Designation: D 5796 – 99

Standard Test Method for Measurement of Dry Film Thickness of Thin Film Coil-Coated Systems by Destructive Means Using a Boring Device[1]

This standard is issued under the fixed designation D 5796; 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 This test method covers the measurement of dry film thickness (DFT) of coating films by microscopic observation of a precision-cut shallow-angle crater in the coating film.

1.2 The substrate may be any rigid, metallic material, for example, cold-rolled steel, hot-dipped galvanized steel, aluminum, etc. The substrate should be planar.

NOTE 1—Variations in the surface profile of the substrate may result in nonrepresentative organic coating thickness readings. This condition may exist over substrates such as hot-dipped, coated steel sheet. This is true of all "precision cut" methods that are used to determine dry film thickness of organic coatings.

1.3 The range of thickness measurement is 0 to 3.5 mils (0 to 88 μm).[2]

1.4 Measurements may be made on coil-coated sheet, certain formed products, or on test panels.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 3794 Guide for Testing Coil Coatings[3]

3. Significance and Use

3.1 Measurement of dry film thickness of organic coatings by physically cutting through the film and optically observing and measuring the thickness offers the advantage of direct measurement as compared with nondestructive means.

3.2 Constituent coats of an overall thickness of a coating system can usually be measured individually by this test method. (This can be difficult in cases where the primer and topcoat have the same, or very similar, appearance.)

4. Apparatus

4.1 *Dry Film Thickness Device*,[4] is an apparatus consisting of a carbide-tipped boring device (drill) that is automated by a lever that raises and lowers the boring tip perpendicular to the surface to be tested, and a video imaging system, which is attached to an illuminated microscope that views the crater formed by the boring device.

4.2 *Carbide Borer Bit*, this configuration shall be designed to provide a very smooth circular incision in the paint film at a precise angle to the surface (see Fig. 1).[5]

4.3 *Video Camera*, attached to an illuminated microscope, conveys the image onto a closed-circuit television (CCTV) monitor, so that it is an easy matter to line-up the cross hair on the enlarged image. This very effectively minimizes any error or lack of consistency on the part of the operator in lining-up the cross hair.

4.4 The measurement is performed by first boring a shallow-angle crater of known configuration through the coating(s) film into the substrate and then viewing the crater with an illuminated microscope with a measuring reticle. The verification of the instrument calibration is performed by taking measurements on a standard, which is traceable to a National Standards Institution.[6]

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[1] This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.53 on Coil Coated Metal.

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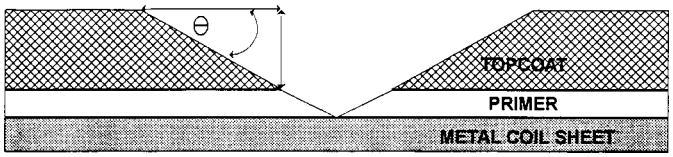
[2] For DFT measurements of films greater than 3.5 mils (88 μm), but less than 63 mils (1575 μm), a 45° borer may be purchased and used in accordance with this test method, with the exception of 6.8, where the micrometer reading would provide a direct read-out, and division by ten would be unnecessary.

[3] *Annual Book of ASTM Standards*, Vol 06.02.

[4] The sole source of supply of the dry film thickness device known to the committee at this time is DJH Designs, 2366 Wyecroft Rd., Unit D4, Oakville, Ont., Canada L6L 6M1. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[5] The angle formed between the surface of the coating and the substrate is set by the manufacturer at 5° 42′ 38″ and the resulting crater is circular.

[6] The sole souce of supply of the standard (silver-plated, copper substrate) known to the committee at this time is DJH Designs. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend. Another acceptable standard (copper and chromium coating on steel, SRM 1357) may be obtained from NIST, Standard Reference Materials Program, Building 202, Room 204, Gaithersburg, Maryland 20899.



NOTE 1—θ = 5° 42′ 38″
Tan θ = A/B = 0.1
A = 0.1B

FIG. 1 Typical Crater Formed by Boring Device

5. Test Specimens

5.1 If multiple coats of paint are to be measured, successive contiguous coats should be of contrasting colors to aid sharp discrimination of interfaces (see 3.2).

