

INFO SHEET

*Performance Through
Technology and Service*

Precision Wet Film Thickness Measurement and Control for Optimal Coating Application and Consequences of Applying Coatings Outside of the Recommended Thickness Range

Precision Wet Film Thickness Measurement

Sponsored by [Paul N. Gardner Company, Inc.](#) Reviewed by Maria Osipova Dec 5 2023

Wet film thickness (WFT) is the measurement of the thickness of a paint or coating immediately after application before it undergoes drying. A Wet Film Thickness Gauge is utilised to gauge this thickness, providing a cost-effective, swift, and straightforward method.



Image Credit: Paul N. Gardner Company, Inc.

These gauges are applicable across a broad range of wet film thicknesses, accommodating both thick protective and thin coil coatings, and can be employed on virtually any substrate.

[Wet Film Thickness Gauges](#), (Click this link to see a short video on how to use correctly) also recognised as Wet Mil Gauges, WFT Gauges, Combs, Comb Gauges, Mil Gauges, Step Gauges, and Notched Gauges, are specifically designed to swiftly and effortlessly assess paint and coating thickness post-application but before curing.

They integrate a set of notches resembling the teeth of a comb.

A Wet Film Thickness Gauge facilitates easy wet film thickness measurement for uncured coatings, such as paints, roof coatings, powder coatings, intumescent coatings, gel coats, wood coatings, and more.

The measurement of wet coating thickness, or wet film thickness, is crucial for the applicator to ensure compliance with the manufacturer's specifications.

The repercussions of applying **excessive coating** include *extended drying time, solvent entrapment, cracking, sagging, and increased material costs.*

On the contrary, *applying **insufficient thickness** may necessitate additional coats, leading to premature coating failure, inadequate hiding, undesirable appearance, and various issues that can result in extended job completion times, potential claims against the applicator, and diminished profits.*

Applicators should promptly measure wet film thickness right after applying the coating, before significant solvent evaporation, to ensure accurate measurements.

Delays, even slight ones, could lead to erroneously low readings due to solvent evaporation before measurements are taken.

Throughout the application process, multiple readings are advisable to verify consistent wet film thickness across all coated surfaces. Therefore, applicators primarily utilize WFT gauges rather than inspectors. Frequent monitoring of wet coating thickness is essential to uphold a consistent coating process in line with manufacturers' specifications.

This practice aids in controlling coating costs and application time, enhancing overall efficiency and profitability for the applicator.

Adjustments to spray gun speed, the number of passes, and spray tips can be made to achieve the desired coating amount, meeting specified wet film thickness and, ultimately, the specified dry film thickness, which can be gauged using a dry film thickness gauge.

Approximate dry film thickness can be predicted by measuring wet film thickness. The calculation involves using the solids-to-liquids ratio. For instance, in a coating with 80% solids and 20% liquid, as the coating dries, the liquid evaporates, leaving only the solids in the dry film.

If the wet film thickness is 100 µm, the dry film thickness will be 80 µm ($100\ \mu\text{m} \times 80\% = 80\ \mu\text{m}$). Dry film thickness (DFT) is the thickness after complete liquid evaporation, expressed as $\text{DFT} = \text{WFT} \times \% \text{ solids}$. Conversely, the equation can be reversed to measure the applied WFT based on the DFT.

How to use a Wet Film Thickness Gauge

Video Credit: Paul N. Gardner Company, Inc.

How to Use

Using [Wet Film Thickness Gauges](#) is a straightforward process. These gauges feature notches (also called teeth) on their sides, aligned as references. The two outer notches, of equal size, rest on the substrate, serving as a zero reference.

The remaining notches on the same side are shorter and gauge the depth of the wet coating and its distance from the zero reference. These distances, measured in mils (0.001") or microns, signify the distance from the substrate surface. Below is a simple guide on how to use these gauges:

1. Position the gauge on the wet coating at a 90° angle, perpendicular to the substrate
2. Gently press it into the coating until contact is made with the substrate
3. Withdraw the gauge and identify the deepest tooth with coating and the adjacent uncoated tooth
4. The wet film thickness is between these two readings
5. Immediately clean the gauge with a suitable solvent and dry it after use, or dispose of it properly

In the accompanying image, the gauge tooth labeled 3 mils has touched the wet coating, while the adjacent tooth marked 4 mils has not. This indicates a wet film thickness measurement between 3 and 4 mils.

