



# Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers<sup>1</sup>

This standard is issued under the fixed designation D 1005; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 This test method covers the measurement of film thickness of dried films of paint, varnish, lacquer, and related products using micrometers. Procedures A and B utilize stationary micrometers and Procedures C and D, hand-held micrometers. Procedures A and C are not recommended for films less than 12.5  $\mu\text{m}$  ( 0.5 mils) in thickness. The minimum thickness required for Procedures B and D is a function of that required to enable removal of the sample as a free film.

1.2 The procedures appear as follows:

1.2.1 *Procedure A*—Stationary micrometer for measuring coatings applied to plane rigid surfaces.

1.2.2 *Procedure B*—Stationary micrometer for measuring free films.

1.2.3 *Procedure C*—Hand-held micrometer for measuring coatings applied to plane rigid surfaces.

1.2.4 *Procedure D*—Hand-held micrometer for measuring free films.

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 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 Practices for Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels<sup>2</sup>

D 2370 Test Method for Tensile Properties of Organic Coatings<sup>2</sup>

## 3. Significance and Use

3.1 This test method is particularly applicable to the measurement of free films and is also satisfactory for the measure-

ment of films on laboratory test panels.

3.2 The accuracy and precision of the thickness measurements may be influenced by the deformability of the coating. This test method is not applicable to coatings that are readily deformable under the load of the measuring instrument.

3.3 The accuracy and precision of the thickness measurements are also influenced by the uniformity of the substrate when the coatings are applied to laboratory test panels.

## 4. Apparatus

### 4.1 Procedures A and B:

4.1.1 The apparatus shall consist of a dial comparator, dial indicator, or micrometer. A rigid base is required for mounting the dial comparator or dial indicator gages. The presser foot of the micrometer or dial indicator shall be circular, from 1.5 to 3.0 mm ( $1/16$  to  $1/8$  in.) in diameter, and shall be flat on the bottom. The presser foot shall be fixed to an indicator that reads to 2.5  $\mu\text{m}$  (0.1 mil). The load on the presser foot shall be between 140 and 275 kPa (20 and 40 psi ). For Procedure B, a smooth uncoated test plate is also required.

4.1.2 Verify the accuracy of instrument calibration by setting to zero with the anvils closed followed by measuring shims of known thicknesses or standards specifically designed for this purpose. Record the standard thickness gage measurement and the micrometer reading. Use these results to construct a calibration curve.

4.2 *Procedures C and D*—The apparatus shall consist of a hand-held micrometer. The anvils of the micrometer shall be circular, from 1.5 to 3.0 mm ( $1/16$  to  $1/8$  in.) in diameter, with flat bottoms. Verify the accuracy of instrument calibration by setting to zero with the anvils closed followed by measuring shims of known thicknesses or standards specifically designed for this purpose. Record the standard thickness gage measurement and the micrometer reading. Use these results to construct a calibration curve.

## 5. Test Specimen

5.1 *Procedures A and C*—Apply test films to a suitable plane, rigid base material from which the dried film may be satisfactorily removed. The panels shall be of sufficient size to permit film thickness measurements to be made 25 mm (1 in.) from any edge.

<sup>1</sup> 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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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 06.01.

5.1.1 Coatings should be applied in accordance with Practices D 823 or as agreed upon between the purchaser and the seller.

5.2 *Procedures B and D*—Free films of the test material are required. Alternatively, the test materials can be applied to an appropriate substrate in order that they can be removed as free films without deformation. If the method of specimen preparation affects the film forming properties of the test material or requires cutting or scraping to remove the free film, use Procedures A or C instead.

5.2.1 Free films may be prepared in accordance with Test Method D 2370.

## 6. Procedure

### 6.1 Procedure A:

6.1.1 Mount the test panel rigidly on a suitable base. Clamp or hold it to the base in such a way that there will be no movement or spring of the panel during the film thickness measurement.

6.1.2 Close the gage slowly until contact is made, but without visible distortion of the film. Read the gage, estimating to 2.5  $\mu\text{m}$  (0.1 mil), and record the reading.

6.1.3 Open the gage and remove the film carefully from the area where the measurement was taken. Any suitable means, chemical or mechanical, may be used to remove the film, taking care not to distort the panel. Close the gage, slowly on the area from which the film was removed, and take a reading, estimating to 2.5  $\mu\text{m}$  (0.1 mil).

6.1.4 The difference in the gage readings before and after the removal of the film is the thickness of the film. Record to 2.5  $\mu\text{m}$  (0.1 mil).

6.1.5 As an alternative to the above, the panels may be measured in distinct locations prior to the application of the coating, and again in the identical locations after the coating has cured. The difference represents the coating thickness.

6.1.6 Take a sufficient number of readings to characterize the panel. A recommended minimum is three determinations for a 75 by 150-mm (3 by 6-in.) panel and more in proportion to size.

### 6.2 Procedure B:

6.2.1 Mount a smooth uncoated test panel rigidly on a suitable base. Clamp or hold it to the base in such a way that there will be no movement or spring of the panel during the film thickness measurement. Fig. 1 illustrates one satisfactory way of rigidly mounting the panel for measurement.

6.2.2 Close the gage slowly until contact is made. Read the gage, estimating to 2.5  $\mu\text{m}$  (0.1 mil), and record the reading.

6.2.3 Open the gage and lay a free film of the test material on the panel in the same area where the measurement was taken. Close the gage slowly with care not to distort the film and take a reading, estimating to 2.5  $\mu\text{m}$  (0.1 mil).