5.2 Generally, test specimens shall be prepared (as test panels) or chosen (as sites on a coil-coated sheet) to be representative of localized coating thickness and variability.

5.3 If test panels are to be laboratory-prepared, this should be done using accepted industry practices, in accordance with Guide D 3794.

6. Procedure

6.1 Select a test panel or choose a site for thickness measurement.

6.2 Using an appropriate surface marker[7] of contrasting color, mark a line on the surface about 1-in. long and ½-in. wide (25.4-mm long and 12.7-mm wide). In most cases, the use of a marker is not necessary, but for certain colors, usually whites, its use may be desirable. Depending upon the paint coating and the type of marker used, however, it is possible for the marker to be absorbed into the coating, up to 0.2-mils (5-µm) deep. This effect can make it difficult to determine the position of the top edge of the crater. The type and conditions of use of such a marker must therefore be agreed upon between the user and customer.

6.3 Place the test panel on the borer stage and align the marked line so that it is positioned under the bit. Clamp the panel into place.

6.4 With a small brush, clean the borer bit and the“ depth stop surface.” Debris in this area will result in a smaller crater, with consequent inaccurate results. Be sure to clean the surface of the panel prior to each test bore.

6.5 Adjust the depth control wheel so that the carbide borer bit just penetrates the metallic substrate, to avoid undue wear on the borer tip. This can only be done by trial and error due to substrate thickness variation.

6.6 If the boring device is automated, follow the instructions in 6.6.1; if the boring device is manually operated, follow the instructions in 6.6.2.

6.6.1 *Automated Boring Device*—Push button to activate boring device.

6.6.2 *Manual Boring Device*—Move the borer head down in a smooth, slow action to its full travel position, and immediately return it to its full rest position. Do not allow the borer head to rest in the “down” position; raged edges or smeared coating may result, rendering accurate film measurement more difficult. Do not make a second stroke into the same crater; do not allow the borer head to penetrate a previously tested crater.

6.7 Place the test panel on the measure stage, and locate the crater on the monitor by moving the panel either with your hands, or with the two micrometers that control the movement of the stage.

6.8 Adjust the zoom lens to 4.5, re-center the crater, and focus. Align the cross hair in the center of the crater, and, using the micrometer adjustments that control the vertical and horizontal movement of the stage, move the cross hair to the inner edge of the paint film for which the film thickness needs to be measured. Zero the micrometer. Then move the microscope stage with the micrometer adjustments so that the cross hairs are aligned at the outside edge of the paint film. Read the micrometer and divide this reading by ten (10) to obtain the film thickness of the paint film (see Fig. 2 and Fig. 3).

6.9 The reading on the micrometer will be the total film thickness (DFT). Repeat this procedure on the other side of the crater, and average the two readings.

6.10 It may be possible to read both the primer and the topcoat film thicknesses (or any of the constituent layers of a multicoat system) separately, as long as each coat is well adhered to the others, and there is a definite, visible delineation of the film layers.

7. Report

7.1 Report the following information:

7.1.1 *Results of a Thickness Determination*—If more than one measurement is made and specific results for each location are not needed, report the average thickness of all readings. It is not necessary to drill more than one crater, but it is suggested that at least two readings be taken in each crater measured.

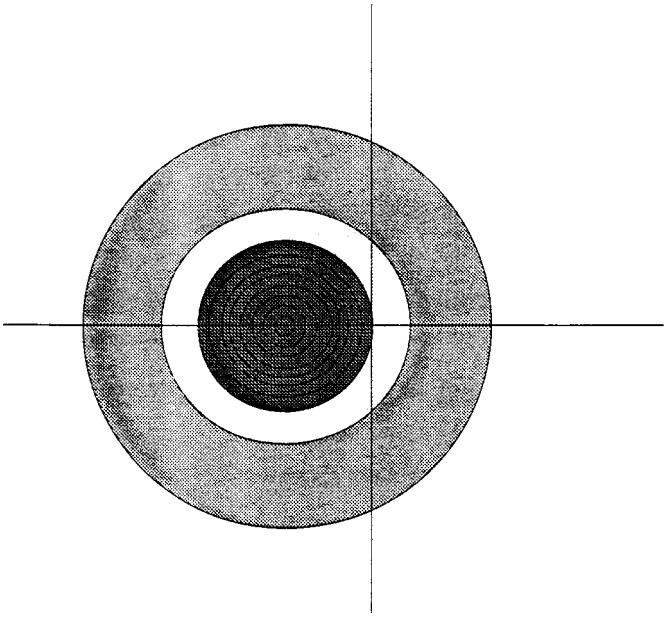


FIG. 2 Cross-Hair at Bottom (Inner Edge) of Crater

[7] The source of supply of the marker used by the committee at this time for this test method is Sanford Corp., Bellwood, IL 60104. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