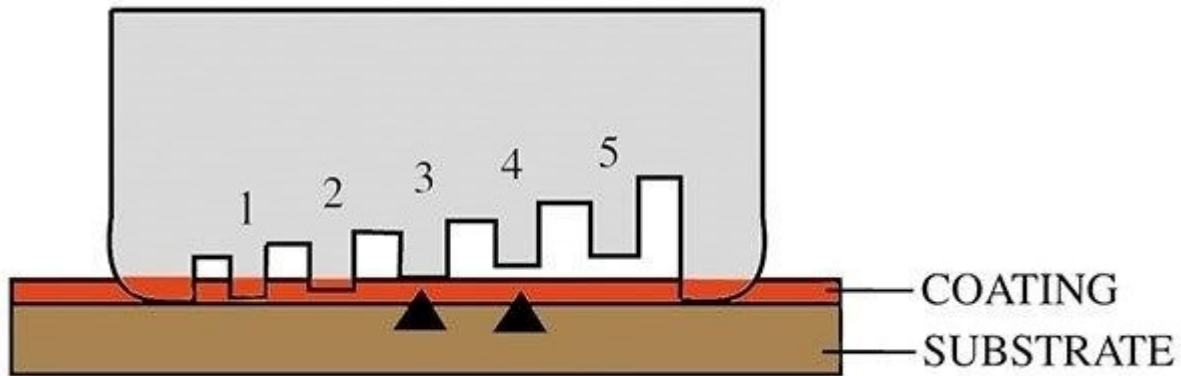


Image Credit: Paul N. Gardner Company, Inc.

When measuring powder coatings, drag the gauge through the uncured powder coating to ensure adhesion to the gauge teeth. To summarize, Wet Film Thickness Gauges are:

- User-friendly
- Cost-effective tools for coating manufacturers and applicators to prevent claims arising from incorrect coating thickness application
- Economical enough to be disposable
- Customizable at a minimal cost
- Integral for achieving high-quality coating applications

Comply with the requirements of the following International Standards: ASTM D4414, ISO 2808-7B, BS 3900-C5 Method 7B, NF T30-125, NASI/NCSL Z540-1



Dulux Protective Coatings Wet Film Thickness Comb
AU \$7.95 a small investment for great savings in repairs or recoating!

(Contact local paint shop or Dulux Trade Centre)

INFO SHEET

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Consequences of Applying Coatings Outside of the Recommended Thickness Range

Thanks to KTA-Tator, Inc. (KTA)



When recommending a coating or coating system for a specification, or when responsible for the application of a coating, the manufacturer's Product Data Sheet (PDS) should always be consulted. The PDS typically contains information regarding appropriate uses and environments, performance characteristics, and application information including mixing, application methods and equipment and the recommended thickness range for the material.

The information provided by the manufacturer should be followed as closely as possible to maximise performance of the coating material. In this article we will investigate the possible failure mechanisms that can occur if a coating is applied at insufficient or excessive coating thickness.

Coating materials are selected for application with a target application thickness in mind. The manufacturer's recommended range and the thickness indicated in the project specification should be in agreement. If a discrepancy exists, the specifier and the coating manufacturer should be contacted for resolution. When applied at the appropriate thickness, the physical and protective properties of the coating material are optimized. Often a problem with coating performance occurs if not enough attention is given to the thickness at which the materials are being applied and the finished product has either insufficient or excessive coating thickness.

INSUFFICIENT COATING THICKNESS

Insufficient coating thickness can occur in a number of ways, but essentially either the coating thickness was not specified or communicated correctly, the application was performed deficiently, or the volume solids content of the coating was not reported accurately.

The quality of the coating application should not be judged on appearance of coverage; i.e., looks good enough. While coatings have a cosmetic advantage, the goal is often protection of the substrate from corrosion or other environmental factors. If a coating material is applied until it appears to cover completely without regard to the manufacturer's specified thickness, the resultant dry film thickness could be lower than the target thickness for optimal coating performance in a specific environment. If an applicator tries to stretch the coverage area of the material with diluents the result will be a coating thickness that is below the acceptable threshold for performance.

When the specified range of coating thickness represents a thinner film of coating such as 1.0 – 1.5 mils, (25 – 37u) the importance of an application within that range is magnified. If the coating is applied at 0.5 mils, (25u) then film thickness is reduced by 32 – 50%. Particular attention must be paid when dealing with thin film application to ensure that the appropriate thickness is obtained. By comparison, if a range of 20 – 30 mils (500 – 600u) is specified and the actual film thickness is 19 mils, (475u) the 5% reduction in coating thickness will likely not present as significant of a problem with the performance of the coating material.

