Field Testing of Wet-Film Thickness and Dry-Film Thickness of Waterproof Coatings

By Robért Hinojosa, RRC, RWC, RRO, PE, CDT

Among the tasks a consultant must perform when specifying and overseeing the application of coatings is to evaluate that film thickness of the coating is properly applied during construction. To do this, the relationship between wet-film thickness (WFT) and dry-film thickness (DFT) must be properly understood. In addition, there are multiple techniques that can be used in the field during the installation to test the WFT and the DFT to ensure that the applicator is applying the specified amount of coating.

When reviewing manufacturers' data sheets during the design and specification process, the consultant is given yield measurement information such as the WFT and DFT, along with a wide range of application rates for theoretical coating coverage, in addition to solids by volume, solids by weight, and warranty requirements. A full understanding of this information will help the consultant properly specify the requirements for final DFT for the project and terms required by the warranty. However, while overseeing the application of coatings, it is imperative that both WFT and DFT tests be performed throughout the entire coating process to analyze proper application. Full knowledge of the coating properties will allow the consultant to obtain proper application with project WFT and final DFT readings during installation and to evaluate the proper end product for the client.

WFT vs. DFT

All waterproofing coatings contain "solids" that are made up of the resins and pigment within the coating. Solids content within a coating is given as a percentage of the weight or volume. Manufacturers' data sheets typically give the percent of solids by volume, and this is what is used when calculating WFT and DFT. The solid content, indicated as a percentage of the coating's volume for a specific coating, represents the amount of material remaining on the surface after the coating fully cures. For example, if the coating data sheet states that the coating is 50% solids by volume, one half of the volume of material is made up of solids and the other half is the solvent that evaporates after application. As such, when measuring WFT of this particular coating, keep in mind the WFT will cure to approximately 50% of the original volume, resulting in a DFT of half of the WFT measurement in the field. Coatings are measured in mils, where a mil is an imperial unit of measure equaling one one-thousandth of an inch. The relationship can be shown as a mathematic equation:

DFT (mils) = % solids by volume x WFT (mils)

Example

An elastomeric coating with 45% solids by volume is applied at 20 mils wet. What will the DFT be? Using the equation above:

DFT = .45 x 20 WFT (mils)

DFT = 9 mils

During application, the consultant should perform periodic WFT measurements to evaluate if the specified and required DFT will ultimately be achieved on

WFT and DFT Standards

- ASTM D4114-95, Standard Practice for Measurements of Wet-Film Thickness by Notched Gauges
- ASTM D4138, Standard Practice for Measurement of Dry-Film Thickness of Protective Coating Systems by Destructive, Cross-Section Means
- ASTM D1005, Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers

Figure 1 – A notched gauge used on a wall in the field immediately after application of an elastomeric coating.

