Designation: ~~D5235 – 13~~ D5235 – 14

Standard Test Method for ~~Microscopical~~Microscopic Measurement of Dry Film Thickness of Coatings on Wood Products[1]

This standard is issued under the fixed designation D5235; 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 of coatings applied to a smooth, textured or curved rigid substrate of wood or a wood-based product

1.2 This test method covers the preparation of wood or wood-based specimens for the purpose of ~~microscopical~~microscopic measurement of dry film thickness.

1.3 This test method suggests an ~~interpretation~~analysis of dry film thickness of coatings on wood or wood-based products ~~when porous substrates are coated.~~using a microscopic measurement.

~~1.4 This test method suggests an interpretation of dry film thickness of coatings on wood or wood-based products when substrate attached or non-attached fibers occur in the dry film.~~

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values ~~given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered~~ 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.

1.5 *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.~~Some specific hazards statements are given in Section 7 on Hazards.~~*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *dry film ~~thickness,~~ thickness or DFT, n*—~~that layer of~~ the thickness of ~~dried coating above the microscopically visible board surface that also comprises~~dried, cured coating film on the substrate surface which may include attached fibers but excludes free fibers that are encapsulated in the layer itself.

2.1.2 *edge face, n*—that part of the specimen that is a plane perpendicular to the surface showing a cross section of the coating and substrate.

2.1.3 *soak in, n*—refers to a coating on a porous ~~substrate~~(wood) where the coating does not lie essentially on the surface of the wood or wood-based product, but has penetrated into the fiber structure of the wood or wood-based material.

[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 D01.52 on Factory Coated Wood Products.

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2.1.3.1 *Discussion*—

Wood or wood-based products are generally of a porous nature; sometimes exhibiting uniform absorption of coatings. Frequently absorption of coatings is of a ~~nonuniform~~non-uniform nature and influenced by localized surface density differences or wood pore size. These conditions of coating absorption are commonly referred to as soak in.

3. Summary of Test Method

3.1 A specimen of coated wood or wood-based product is cut to convenient size and edge ~~polished with sandpaper.~~face with the coating film cross-section is prepared by polishing or cutting with a sharp blade.

3.2 The ~~polished~~prepared edge of the specimen is ~~viewed through~~imaged by a calibrated ~~microscope~~ imaging system with known magnification in order to measure ~~dry film thickness.~~the dry film thickness using an image analysis computer program.

3.3 Suggestions regarding interpretation of dry film thickness on porous wood or wood-based material are offered.

~~3.4 Suggestions regarding interpretation of dry film thickness on wood or wood-based material that have attached or encapsulated fibers in the coating are offered.~~

4. Significance and Use

4.1 As a base for calibration adjustment or accuracy verification of dry film coating thickness measuring instruments.

4.2 The dry film thickness of coatings on wood or wood-based products is specified in written product warranties for proper decorative and protective performance of coatings on wood or wood-based products.

4.3 The minimum and maximum dry film thickness of coatings is recommended by coating companies for satisfactory decorative and protective performance on wood or wood-based products.

4.4 The average dry film thickness of coatings on wood or wood-based material may be used by manufacturing companies to ~~calculate~~ estimate the theoretical cost of applied coatings. ~~By comparison with actual cost, utilization efficiency may be calculated.~~

4.5 The ratio of ~~peak~~minimum to ~~valley~~maximum dry film thickness on textured products is used as an indication of coating uniformity.

4.6 Specific coated product requirements may dictate certain film thickness determinations to be made. ~~Discussions~~Agreement between buyer and seller may be advisable to accommodate product needs relative to dry film thickness.

5. Apparatus

5.1 ~~*Calibrated Monocular Microscope*~~*Microscope with Attached, Digital Camera (see Note 1),* ~~equipped with an optical system~~providing sufficient ~~resolution of 0.1-mil (2.54-μm) dry film thickness. One system consisting of a 16-mm objective and a 10-power filar micrometer eyepiece, resulting in a magnification of at least 100 diameters, has been found satisfactory. Other combinations of objectives and eyepieces and other magnifications may also be suitable, although magnifications above 200 diameters may result in distortion of the viewed cross section.~~magnification and image quality in the field of view; generally 100× to 200× magnification is sufficient.

NOTE 1—Certain digital cameras can provided sufficient magnification and image quality of the coating cross-section without a microscope.

5.2 *Source of Oblique Illumination,* for the microscope.

5.3 *Image Analysis Program,* with capabilities for lines to be drawn along the coating/substrate interface and the coating surface and for calculation of the average distance between these lines on the specimen image.