Several problems can occur when the coating film is applied at a range significantly below the recommended thickness range:

Visibility of Substrate

When proper coverage is not achieved, the substrate or underlying coating may be visible through the coating material. While this is not an ideal aesthetic condition, it may also leave underlying coating materials or substrates vulnerable to corrosion, degradation by exposure to solar radiation (sunlight) or other environmental effects. For example, if a urethane topcoat is applied over an epoxy coating and there are several scant areas present, the epoxy coating is more susceptible to chalking due to unintended exposure to ultraviolet light. The results include blotchy color and gloss, uneven erosion patterns and a shorter time until maintenance painting may be necessary.



(Photo 1) – Scant coating coverage of wood siding. The substrate is visible through the thin coating application.

NOTE: With PNF the opacity is high, meaning even a thin coating (below the required thickness) will quite easily hide the substrate. This creates a false expectation of adequate coverage and there for long term protection.

Pinpoint Rusting

Pinpoint rusting can occur when the thin film has not provided enough barrier or cathodic protection to the underlying metal substrate. For example, any primer, including a zinc-rich primer applied to an abrasive blast cleaned steel surface with a surface profile having greater depth than the thickness of the coating will not adequately cover the tips of the anchor profile peaks (particularly rouge peaks) leaving tips of steel with little or no protection and likely sticking through the coating. Failure to agitate zinc rich paints during application can exacerbate the problem by not providing enough zinc material to effectively protect the steel from corrosion. Rusting will occur at the points with the least protection.



(Photo 2) – Pinpoint rusting through the topcoat. Cracking/Brittleness of Coating

When the coating film is applied below the target thickness range, the physical properties of the film itself may be jeopardized. For instance, a modified polyurethane lining that inherently has a high degree of cohesive strength at a thickness of 30 mils (600u) will be more brittle than intended based upon an applied thickness of 5 – 8 mils. (125 – 200u) The decreased flexibility of the coating corresponds to reduced cohesive strength of the film and can result in cracking or delamination.



(Photo 3) – Cracked topcoat of a system applied approximately 20 mils below the minimum specified thickness range.

Correcting deficient coating film thickness is not always as simple as adding more or making the next coat thicker. Inorganic zinc coating generally has poor intercoat adhesion when applied in multiple coats. Corrosion inhibitive epoxy primers have drying and curing recoat intervals to consider, and the loss of primer thickness is also a decrease in primer function—something the next, thicker coat may not make

up for. Finish coats are likely to require scarification prior to application of an additional coat. Clearly, owners do not want to deal with the consequences of low coating film performance. Contractors certainly do not want to deal with correcting low film thickness. Both good arguments for hitting the minimum film thickness required. The other side of this coin is failing to stay below the maximum coating thickness. This can have consequences as well.

EXCESSIVE COATING THICKNESS

As with insufficient thickness, a cause of excessive coating thickness is application related however the reason for the application error is variable. Often an applicator is not aware of the impact of excessive coating thickness on coating performance. Protective coatings are designed to perform at a specific thickness range based upon the chemistry of the coating and the intended service.

Therefore, with protective coatings more is not equivalent to better. In fact, several additional issues or modes of failure are attributed to excessive coating thickness than those described for insufficient thickness. Several consequences of excessive coating thickness are discussed below.

Sagging/Running

If the coating material is applied in excess, the wet coating can run or sag on vertical surfaces. Coating materials with lower viscosities are particularly susceptible to sags and runs if applied excessively thick. When the coating film sags we are left with an uneven film surface. This creates not only excess film build in the sagging areas but may also lead to surfaces of insufficient thickness and the issues discussed above.

