This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D8331/D8331M – 20

Standard Test Method for Measurement of Film Thickness of Thin-Film Coatings by Non-Destructive Means Using Ruggedized Optical Interference[1]

This standard is issued under the fixed designation D8331/D8331M; 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 encompasses measuring the film thickness of a coil coated organic coating layer. Operators can use this method in process during the coating application or in a laboratory setting.

1.2 This test method does not specify the expected film thickness/test results for a coating, nor the specific "recipe" file needed to measure a coating.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *producer, n*—primary manufacturer of the coil coated material, that is, the coil coater, from which parts are fabricated.

2.2 *recipe, n*—a combination of specified settings in the Ruggedized Optical Interference (ROI) measurement system which is used by the instrument to interpret the reflectance information gathered during a reading and provide an output in a specified unit of film thickness measurement.

2.3 *ruggedized optical interference (ROI), n*—a term used to distinguish this instrument that is suitable for use in an industrial environment from other optical interference devices that are only suitable for use in a laboratory environment.

2.4 *supplier, n*—the organization or person contracted to supply the coil coated material who may or may not be the producer (that is, coil coater, service center, or other seller).

2.5 *user, n*—the person or organization that makes use of the coil coated product.

3. Summary of Test Method

3.1 An instrument is used to measure either a single paint layer, like a primer, or the total film thickness of a multi-layer organic coil coating system through a non-contact, non-destructive, ruggedized optical interference (ROI) method.

3.2 It is recommended that this system only be used to determine total system thickness if the optical properties between multiple layers are similar (for example, topcoat over primer). Individual layers may be able to be distinguished if the optical properties vary enough (for example, clear over pigmented layer).

4. Significance and Use

4.1 Coating film thickness plays a critical role in the performance of the final product. This includes physical properties (abrasion/scratch resistance, color, gloss), chemical properties (solvent resistance), corrosion resistance, and long-term durability (color change, chalk, fade).

4.2 The non-destructive measurement system based on ruggedized optical interference transforms signal outputs in coating film thickness using digital formulas (or "recipes") which are reproducible from one instrument to another.

4.3 The ROI measurement unit takes a significant number of measurements which can be read in a determined period of time and each of these data points is recorded and reportable.

4.4 Due to the number of variables that can affect film thickness during application and the number of variables that must be set in the measurement unit while determining a

[1] 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 D01.53 on Coil Coated Metal.

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recipe, it is important for the producer and the user to agree upon recipe settings depending on the coating system.

5. Interferences

5.1 Probe setup is one of the critical items needed for good measurement. The probes can be set at a certain height within the manufacturer's specification from the sample. Once the height is established, the light will need to be focused at this height. Changes to the height will require a refocusing of the light.

5.2 Perpendicularity of the lens will affect accuracy of the readings, as will the cleanliness of the lens. Refer to the instrument manufacturer's instructions for proper alignment of the lens and cleaning procedures.

5.3 The sample has to be in motion during the scan time of measurements. No measurements will be obtained if the sample is not moved or if the movement is too slow (for example, less than 5.0 mm per second is too slow).

6. Apparatus

6.1 *ROI film measurement unit,* with operator instructions.

6.2 The most common measurement method for the system for offline measurement is the scan mode, which requires sample movement under the probe either by semi-automated or manual means. The average thickness of the area measured during movement shall be recorded.

6.3 In-line systems measure using only a continuous mode. In-line units may have multiple probes or one probe may mechanically traverse across the width of the coil.

7. Reagents and Materials

7.1 *Sample to be Analyzed*—Coated samples from a metal coil representative of the final applied coating product.

8. Sampling, Test Specimens, and Test Units

8.1 For laboratory testing, obtain representative, coated, flat panels, and cut the panels to an appropriate size for the test machine. It is recommended that sample panels be measured over an expanded surface area (minimum of 300 mm^2 [0.5 in.^{2}]), rather than at one focused point in order to ensure a representative area of the product is measured and to ensure that the sample can be measured under the light source without the beam moving off the sample. Note that the actual measurement area may vary by product and must be agreed upon by producer and user.

8.2 In-line measurements may be taken during the coating process on the wet film before curing or on the dried film after curing has occurred.

8.3 For products that may have varied coating thickness and cure across the item (that is, across the width of a coated coil), it is recommended that samples representing that variation be collected.