5.4 *Microscope Image Calibration Tool.*

5.5 *Cutoff Saw.*

5.6 *Belt or Disc Sander.*

5.7 *C-Type Clamp.*

5.8 *Sharp Utility Knife or Razor Blade.*

6. Materials

6.1 *200 and 600-Grit Sand Paper.*

6.2 ~~*Mold,*~~*Mould,* such as a paper cup, aluminum weighing dish, or a ~~2 in. (50.8 mm)~~50.8 mm [2 in.] or larger diameter plastic pipe that is at least ~~1 in. (25.4 mm)~~25.4 mm [1 in.] high.

6.3 *Source of Sanding Adhesive,* which is used as encapsulating medium such as:

6.3.1 *Hot Melt Glue,*

6.3.2 *Fast-Cure Acrylic Mounting Kit,*~~, and~~or

6.3.3 *Epoxy.*

6.4 *Solvent-borne Tint Dispersion,* which is compatible with the sanding adhesive.

6.5 *Mineral Oil.*

6.6 *Automotive Red Transmission Oil.*

6.7 *Zinc Stearate Powder.*

~~7. Hazards~~

~~7.1 Use saws and sanders with goggles, dust mask, and proper machine safeguards to prevent injury to body limbs.~~

~~7.2 Solvent-based tint dispersions and adhesives may be flammable and contain toxic solvents. See manufacturer's instructions for use and proper disposal.~~

7. Procedure

7.1 *Specimen Preparation*—Select the area to be measured for coating thickness and remove it from the coated wood or wood-based material by a suitable method. Methods of sawing, core drilling, chiseling etc., can be used. Avoid collection of samples near the edges of sheeting material or the ends of boards, particularly those coated in vacuum coaters, unless defective coating application is being investigated. For textured surfaces, areas representative of varying degrees of texture (average, extreme, minimal or non-existent) should be selected. Take care that areas of interest are not damaged. Cutting across wood grains is preferable in exposure of area of the interest and must be conducted when a coated rough wood surface is being tested. Inspection of the surface of interest for excessive damage, as well as preliminary assessment of coating conditions and uniformity of application should be conducted under a microscope. Appropriate areas for coating dry film thickness measurements should be selected based on testing purpose.

7.1.1 Frequently the purpose of testing is the measurement of the average coating dry film thickness for coating spread assessment or identification of areas with excessively thick or thin coating dry film thickness.

7.2 *Specimen Surface Preparation*—Two methods are described for specimen surface preparation due to the variability in the properties of wood coatings. Method A is recommended to be used for hard coatings, for example, melamine furniture coating or polyester coating, which are brittle at room temperature and could shatter in contact with a sharp blade. Method B is recommended for flexible, exterior finishes, which would smear in contact with sandpaper. Such smearing may mask the appearance of voids or fracture lines in the coating and substrate and may eliminate coating/wood substrate interface details, thereby increasing measurement error.

7.3 ~~*Specimen Preparation:*~~*Method A:*

7.3.1 Select the desired coated area of a wood or wood-based material that is to be measured for dry film thickness. With the cutoff saw, cut off a sample at least ~~1~~38.1 mm [1½ ~~in. (38.1 mm)~~in.] wide from this ~~area.~~area for mounting and encapsulation in casting resin (Note 2).

NOTE 2—Some specimens could be satisfactorily prepared and tested without mounting. Mounting may be omitted, if careful microscopic inspection of the sanded specimen does not show any damage to the area of interest or coating edge distortion.

7.3.2 Cut this specimen to a length that is at least 12.7 mm [½ ~~in. (12.7 mm)~~in.] less than the inside diameter of the mold to be used.

7.3.3 Place the specimen, with the sample edge to be measured, face down and approximately centered in the mold.

7.3.4 Prepare the sanding adhesive according to the manufacturer's ~~direction~~directions for use. A dispersed pigment may be added to the adhesive for better microscopic contrast between the dry film and the adhesive.

7.3.5 Pour the sanding adhesive around the sample in the mold and allow to harden according to the manufacturer's directions.

7.3.6 Remove the mold from the hardened and encapsulated specimen edge.

7.3.7 Using a disc sander, belt sander or 200-grit sandpaper mounted on a glass plate, sand the edge face of the encapsulated specimen ~~to be measured~~ until the edge face is relatively smooth. Maintain the edge face of the specimen as flat as possible during sanding. Avoid heat buildup of the sanding adhesive by intermittent sanding if necessary.