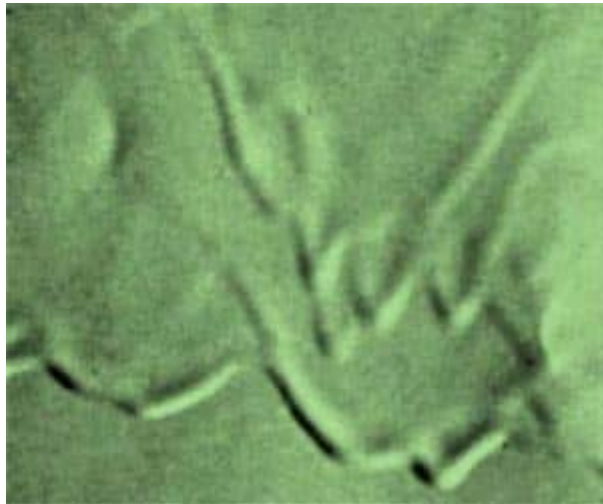


Photo 4 – Sagging coating on a vertical surface. Cracking/Delamination

Some coatings, such as epoxies (and PnF) are susceptible to cracking and delamination when applied at a thickness above the manufacturer's recommended range. The high epoxide functionality of these resins forms a highly cross-linked polymer network post-cure that displays high temperature and chemical resistance, but low flexibility. The additional internal stress associated with excessive coating thickness often results in cracking of the material which may subsequently result in delamination of the

coating. Typically, delamination occurs at the weakest interface.

When a coating is applied too thick, the cohesive strength of the material is often compromised. A cohesive break in the coating layer that is applied too thick is not uncommon with cross-linked coatings (e.g. PnF). Additionally, a smooth substrate in combination with a thicker than recommended coating may cause delamination from the substrate as the stresses introduced to the system are greater than the adhesive bond of the coating to the substrate.

Wrinkling

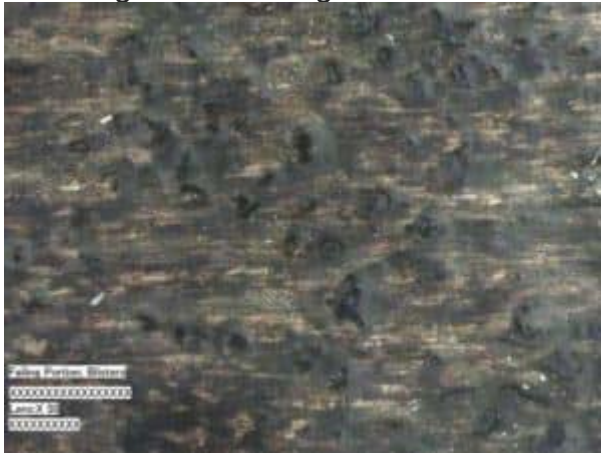
In cases of excessive coating thickness, the top surface of the coating may dry or cure prior to the bulk of the coating. In these cases, the top surface creates a skin of stationary dry material over the flexible, soft uncured material which can result in deformation of the surface upon movement of the underlying material. The ridges and valleys in the skin are seen as wrinkling. Alkyd coatings are particularly susceptible to wrinkling of the surface when applied excessively because they cure by atmospheric exposure to oxygen. The oxidation process will occur first at the surface and continue throughout the coating thickness but at a much slower rate. An issue arises with films applied excessively thick such that the bulk of the film remains soft and uncured with less exposure to the atmosphere.

Increased Dry Time

Dry time and curing time of coatings are often directly related to the application thickness. If the coating is applied too thick the delayed dry time can affect recoat schedule, solvent release and dirt and debris pick-up due to an unusually extended soft surface. This may result in a poor surface for over-coating or an unwanted appearance.

Improper Curing

As with wrinkling and increased dry time, the excessive film build may cause issues during curing. Some materials may not fully cure prior to being put into service leaving a coating surface that is too soft, easily damaged and unfit for service. Solvent entrapment may also occur if the top surface cures and the underlying material does not. (e.g. PnF) Since a thicker film creates a thicker, less permeable barrier, any entrapped solvent or moisture would have a more difficult time permeating through the system. This solvent entrapment could lead to blistering of the coating.



(Photo 9) – Blisters occurring in a clear-coat applied at three times the recommended thickness over wood substrate.

METHODS OF COATING THICKNESS MEASUREMENT

In a perfect situation, the wet film thickness of the coating material should be checked as application occurs to help ensure that the specified thickness range is being met. This can be done using a wet film thickness gauge at the time of application. **(see article above on these you can buy and use)** If incorrect dry film thickness is suspected, several techniques or instruments can be used to measure the thickness of a coating system.

Tooke Gauge

A Tooke gauge can be used in the field or in the laboratory. To determine the film thickness with this instrument, an incision is made into the coating down to the substrate using an angled blade selected based on the expected thickness range. The incision is then viewed using the microscope (ocular) and scale that is visually evident through the ocular of the gauge. A conversion employing the selected cutting blade as well as the scale reading will provide the coating thickness for each visible coating layer. ASTM D4132, "Standard Practices for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive, Cross-Sectioning Means" describes the procedure for using this type of instrumentation.