6.2.4 The difference in the gage readings is the thickness of the film. Record to 2.5  $\mu\text{m}$  (0.1 mil).

6.2.5 When conditions permit, perform a minimum of three determinations adjacent to one another on each film.

### 6.3 Procedure C:

6.3.1 Hold the hand-held micrometer in such a manner that the micrometer can be steadied against a film surface. Separate the micrometer anvils to a distance at least twice that of the

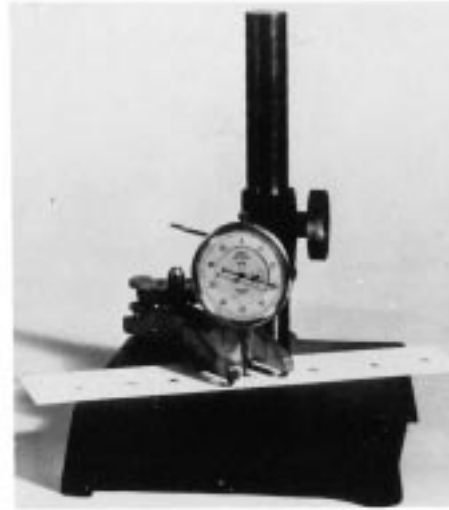


FIG. 1

film thickness to be measured.

6.3.2 Place the coated base material between anvil contacts. Be sure to align the panel so that it is perpendicular to the contact points. Carefully bring the micrometer anvil into contact with the film by releasing the spring tension or rotating the adjustment barrel. Do not compress the film.

6.3.3 Record the film thickness to 2.5  $\mu\text{m}$  (0.1 mil). For spring-loaded micrometers, record the value directly from the dial indicator. For barrel micrometers, record the value using the instrument in the friction mode. The friction mode allows the thimble sleeve to slip without further turning the measuring screw. The friction mode provides for a consistent measuring pressure from panel to panel.

6.3.4 Open the gage and remove the film carefully from the area where the measurement was taken. Any suitable means, chemical or mechanical, may be used to remove the film, taking care not to distort the panel. Close the gage, slowly on the area from which the film was removed, and take a reading, estimating to 2.5  $\mu\text{m}$  (0.1 mil).

6.3.5 The difference in the gage readings before and after the removal of the film is the thickness of the film. Record to 2.5  $\mu\text{m}$  (0.1 mil).

6.3.6 As an alternative to the procedures in 6.3.2 through 6.3.5, the panels may be measured in distinct locations prior to the application of the coating, and again in the identical locations after the coating has cured. The difference represents the coating thickness.

6.3.7 Take a sufficient number of readings to characterize the panel. A recommended minimum is three determinations for a 75 by 150-mm (3 by 6-in.) panel and more in proportion to size.

### 6.4 Procedure D:

6.4.1 Hold the hand-held micrometer in such a manner that the micrometer can be steadied against a film surface. Separate the micrometer anvils to a distance at least twice that of the film thickness to be measured.

6.4.2 Place the free film to be measured between anvil contacts. Be sure to align the film so that it is perpendicular to the contact points. Carefully bring the micrometer anvil into

contact with the film by releasing the spring tension or rotating the adjustment barrel. Do not compress the film.

6.4.3 Record the film thickness to 2.5  $\mu\text{m}$  (0.1 mil). For spring-loaded micrometers, record the value directly from the dial indicator. For barrel micrometers, record the value using the instrument in the friction mode. The friction mode allows the thimble sleeve to slip without further turning the measuring screw. The friction mode provides for a consistent measuring pressure from film to film.

6.4.4 When conditions permit, perform a minimum of three determinations adjacent to one another on each film.

## 7. Report

7.1 Report the results as the mean thickness of a number of determinations, accompanied by a statement of the number of observations and the standard deviation of the determinations.

## 8. Precision and Bias

8.1 *Precision*—On the basis of an interlaboratory study of Procedure C in which operators in two laboratories on two or three days made four replicate measurements on each of three coated panels differing in film thickness, the within-laboratory standard deviations were found to be 0.17 mil at the 1-mil thickness level, 0.32 mils at the 4-mil thickness level, and 0.28 mil at the 8-mil thickness level. On the basis of the same interlaboratory study of Procedure C in which operators in

seven laboratories made four replicate measurements on each of three coated panels differing in film thickness, the between-laboratories standard deviations were found to be 0.09 mil at the 1-mil thickness level, 0.29 mil at the 4-mil thickness level, and 0.33 mil at the 8-mil thickness level. Based on these standard deviations, the following criteria should be used to judge the precision of results at the 95 % confidence level:

8.1.1 *Repeatability*—Two measurements, each the mean of four replicates, obtained by the same operator should be considered suspect if they differ by more than 0.7 mil at the 1-mil thickness level and by more than 1.2 mils at the 4 to 8-mil thickness level.

8.1.2 *Reproducibility*—Two measurements, each the mean of four replicates, obtained by operators in different laboratories should be considered suspect if they differ by more than 0.3 mils at the 1-mil thickness level and by more than 1.1 mils at the 4 to 8-mil thickness level.

8.2 *Bias*—Bias depends almost entirely on the accuracy of the measuring devices and care taken to set up the equipment. No interlaboratory data are available with which to estimate bias.

## 9. Keywords

9.1 dial comparator; dial indicator; dial indicator gage; film—dry film thickness; measurement of organic coatings; micrometer

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