9. Preparation of Apparatus

9.1 Prepare in accordance with the manufacturer's instructions.

9.2 Power on the instrument.

9.3 Open the software menu program.

10. Calibration and Standardization

10.1 ROI measurement systems may come with NIST traceable thickness standards. The system cannot be calibrated on site, but the calibration of optics can be verified with the readings on NIST traceable thickness standard. The measurement of this standard should be conducted per the instrument manufacturer's specifications.

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FIG. 1 In-Line System

10.2 NIST standards must be certified by NIST along with the certification date.

11. Procedure

11.1 Select software initiation button on the instrument.

11.2 Select the appropriate probe for the sample to be read.

11.3 Select the recipe specified for the selected sample.

11.4 Ensure that the count (number of scans) and scan time (seconds) match the values agreed upon by producer and user.

11.5 Place the sample to be measured under the correct probe.

11.6 Begin moving the sample under the correct probe. This motion should ensure that the scan will cover the agreed upon area of the sample and that the scanning light does not leave the surface of the sample. The scan should not linger in the same area and the sample should remain relatively flat and even during motion under the probe to reduce rejected scan values.

11.7 Repeat step 11.5 through 11.6 until the number of scans matches the count number selected in 11.4.

11.8 Calculate the average film measurement for all scans taken and record this value to be reported. This may be reported by the software.

11.9 Record or discard readings per agreement between producer and user.

11.10 Finish the program.

12. Report

12.1 Identity of the machine used, including model number.

12.2 Identity of the coated sample tested.

12.3 The recipe used to measure the samples. If two parties have agreed upon a naming convention for the recipe this is acceptable with the understanding that the totality of information in the recipe is identical when comparing readings between separate instruments.

12.4 The probe used to take the readings.

12.5 The time used to scan the sample.

12.6 The number of scans used to generate the reading.

12.7 The average film measurement for all scans taken. The number of scans is determined by the count option and is agreed upon between producer and user. For continuous line measurements, the reported value will be the average measurement for all scans taken during a specified measurement cycle. The length of the measurement cycle will be agreed upon by the producer and user.

13. Precision and Bias[2]

13.1 *Precision*—Statistical analysis of an intra-laboratory (repeatability) and inter-laboratory (reproducibility) round robin study, conducted using eight (8) coated Galvalume[3] samples, identified as materials A through H, yielded separate results for the ruggedized optical interference instrument described in this standard.

13.1.1 *Precision Statement for the Optical Interference Device*—Precision, characterized by repeatability, S_r, r, and reproducibility, S_R, and R, has been determined for the materials in Table 1.

13.1.2 *Repeatability*—Two results obtained by the same operator using the ruggedized optical interference device should be considered suspect if they differ by more than 0.02 mils [0.5 µm], depending upon the thickness of the coating.

13.1.3 *Reproducibility*—Two results obtained by operators using the ruggedized optical interference device in different laboratories should be considered suspect if they differ by more than 0.06 mils [1.5 µm], depending upon the thickness of the coating.

13.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

14. Keywords

14.1 coil coating; film thickness; film thickness measurement; non-destructive; ruggedized

[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D01-2000. Contact ASTM Customer Service at service@astm.org.

[3] Galvalume is a registered trademark of BIEC International Inc.

TABLE 1 Precision Statement for the Optical Interference Device

(All values in mils of coating)	Average	S_r	S_R	r	R
Material A: Sample 1--Primer Only NIR	0.234	0.004	0.005	0.010	0.013
Material B: Sample 2--Primer/Backer NIR	0.419	0.003	0.006	0.008	0.017
Material C: Sample 3--Topcoat/Primer EXR 0.8-1.0	0.790	0.003	0.010	0.007	0.027
Material D: Sample 4--Topcoat/Primer EXR 0.9-1.1	0.992	0.004	0.015	0.012	0.042
Material E: Sample 5--Topcoat/Primer EXR 0.9-1.1	0.943	0.005	0.012	0.014	0.032
Material F: Sample 6--Topcoat/Primer EXR 0.9-1.1	0.995	0.005	0.016	0.014	0.045
Material G: Sample 7--Topcoat/Primer EXR 0.9-1.1	0.936	0.007	0.018	0.019	0.050
Material H: Sample 8--Topcoat/Primer EXR 1.0-1.2	1.014	0.004	0.020	0.011	0.055

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