7.3.8 Polish the edge face of the rough sanded specimen as follows:

7.3.8.1 Mount a piece of 600-grit sandpaper on a flat glass plate. Rub the edge face of the rough sanded specimen over the 600-grit sandpaper in one direction, then reverse direction by 180° for several more rubs. Zinc stearate powder can be sprinkled on the 600-grit sandpaper or the 600-grit sandpaper can be wetted with mineral oil to produce a highly polished edge face free of scratches.

7.3.8.2 Some laboratories find that a mold for the specimen encapsulation with sanding adhesive is not necessary. In this case two specimens are prepared with the cutoff saw. The sanding adhesive after proper mixing is generously applied to the coated face of each specimen, the specimens are placed together and a C-clamp is used to squeeze out some of the sanding adhesive. The C-clamp is not removed until sanding adhesive has hardened.

~~8.1.9 To improve the microscopic contrast between the coating and the wood or wood-based product, wipe a light film of mineral oil or automotive red transmission oil across the polished edge face with a clean cotton rag or equivalent.~~

~~8.1.10 Some coatings and substrates are hard enough that encapsulation with a sanding adhesive is not necessary. Although in all cases, use of the encapsulating sanding adhesive will lead to the sharpest microscopic edge face and the highest degree of accuracy.~~

~~8.1.11 Some laboratories find that a mold for the specimen encapsulation with sanding adhesive is not necessary. In this case two specimens are prepared with the cut off saw. The sanding adhesive after proper mixing is generously applied to the coated face of each specimen, the specimens are placed together and a C-clamp is used to squeeze out some of the sanding adhesive. The C-clamp is not removed until the sanding adhesive has hardened.~~

7.4 *Method B:*

7.4.1 Select the desired area of coated wood or wood-based material that is to be measured for dry film thickness and obtain a suitable sample using the cutoff saw or other appropriate tool cut off a suitable sample. There is a handling advantage if the sample to be tested has a rectangular shape.

7.4.2 To aid in the preparation of the cross-section for testing, the sample must be additionally cut at an acute angle 70 to 85° with respect to the coated surface (Fig. 1). Then, using a sharp blade in a slow continuous movement, make a shallow cut parallel to the edge face with the coating cross-section, cutting from the coating surface into the substrate to remove any loose wood fibers and/or damaged coating from the area of interest. Inspect the obtained cross-section under microscope for surface quality. A clean view of the cellular wood structure and clear focus along the coating cross-section with well-visible interface details is a good indication of proper surface preparation. The cutting direction depends on the wood grains and coating properties.

7.5 ~~*Measurement for the Microscopic*~~ *Dry Film Thickness* *Measurement From the Image* *of the* ~~*Polished*~~ *Edge Face of the Specimen:*

7.5.1 Place the polished or clean cut edge face under the microscope lens.

7.5.2 Adjust the illuminating light at a convenient oblique angle. Proper light angle adjustment is helpful in obtaining good contrast along the coating surface edge, inter-coat boundaries, and coating/wood interface. This is particularly important when measuring transparent coating DFT.

7.5.3 Adjust magnification. Generally 100× magnification is sufficient for coating DFT above 50 µm and 200× magnification is sufficient for coating DFT above 25 µm. Lower magnification allows for a larger field of view which is beneficial when measuring a coating applied to rough wood containing peaks and valleys.

7.5.4 Adjust contrast and lighting for best imaging of the coating surface edge and coating/wood interface.

7.5.5 To improve contrast between wood and coating interface light coat of mineral oil or automotive red transmission fluid may be applied.

7.5.6 ~~Focus the 10-power filar micrometer eyepiece on one side of the dry film thickness spot to be measured.~~Capture image of the edge face of the specimen preferably with the coating film cross-section in the centre of the field of view.

7.5.7 Capture calibration image (Note 3) at the same magnification.

NOTE 3—A certified silicon test specimen, with a 10 micron grid and 1.9 micron dividing lines, for imaging system calibration could be used. Such a specimen can be supplied by Agar Scientific.[2] Other objects with known dimensions measured with certified tools could also be used for imaging and calibration.

7.5.8 ~~Advance 10-power filar micrometer so as to reach the other side of the spot to be measured in~~Enter the calibration data into the image analysis program according to the software manufacturer's[3] ~~8.2.3.~~instruction.