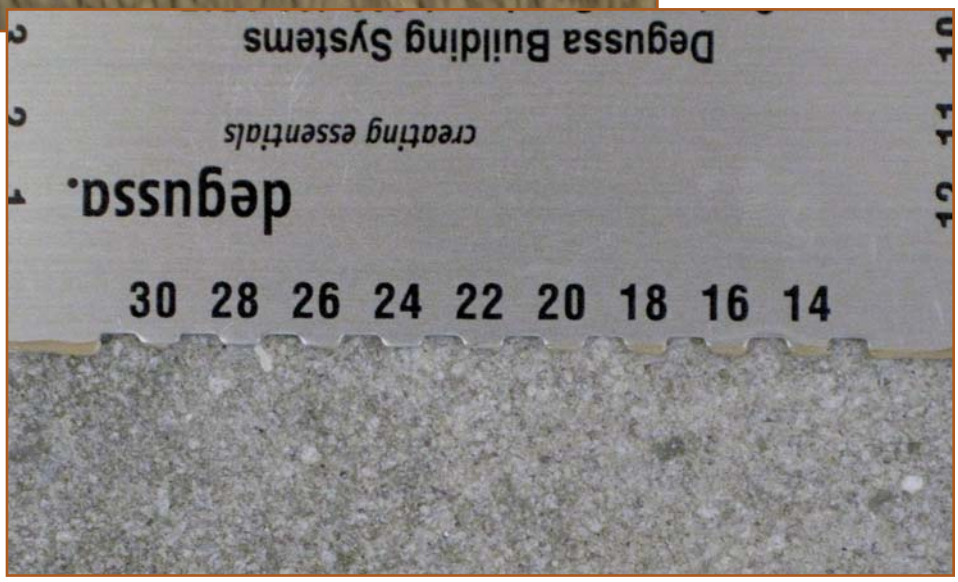

Figure 2 – The reading from a notched gauge during a WFT test performed in the field exhibited a coating thickness of 20 wet-film mils.

the building. The consultant should understand how many coats the contractor will apply to achieve the desired DFT. Then the WFT-to-DFT calculations can be performed so that the WFT readings can be read per coat during application to determine if adequate coating material is being applied or if additional material is required.

TESTING WFT

The simplest way for a consultant to assess if the required DFT is being properly applied on a building is to perform multiple periodic WFT tests during the installation. The most widely used and industry-accepted measure of the WFT is done with the use of notched gauges. Notched gauges are not extremely accurate, but they are useful in determining approximate WFT readings during the coating application process. The process is simple, and by performing periodic testing during application, a consultant can, with some assurance, validate that requirements set forth by specifications are being achieved or application can be adjusted accordingly, based on these tests, to assess if proper DFT is achieved.

The most commonly used notched gauge is a rectangular, rigid, metal gauge with notches on all four sides to measure the WFT ranging from 0.5 to 80 mils (*Figure 1*). The gauge is used immediately after installation of the coating on the wall. The gauge is placed on the wall on an area where both flat end tabs rest firmly on the wall. The gauge is removed from the wall and wet film WFT is measured by the shortest tab that is wetted from the coating (*Figure 2*). This method is described as Procedure A in ASTM D4114-95, Standard Practice for Measurements of Wet-Film Thickness by Notch Gauges. This standard describes the specific process and requirements for performing WFT tests with a rectangular gauge. The test standard recommends taking a minimum of three readings on the area being tested. Multiple readings are typically taken to ensure a "good" reading. Variations in the finish of the substrate, the experience of the person taking the readings, and other factors may determine the number of readings required to obtain a "good" estimate. If the surface is coarse and false readings are produced (as is often the case with stucco or EIFS-textured finishes), or if the gauge slips, those readings should

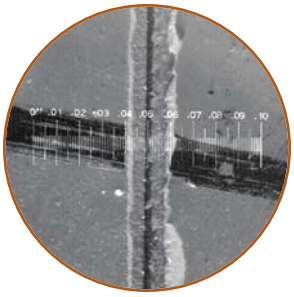

Figure 3 – The angled cut is observed vertically through an illuminated microscope bearing a measuring reticle. The English version shown here denotes the recticle mark in mils.

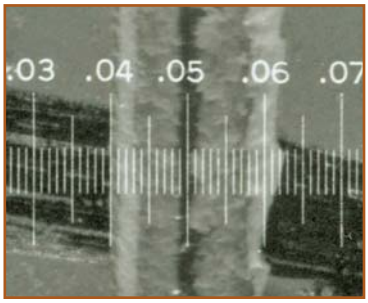

Figure 4 – A close-up view of the reticle from Figure 3 shows the divisions.

be ignored. Once multiple "good" readings are taken, the consultant should calculate the range and average of the readings in order to calculate the DFT that was produced by the application of the coating at the specific test location.

