conventional or automatic methods of spray, dip, flow and brush application may be used, provided dry film thicknesses conform to the requirements in Table X1.1. See Practice D823 for a descriptions of the spray and dip methods of application.

8.4 Measure the dry film thickness of the test films with an appropriate film thickness gage. A micrometer or dial indicator, as described in Test Methods D1005, has been found suitable for glass substrates.

TEST METHOD A—STRAIGHT LINE DRYING TIME

9. Apparatus

9.1 *Straight Line Drying Time Recorder,* consists of multiple styli 2 mm (0.08 in.) in diameter with rounded tips, being drawn over multiple parallel-coated glass panels typically measuring 300 by 25 mm (12 by 1 in.). The stylus arm generally comes with 5-g brass weights that may be added to apply greater pressure on the needles and thus record through drying. Other weights can be adapted as agreed upon between purchaser and seller. Speed can be varied to cover drying periods from 6, 12 and 24 h.

10. Procedure

10.1 Apply the coating to the glass plates or strips. Record time of application. Immediately attach the glass plates or strips to the instrument, and lower the stylus carrier so that the stylus carrier is at the starting position. Lower the clean stylus gently into position on the strip. Always assure that the tip of the styli is clean and free from dried paint from previous tests prior to use. Switch on the motor and the stylus will be drawn along the glass strip by the carrier.

10.2 Always mark the point on the glass strip where the stylus is first lowered into the wet film by use of a marker pen or similar method. This will aid measurement of times along the strip during the assessment stage as it is often not obvious at what point the track starts, as paint flows back into the groove.

10.3 After drying, evaluate the glass plates or strips to determine the stages of drying time as shown in Fig. 1. The use of magnification (7× etc.) will enhance the evaluation.

TEST METHOD B—CIRCULAR DRYING TIME

11. Apparatus

11.1 *Circular Drying Time Recorder,* consisting of a motor that is mounted on a rubber-tipped tripod. The motor shaft is oriented in the vertical, with a pivotal arm assembly attached to the shaft to operate a counter-poised vertical stylus consisting of a teflon stylus approximately 10 mm (⅜ in.) in diameter. The teflon stylus, typically under a weighted load of 12 g, scribes an arc in the drying film. The arm assembly includes a counter weight to permit adjusting the pressure on the needle to near zero. The stylus is moved in a 360° arc at a selected constant speed. Recorders are available to cover various drying times, such as 1, 6, 12 or 24 h.

11.2 *Template*—A transparent template with scale graduations, corresponding to the particular motor speed, is used for timing the various stages of drying revealed by differences observed in the scribed pattern.

12. Procedure

12.1 *Panel Preparation*—Prepare specimens following procedures outlined in 8.1 through 8.4. Glass plates or panels, about 150 by 150 mm (6 by 6 in.), are used for the determination of drying times using this recording device.

12.2 Apply the coating to the glass plates or panels. Record time of application. Immediately attach the glass plates or panels to the instrument, and lower the clean stylus gently into position on the panel. Always assure that the tip of the stylus is clean and free from dried paint from previous tests prior to use. Switch on the motor so the stylus is drawn along the glass panels.

12.3 Always mark the point where the stylus is first lowered into the wet film by use of a marker pen or similar method. This will aid measurement of times along the track during the assessment stage as it is often not obvious at what point the track starts, as paint flows back into the groove.

12.4 After drying, evaluate the glass plates or panels to determine the stages of drying time as shown in Fig. 2. The use of magnification (7× etc.) will enhance the evaluation.

13. Report

13.1 *Report the following information:*

13.1.1 Test results of drying time determinations,

13.1.2 Type of coating material used,

13.1.3 Method of application,

13.1.4 Film thickness used,

13.1.5 Type of mechanical drying recorder used, and

13.1.6 All applicable conditions that deviated from the standards as outlined or special conditions or tests used.

14. Precision and Bias[4]

14.1 *Precision*—In an interlaboratory study of these test methods, drying times were recorded in four laboratories for four drying stages of four different coatings varying widely in drying characteristics. The intralaboratory coefficient of variation was found to be 20.35 % with 56 df and the interlaboratory coefficient 20.35 % with 42 df with no values discarded. Based on these coefficients, the following criteria should be used for judging at the 95 % confidence level, the acceptability of results:

14.1.1 *Repeatability*—Two single results obtained by the same operator at different times should be considered suspect if they differ by more than 57.7 % of their mean value.

14.1.2 *Reproducibility*—Two results, each the mean of two repeat determinations, obtained by operators in different laboratories should be considered suspect if they differ by more than 58.15 % of their mean value.

14.2 *Bias*—Bias cannot be determined because there is no standard reference material available.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-1119. Contact ASTM Customer Service at service@astm.org.

15. Keywords

15.1 drying stages mechanical devices; drying time

APPENDIX

X1. SUGGESTED FILM THICKNESS OF MATERIALS

TABLE X1.1 Suggested Film Thickness of Materials to be Tested[A]

Material	Dry Film Thickness
Oil paints	45 ± 2.5 µm (1.8 ± 0.2 mil)
Enamels	25 ± 2 µm (1.0 ± 0.1 mil)
Waterborne paints	25 ± 2 µm (1.0± 0.1 mil)
Drying oils	25 ± 2 µm (1.0 ± 0.1 mil)
Varnishes	20 ± 2 µm (0.85 ± 0.1 mil)
Resin solutions	20 ± 2 µm (0.85 ± 0.1 mil)
Lacquers	12.5 ± 2 µm (0.5 ± 0.1 mil)

[A] This table is a general guide to be used when there is no specific agreement between the purchaser and the seller.

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