



Designation: **D1640 – 03 (Reapproved 2009) D1640/D1640M – 14**

Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature¹

This standard is issued under the fixed designation **D1640/D1640M**; 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 These test methods cover the determination of the various stages and rates of film formation in the drying or curing of organic coatings ~~normally used under~~ laboratory controlled conditions of ambient room temperature, air temperature, (low, ambient and/or elevated) and/or humidity. Procedures for assessing drying under prevailing conditions of temperature and humidity in the shop and field are also described.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as ~~the standard~~. The values ~~given in parentheses are for information only~~ stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

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 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/D4414 Test Method Practice for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers](#) [Wet Film Thickness by Notch Gages](#)

2.2 ISO Standards:

[ISO 9117-4 Paints and varnishes — Determination of drying — Part 4: Method using a mechanical recorder](#)

3. Significance and Use

3.1 These test methods ~~are can be used to determine the various stages and rates of drying, curing, and film formation of organic coatings for the purpose of comparing types of coatings or ingredient changes, or both. This is significant in the development of organic coatings for various end uses and also for production quality control.~~ coatings, assessing the impact of compositional changes on drying time, or for assessing drying/curing time in the shop or field. Low temperature can significantly slow the drying rate of coatings so low temperature curing agents, catalysts and/or accelerators are often available to aid drying and film formation under cooler temperatures. Method B is designed to evaluate these components and/or to determine the effect of cooler temperatures on drying rates. Conversely, the drying/curing rate of certain coatings can be accelerated under elevated temperature/humidity conditions, while others may be adversely impacted by elevated humidity. Method C is designed to evaluate the effects of elevated temperature and relative humidity conditions on drying, curing, and film formation of paints and coatings. The terms dry or drying, cure or curing, and film formation are used interchangeably throughout this standard.

3.2 Test Methods A, B and C are limited to a comparison of paints/coatings applied to smooth, non-absorbent substrates and do not reflect the effect of absorption of the paint vehicle into the substrate material.

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.

Current edition approved ~~Aug. 1, 2009~~ Dec. 1, 2014. Published ~~August 2009~~ February 2015. Originally approved in 1959. Last previous edition approved in ~~2003~~ 2009 as **D1640 – 03**; **D1640 – 03 (2009)**. DOI: ~~10.1520/D1640-03R09~~ 10.1520/D1640_D1640M-14.

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~~ standard's Document Summary page on the ASTM website.

4. Coatings and Recommended Substrate, Coating Application Method and Film Thicknesses

4.1 Whenever tests are to be performed on coatings not listed in Table 1, there should be a prior agreement between the purchaser and seller contracting parties as to the substrate, wet film thickness, thickness (WFT), and application method for testing the specific coating involved. The product is tested as manufactured (without reducer, unless otherwise agreed upon by contracting parties). Unless otherwise agreed, the thickness of the cast film shall conform to the coating manufacturer's product data sheet. If the wet film thickness is not stated on the manufacturer's product data sheet, it can be calculated using the formula in 4.1.1 based on the manufacturer's recommended dry film thickness (DFT) and percent non-volatile by volume (% solids by volume). If this information is not provided, contact the coating manufacturer to obtain the recommended wet film thickness for testing.

$$4.1.1 \text{ WFT} = (\text{DFT} \div \% \text{ Solids by Volume})$$

5. Test Conditions

5.1 Conduct all drying tests in a well-ventilated room or chamber, free from direct drafts, dust, products of combustion, laboratory fumes and under diffused light (see 5.4). Make all measurements at a temperature of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity with the coated panels in a horizontal position while drying. *Method A (Laboratory Procedure — Normal Drying Conditions):*

5.1.1 Conduct all drying tests in a well-ventilated room or chamber, free from direct drafts, dust, products of combustion, laboratory fumes and under diffused light (see 5.1.4). Make all measurements at an air temperature of $23 \pm 2^\circ\text{C}$ and $50 \pm 5\%$ relative humidity with the coated panels in a horizontal position while drying.

5.1.2 Apply the wet film according to the coating manufacturer's instructions. In the absence of any specific material specification or product data sheets, instructions for casting the film should be agreed upon between contracting parties.

5.1.3 Films to be tested should have practical thicknesses commensurate with the coating manufacturer's recommendations. All testing should be performed within an area at least 15 mm [$\frac{1}{2}$ in.] from any film edge.

5.1.4 Illumination of the films during the entire drying test period must be from low, non-radiant energy light sources, such as normal laboratory or sky sources, never from direct sunlight.

5.2 Tests should be carried out at practical viscosities at which films can be applied to the proper film thickness with resultant good flow and leveling properties. In the absence of any specific material specification, instructions for preparation of the film should be determined and agreed upon between the purchaser and the seller. *Method B (Laboratory Procedure — Low Air Temperature Drying Conditions):*

5.2.1 Conduct all drying tests in a ventilated temperature and humidity-controlled chamber. Allow the temperature and relative humidity to stabilize within the chamber prior to use.

5.2.2 Condition the substrate material, the coating to be tested, and the application device for a minimum of 1 h in the temperature/humidity-controlled chamber prior to casting the wet film.

5.2.3 Make all measurements at a temperature and relative humidity as agreed upon between contracting parties. Record the actual temperature and relative humidity employed for testing. All dry time measurements are made with the coated panels in a horizontal position while drying.

5.2.4 Apply the wet film according to the coating manufacturer's instructions. In the absence of any specific material specification or product data sheets, instructions for casting the film should be agreed upon between contracting parties.

5.2.5 Films to be tested should have practical thicknesses commensurate with the coating manufacturer's recommendations. All testing should be performed within an area at least 15 mm [$\frac{1}{2}$ in.] from any film edge.

5.2.6 Minimize opening and closing of the temperature and humidity-controlled chamber to prevent fluctuations in conditions.

5.3 Films to be tested should have practical thicknesses commensurate with performance characteristics expected under actual usage for the type under test. All testing should be done within an area, any point of which is not less than 15 mm ($\frac{1}{2}$ in.) from the film edge. *Method C (Laboratory Procedure — Elevated Air Temperature and Humidity Drying Conditions):*

5.3.1 Conduct all drying tests in a ventilated temperature and humidity-controlled chamber. Allow the temperature and relative humidity to stabilize within the chamber prior to use. If elevated temperature without consideration for humidity is desired, a convection oven can be used.^{4,5}

5.3.2 Condition the substrate material, the coating to be tested, and the application device for a minimum of 1 h in the temperature/humidity-controlled chamber prior to casting the wet film.

5.3.3 Make all measurements at a temperature and relative humidity as agreed upon between contracting parties. Record the actual temperature and relative humidity employed for testing. All dry time measurements are made with the coated panels in a horizontal position while drying.

5.3.4 Apply the wet film according to the coating manufacturer's instructions. In the absence of any specific material specification or product data sheets, instructions for casting the film should be agreed upon between contracting parties.

⁴ The standard tack tester is fully described in the U.S. Patent 2,406,989, Sept. 3, 1946. Consider potential safety hazards associated with the flash point of any organic solvents included in the paint/coating vehicle.

⁵ See Prane, J. W., "A Latin Square Drying Time Study," *Paint Industry Magazine* (August 1961), for a study of precision of drying time measurements. A hot plate may be used to generate different air and surface temperature, if required.