TESTING DFT

While it is beneficial to take WFT readings often during the application of the wall coating, often it is not practical. In this author's experience, vertical wall coatings are installed from swing stage equipment and in areas that are not easily accessible by the consultant. In addition, the consultant is most likely not on site full time and is only contracted to perform periodic quality assurance inspections. As such, it is always prudent to perform a certain number of DFT tests. With DFT, the coating has time to properly cure, after which its thickness can be measured by various means and/or devices after a sample it is removed from the wall. During a waterproof coating project, this author recommends performing WFT readings on a mock-up or sample location and then performing DFT readings after the mock-up or sample has properly cured to compare the accuracy of the WFT readings being taken at the project. This will set a benchmark or standard for continual testing and monitoring that can be used throughout the project and can be accepted by all parties.

There are many different devices and methods for determining the DFT of coatings installed on walls. Some are only as accurate as the notch gauges, while others are extremely accurate. Consultants can use a number of different ways to determine DFT of coating materials, depending on the individual project and its requirements. A couple of quick field tests will be described, as well as tests that require sending samples to laboratories for testing that will provide extremely accurate measurements.

FIELD TESTING

One test that is commonly used in the field is conducted by performing a cut into the coating and using a microscopic observation measurement. ASTM D4138, Standard Practices for Measurement of Dry-Film Thickness of Protective Coating Systems by Destructive, Cross-Section Means, describes the protocols for this process. For this method, a very smooth cut is made in the coating film on the wall at a precise angle. To measure the DFT, an illuminated microscope with a scale reticle is used. The

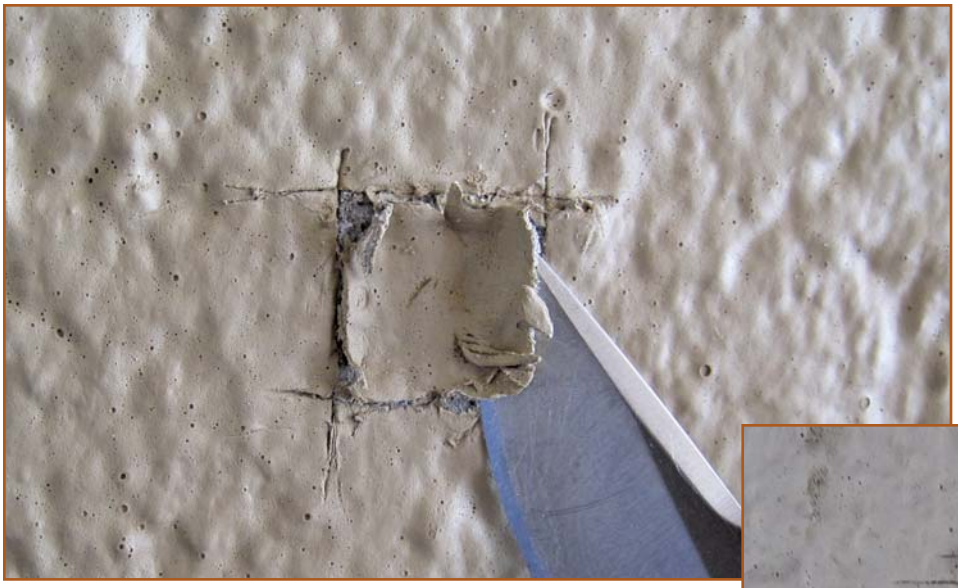

Figure 5 – A physical sample of the coating application is removed from the wall with a knife. The coating sample can then be easily measured via multiple simple tests.

Figure 6 - The destructive method of removing a small sample of coating will require that the area be "touched up" after the DFT is measured.

illuminated microscope typically has a 50x magnification. The measurement can be read by using the scale and measuring the distance from the coating up the longer slope of the incision to the cut edge of the coating (*Figures 3* and *4*). A common tool used for this is the Tooke gauge.