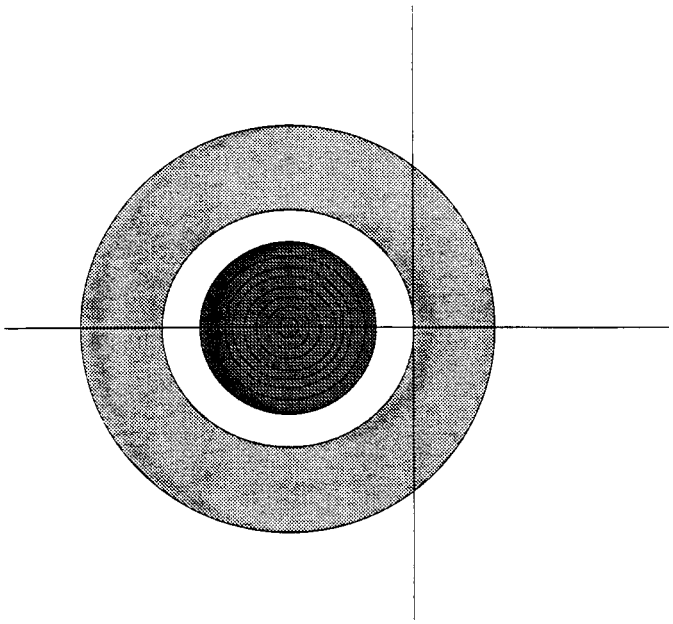


FIG. 3 Cross-Hair at Top Edge (Rim) of Crater

8. Precision and Bias

8.1 *Precision*—Statistical analysis of an intralaboratory (repeatability) and interlaboratory (reproducibility) round robin study yielded separate results for the use of the automated boring device (described in 6.6.1) and the manual boring device (described in 6.6.2).

8.1.1 *Precision Statement for the Automated Boring Device:* Precision, characterized by repeatability, Sr, r, and reproducibility, SR, and R, has been determined for the following materials to be:

Materials	Average	Sr	SR	r	R
1006	0.87889	0.05637	0.06987	0.15784	0.19563
1088	1.01000	0.02698	0.04207	0.07554	0.11779
1104	0.91333	0.04372	0.05596	0.12241	0.15670
1105	0.86389	0.02494	0.02755	0.06984	0.07713

8.1.1.1 *Repeatability*—Two results obtained by the same operator using the automated boring device should be considered suspect if they differ by more than 0.11 mils (2.75 µm).

8.1.1.2 *Reproducibility*—Two results obtained by operators using the automated boring device in different laboratories should be considered suspect if they differ by more than 0.14 mils (3.50 µm).

8.1.2 *Precision Statement for the Manual Boring Device:* Precision, characterized by repeatability, Sr, r, and reproducibility, SR, and R, has been determined for the following materials to be:

Materials	Average	Sr	SR	r	R
1006	0.90050	0.04228	0.06752	0.11838	0.18906
1088	1.04150	0.03678	0.07761	0.10298	0.21731
1104	0.92122	0.01724	0.04644	0.04826	0.13003
1105	0.90367	0.01936	0.04446	0.05422	0.12450

8.1.2.1 *Repeatability*—Two results obtained by the same operator using the manual boring device should be considered suspect if they differ by more than 0.08 mils (2.00 µm).

8.1.2.2 *Reproducibility*—Two results obtained by operators using the manual boring device in different laboratories should be considered suspect if they differ by more than 0.17 mils (4.25 µm).

8.2 *Bias*—Work is underway to determine the bias of this test method, and it will be reported in a future revision.

9. Keywords

9.1 borer bit; boring; crater; destructive; dry film; measure stage; micrometer; thickness; thin films; video camera