7.5.9 ~~Read the micrometer and calculate the dry film thickness by multiplying the distance in~~ Determine the average coating DFT using the image analysis program following software manufacturer's instruction (Note 4~~millimetres or inches per drum division on the micrometer by the number of drum divisions in the reading by the calibration factor.~~).

~~8.2.6 Multiply the calculated number in 8.2.5 by 1000 for English units (39.37 for metric units), for conversion to a dry film thickness in mils.~~

[2] ~~Consult the microscope manufacturer's operational manual for the correct calibration procedure.~~Available from Agar Scientific, 66a Cambridge Rd, Stansted, Essex CM2A 8DA, England.

[3] ~~Video microscope instruments are available that are also capable of the required resolution and measurement accuracy.~~ImagePro Premier, ImagePro Premier On Line and ImagePro Inside, available from Media Cybernetics, 8788 Georgia Ave., Silver Spring, MD 20910, were found suitable for this application.

[4] ~~The sole source of supply of this item known to the committee at this time is Buehler Ltd., 41 Waukegan Rd., P. O. Box 1, Lake Bluff, IL 60044. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.~~

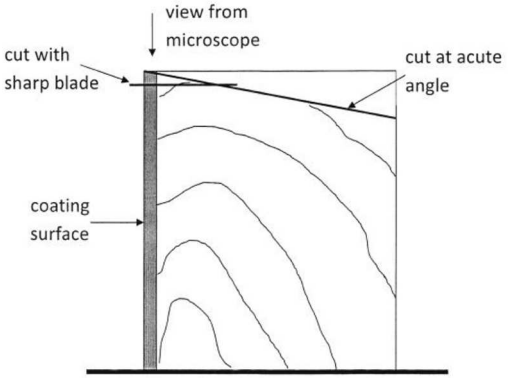

FIG. 1 ~~Illustrates Film Thickness above the Wood Surface where the Coating Layer Encapsulates Free Wood Fibers~~Diagram of Sample Cutting

NOTE 4—This analysis usually involves drawing two lines: one along the entire coating surface edge and another along the entire coating/wood interface or interface of interest. Porous substrates tend to have the coating soaked into their open cellular structure and fibers of the wood or wood-based product. A clear demarcation line between substrate and coating may not be discernible. In this case, such a demarcation line should be drawn as shown in Figs. X1.1-X1.9.

7.5.10 ~~Porous substrates tend to have the coating soaked into the open fiber structure of the wood or wood-based product. A clear demarcation line between substrate and coating is not discernible. In this case, it is suggested that film thickness is that layer of dry film thickness above the microscopically visible board surface that also comprises attached fibers but excludes free fibers that are encapsulated in the layer itself (see~~The average coating thickness for a tested group of samples is reported based on the average DFT calculated for all tested samples. The minimum DFT of the coating is reported as the lowest average DFT found within the tested samples while the maximum DFT of the coating is reported as the largest average ~~Fig. 1,~~DFT ~~Fig. 2 and~~found within ~~Fig. 3).~~the tested samples. A minimum of three samples taken at different locations must be tested.

7.5.11 ~~Several microscope companies have advanced optical systems and useful accessories for measuring~~Repeat measurements a sufficient number of times to obtain statistically valid average dry film thickness of ~~coatings on properly prepared coated wood or wood-based specimens. The use of their equipment for the measurement of dry film thickness on wood or wood-based products is highly recommended. The directions for use of the equipment are specific to each microscope company. Closely follow the manufacturer's instructions.~~the coating on the substrate of the interest and required data about maximum and minimum DFT.

8. Report

8.1 Description of the material tested, including form of wood or wood-based product, wood or composite grade, smooth or rough sawn and type of the composite surface finish, volume of coated material, number of specimens collected, and technique used for selection of the sampling area.

8.2 Report ~~the~~ number of samples tested. Average and average standard deviation, minimum, and maximum dry film thickness ~~of the spot to be measured in mils or microns.~~for the tested group of samples in microns (with mils given in parentheses).