Other methods and devices for testing are performed through destructive testing by removing a sample of the coating and using measuring devices to measure the DFT of the sample removed from the wall (*Figures 5* and *6*). Samples can be removed and measured with micrometers or other devices that simply and easily read the

Figure 7 – A monopolar, magnetic induction device is used to determine the DFT of a coating sample removed from a wall area. On this particular project, a minimum of 16 DFT was required for warranty. This sample satisfied the requirements for the project.

DFT. ASTM D1005, Standard Test Method for Measurement of Dry-Film Thickness of Organic Coatings Using Micrometers, Procedure D describes the process for selectively removing a piece of coating and measuring the DFT with a micrometer. With this method, there are areas of concern that can affect the accuracy of the DFT reading, including the equipment and method for removing the coating sample; the profile of the concrete, stucco, or EIFS surface from which the coating sample was removed; and the hardness of the coating material. All these things need to be taken into consideration when using the micrometer and, as with all methods, the experience of the person taking the reading will factor into the accuracy of the readings taken. A micrometer typically can measure the DFT from a few mils to over 250 mils, which covers the entire range of typical waterproof coating applications.

A more accurate way of determining the DFT of a sample removed from the wall is with a device that utilizes monopolar, magnetic induction. When a magnet comes into contact with a bare magnetic metal surface such as iron or steel, a magnetic flux circuit is created. When the nonmagnetic coating sample (acrylic or elastomeric) is placed between the two, a "gap" in the magnetic flux is created. The difference in the magnetic flux is proportional to the thickness of the coating. These types of coating thickness gauges measure the difference in flux intensity to provide an accurate indication of the coating thickness being measured (*Figure 7*).

LAB TESTING

While micrometer and magnetic, monopolar-induction testing are simple ways to measure coating thickness during application, more accurate tests can be performed by sending samples to a lab. When