Limitation – This is a destructive test. The cutting blade will expose a small portion of the substrate.

Non-destructive Coating Thickness Gauge

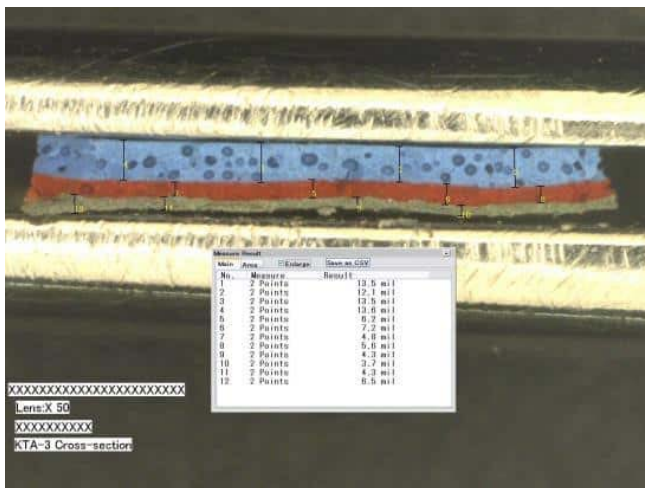
A non-destructive coating thickness gauge can be used in the field or in the laboratory. These gauges are available in ferrous and non-ferrous models and can obtain coating thickness measurements from various metals. Ultrasonic gauges are useful for coatings on concrete or masonry surfaces. These gauges send an ultrasound signal into the coating using a probe (i.e. a transducer) with the assistance of a couplant applied to the surface. Gauges used to

measure coatings on metal surfaces use eddy current and/or magnetic induction technologies. The gauge is placed on the coated surface and a digital reading of the total coating system thickness is provided. ASTM D7091, “Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals” and ASTM D6132, “Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Coating Thickness Gauge” describe the procedures for using this instrumentation.

Limitation – Only the total coating system thickness measurement can be obtained using this method; individual coating layers cannot be measured after they are all applied. Note that some ultrasound gauges can distinguish coating layers but may not be able to measure the thickness of coatings with air-entrained voids or containing glass flake.

Microscope Equipped with Scale

Cross-section thickness of coatings is predominantly performed in the laboratory with samples collected from the field. Some microscopes have a scale fitted in one of the ocular pieces, similar to the Tooke gauge (described earlier). Digital microscopes often have a measuring tool where two points are selected along with the current magnification to calculate the coating thickness which can be expressed in mils, inches, micrometres, millimetres and other units. Photographs are often obtained through the microscope.



(Photo 10) – Example of thickness measurements obtained from a digital microscope

Multiple layers can be measured by a microscope when the cross-section of the sample is viewed. An advantage of the cross-section view in the microscope is a magnified view of each coating layer. Splits between or within coating layers can be observed as well as voids within the coating layers or other objectionable properties.

Limitation – Microscopes are typically not appropriate for field use. There is a possibility of viewing an incomplete coating system if samples are not removed cleanly from the substrate.

CONCLUSION

There are an abundance of coating performance deficiencies, defects, and modes of failure that can occur related to insufficient or excessive coating thickness. This article provides eight common examples of coating problems associated with coating thickness.

When investigating coating performance issues, the applied coating thickness as compared to the specification requirements and/or the manufacturer’s recommendations is an important consideration. That is, if the material was applied outside of the recommended thickness range, it is reasonable to conclude that the performance of the product has been impacted to some degree and that impact should be evaluated. Note however that during a coating failure investigation, a thorough survey of coating thickness may reveal insufficient and/or excessive coating thickness in both failing and non-failing areas, so thickness alone may not be the sole

cause of a coating problem. Nevertheless, an objective investigation that looks at all of the facts is critical to identifying the root cause and corrective actions. The dry film thickness should always be determined, if for no other reason to exclude it as contributory.

KTA-Tator, Inc. (KTA) provides facility owners, architects/engineers, contractors, fabricators, and manufacturers peace of mind that the integrity of steel and concrete structures and other assets are properly assessed and protected.

KTA's specialties include coatings and corrosion engineering and inspection; steel and concrete fabrication inspection; field and laboratory coatings failure analysis; environmental, health and safety consulting; and contract administration for maintenance and construction activities.



Two good examples of variable paint thickness and wearing away where too thin, prematurely.

You can see roller – brush lines and light and darker shading.

So, use a wet film gauge to know the film thickness as you apply it and prevent this happening.