8.3 Observations related to coating cross-section such as non-uniformity, air voids, cracks, and contaminants, etc.

8.4 Attach, if requested, photomicrographs of the specimen edge face with coating cross-section used for measurement.

8.5 For textured substrates, report the following ~~information (see~~information, if ~~Fig. 4):~~requested:
8.5.1 The dry film thickness ~~in the valleys,~~measurement for extreme textured areas,
8.5.2 The dry film thickness ~~on the shoulders or slopes,~~for average textured areas, and
8.5.3 The dry film thickness ~~on the peaks,~~for flat areas.
~~9.2.4 The dry film thickness on the flat areas if any, and~~
~~9.2.5 Optionally some laboratories report the ratio of the peak to valley dry film thickness or the average of multiple dry film readings of one or all of these substrate areas.~~

8.6 ~~For woods with large pores ignore the soak in of coating into the wood pore or cell and report only the dry film thickness above the microscopically visible board surface (see~~ Optionally, some laboratories report the ratio of the peak to valley dry film thickness.~~Fig. 5).~~

9. Precision and Bias

~~10.1 The precision and bias for this test method are primarily dependent upon each operator choosing exactly the same spot on the polished specimen for measurement.~~

9.1 The precision and bias ~~statements~~statement will be developed in round-robin testing.

10. Keywords

10.1 coated wood or wood-based product; dry film thickness; microscopic measurement

APPENDIX

X1. EXAMPLES OF IMAGES OF COATING/WOOD SUBSTRATE CROSS-SECTIONS, WITH SUGGESTED INTERPRETATIONS OF THE COATING AND INTERFACE FEATURES FOR DRY FILM THICKNESS MEASUREMENTS

X1.1 The following recommendations and photographs are provided to familiarize individuals conducting coating dry film thickness measurements with features that frequently appear in coating film cross-sections and at the coating/wood or wood-based product interface. The images are intended to provide some guidance in the interpretation and selection of the boarders of interest for coating/wood or intercoat interfaces. It should be noted that the features shown are only examples and individuals conducting the measurements must use their own judgement for specific image interpretations. Generally, the following rules are recommended:

(1) Wood vessels and cellular structure fully filled with coating material, such as encapsulated wood fibers or entrapped air voids in the coating, are to be included in the thickness of the dry coating film being measured.

(2) Wood vessels and cellular structure partially filled with coating material, such as wood fibers protruding into the coating film but connected with the wood substrate or air voids at the wood substrate surface preventing direct contact of the coating with the wood, are to be excluded from the thickness of the dry coating being measured.

X1.2 List of Figures:

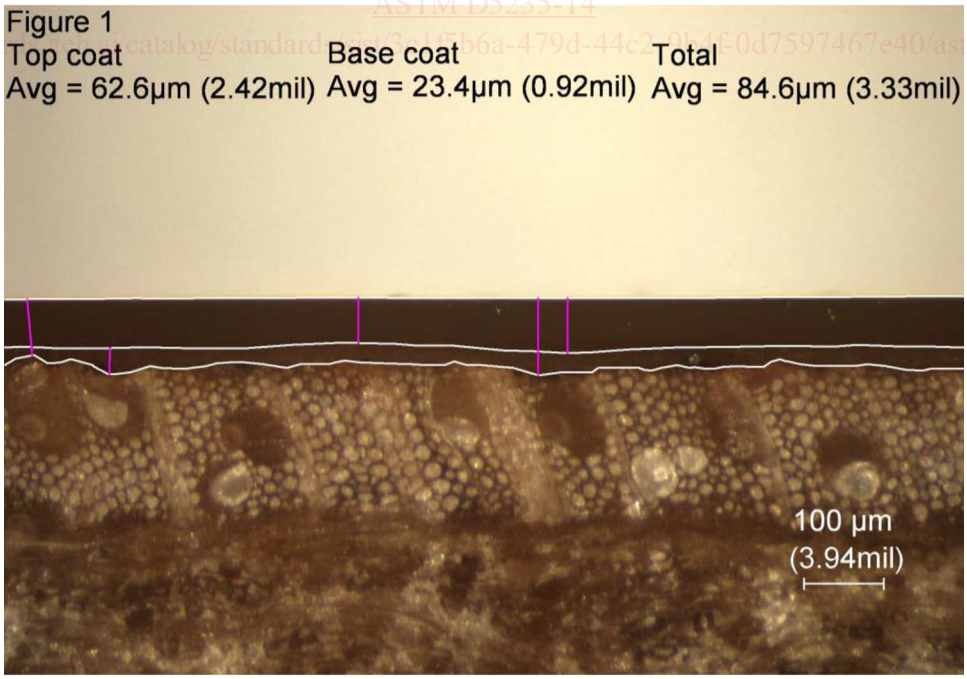

FIG. X1.1 Medium Density Fiber (MDF) Board with Smooth Hardwood Veneer Finished with Sealer and Solvent Based Topcoat. The sealer was sanded before topcoat application. The variable thickness of the sealer filling some of the veneer roughness and a relatively uniform top coat film can be seen and were included in the dry film thickness measurement.