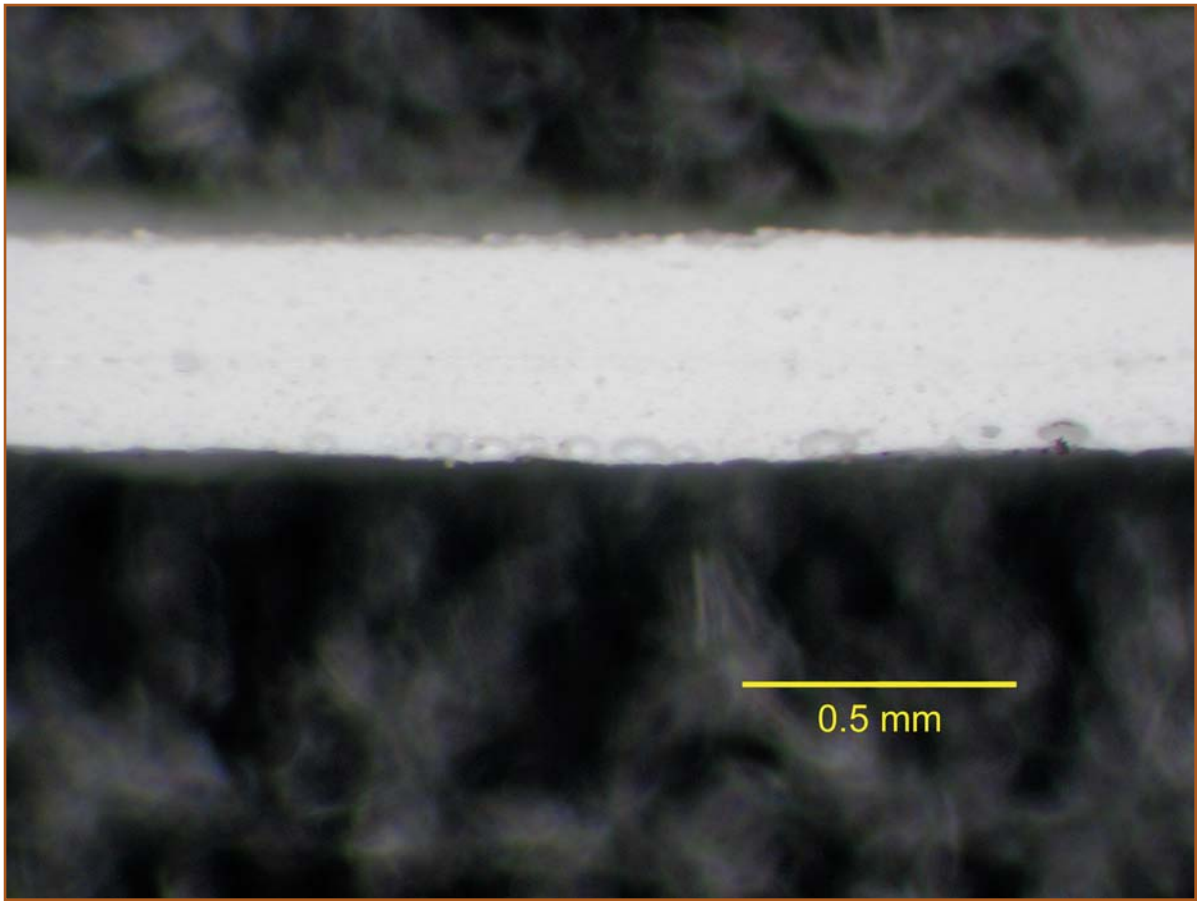

Figure 8 – A view of a sample under a high-powered microscope. The lab will typically cut a minimum of three cross sections through the sample and measure the thickness at the midpoint of the section. Photo courtesy of MicroMaterials Research.

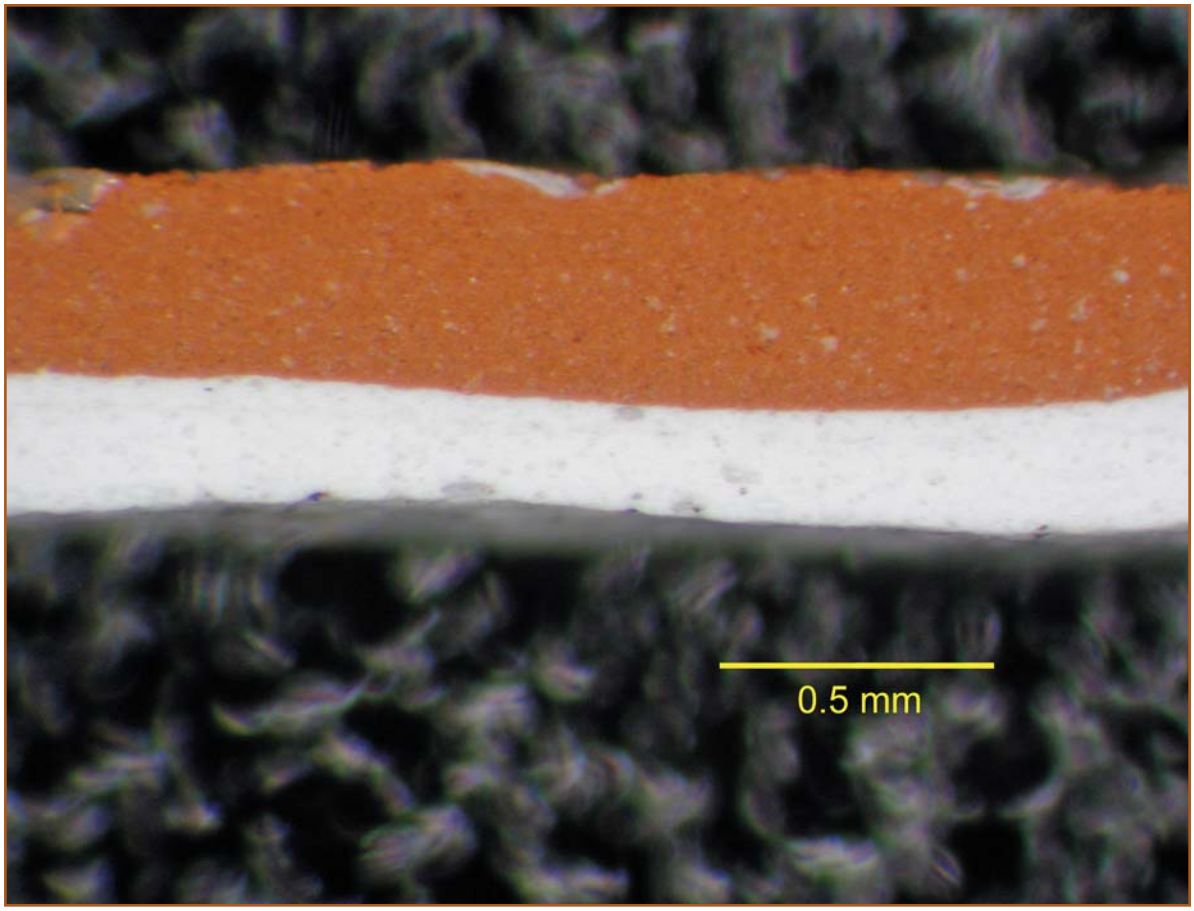

Figure 9 – Labs can also accurately measure the thickness of a coating on a substrate when it is too difficult to remove the sample from the substrate. In this exhibit, a piece of the substrate with coating was removed, and the lab was able to easily distinguish and measure through its high-powered microscope. Photo courtesy of Micro-Materials Research.

taking WFT and DFT tests during coating projects, this author has found that the quick field tests described above are often challenged, especially when the consultant reports to the contractor that the WFT and DFT installed do not meet the thickness required by the specifications. As such, it may be necessary to send samples from the wall to a lab to substantiate other test methods. Two of the ways in which the lab will measure the DFT are (1) by measurement of the sample under a high-powered microscope (*Figure 8*), and (2) by freezing the sample with liquid nitrogen to negate the deformability of the coating (which is often the reason for inaccuracy in other measurement methods), shattering the sample into multiple pieces, and then measuring the different pieces of the sample under the high-powered microscope to determine a range and average thickness of the sample (*Figure 9*). It should be understood that sending samples to a lab that has high-powered microscopes not commonly utilized by waterproofing consultants, and other methods of measuring DFT are extremely accurate, but they are also time consuming and expensive. However, in instances where the day-to-day WFT and DFT measurements are challenged or litigation may ensue, it is necessary to obtain the most accurate readings possible.

When hired to design, specify, and oversee a coating project, it is imperative that

the consultant evaluate the client's requirements and specify the proper coating and ultimate DFT to obtain the desired warranty. The manufacturer of the coating material will dictate the specification requirement for the minimum DFT of the coating to obtain the desired warranty. It is ultimately the contractor's responsibility to apply the coating to meet the required DFT and provide the client with the desired warranty. It is the consultant's job to provide quality assurance throughout the project to assess the specified DFT application of the coating. By regularly utilizing some of these WFT and DFT test methods, the consultant will provide the client with the best coating project possible.

Robért Hinojosa, RRC, RWC, RRO, PE, CDT

Robért Hinojosa is the principal engineer and a primary shareholder of Building Engineering-Consultants, Inc. (BE-CI), an engineering consulting firm that specializes in investigation, repair, design, and restoration of building envelopes. BE-CI is based in Destin, FL, with offices also in Gulf Shores, AL, and Houston, TX. Mr. Hinojosa has a bachelor's degree in civil engineering from Texas A&M University and a master's in business administration from the University of Houston. He is a registered professional engineer in Texas, Louisiana, Mississippi, Alabama, Florida, and Georgia. He is also a Construction Document Technologist (CDT) through the Construction Specifications Institute. Robért is a member of RCI, CSI, and ASCE, and is the current president of the Florida Panhandle Branch of the Florida Chapter of RCI, Inc.