



Film Build Control

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Applying the correct film build to a substrate is a critical aspect of any coating operation, primarily because of its effect on finish quality and finish performance. Film build efficiency also has an impact on production costs and air emissions. For example, if a dry film thickness (DFT) of two mils is recommended for optimum coating performance but four mils are applied, coating purchase costs and air emissions double. Finish appearance and performance may also suffer because of runs, sags, cracking, solvent popping or excessive orange peel. On the other hand, if we apply a DFT of one mil, finish appearance and performance problems will most certainly follow (e.g., premature chalking, poor corrosion resistance, a streaky appearance and/or poor hiding). Light film builds result in rework, product replacement and/or dissatisfied customers.

In order to control film build, one needs to recognize the variables that affect it. Film build must also be monitored. Finishing operations that stress finish quality and performance quickly lose credibility when it is discovered they do not possess (or use) the equipment needed to monitor film build.

A number of interrelated factors affect film build. In a broad sense, these include the solids content of the coating, degree of atomization, spray gun output and finishing technique. The following briefly outlines how these factors affect the film build applied to a substrate.

Solids Content

The solids content of a ready-to-spray liquid coating has an obvious effect on film build rates. For a given fluid delivery rate and spray gun speed (i.e., spray gun movement speed of the

operator), coatings with a high solids content produce faster film build rates. In regard to film build and spray finishing, it is important to remember that we are concerned about the solids content by volume rather than by mass. After all, in a spray finishing process, we are typically applying a thin film of a certain thickness and areal extent (i.e., volume) on the substrate. I recall one company that could not understand why they were unable to achieve their target film build even though calculations (using wet film measurements and percent solids numbers) indicated they should have easily achieved their desired film build. After a review of their product specification sheet, it became apparent that they were using the coating's solids content *by mass* rather than *by volume*. As the solids content by mass was considerably higher than the solids by volume, it made

perfect sense why the applied DFT was always less than the estimated DFT. With respect to finishing applications, solids content by mass isn't very useful except for calculating air emissions.

Degree of Atomization and Spray Gun Output

Degree of atomization and spray gun output directly affect film build rates and applied DFT. A coarse degree of atomization (i.e., a large droplet size) and/or a higher fluid output results in faster film build rates - something that may cause a spray operator to unwittingly apply an excessive DFT to a substrate. Factors that influence fluid delivery and atomization include spray gun setup parameters, the type of application tool used and coating rheology.

Fluid Output

Spray gun output for production

finishing operations is primarily a function of fluid pressure, coating viscosity and fluid tip orifice size. In regard to air spray tools (i.e., HVLP and conventional air spray), increasing your fluid pressure ups the fluid stream velocity from the spray gun fluid nozzle. If the spray gun's atomizing air pressure is left unchanged or cannot be increased because of compliance reasons (i.e., HVLP compliance), the degree of atomization will coarsen simply because the atomizing air cannot "cut up" the fluid stream as effectively as it once did. Remember, with air spray equipment, we rely on compressed air to atomize the paint stream discharged from the spray gun.

Unlike air spray tools, increasing the fluid pressure to hydraulic atomization equipment (i.e., airless or air-assisted airless) actually improves the degree of atom-

ization obtained (for a given fluid tip). However, as you increase the fluid pressure on your airless or air-assisted airless system, you also increase your fluid output (something to keep in mind in regard to film build control).

Fluid Tip Selection

The fluid tip or nozzle selected for the spray gun is another variable that affects atomization. To achieve a given fluid output with air spray equipment, a small diameter fluid nozzle will require more fluid pressure than a large diameter nozzle. This means a higher velocity fluid stream will be discharged from the smaller nozzle. Again, unless the atomizing air is set to excessive levels to begin with (typical), higher velocity fluid streams typically require higher atomization air pressures. With respect to high fluid velocities, low viscosity coatings (e.g.,

stains, conventional solvent-borne coatings and automotive basecoats) are much more forgiving than high solids-high viscosity coatings. That is, for a high velocity fluid stream, an acceptable degree of atomization is more likely to be accomplished if you're spraying a low viscosity-low solids fluid as opposed to spraying a high viscosity-high solids coating. The effect of increasing the velocity of a fluid stream on atomization is much more apparent with high viscosity-high solids coatings because they are typically tougher to tear apart.

Here is the quick (and best) way to assess the fluid delivery rate and efficiency of your air spray operation. Just turn off the spray gun's atomizing air and trigger the gun. If you have a fluid stream that shoots across the room and/or the direction of the fluid stream immediately deviates from the axis of the fluid nozzle as it exits the gun, it is time to revisit spray gun setup procedures.

For airless and air-assisted airless, the coating is atomized in an entirely different manner. Simply put, atomization is accomplished by forcing the coating (typically using fluid pressures of 500 to 3000 psi) through a small diameter fluid tip orifice. For a given fluid pressure, a smaller tip orifice will produce a finer degree of atomization (think of it as a process similar to sticking your thumb over the end of a garden hose - the more you restrict flow with your thumb, the finer the water spray from the hose). Although

smaller orifice tips are more restrictive and may affect the ability to keep up with production, the greatest obstacles to change seem to be more frequent tip plugging and operator/supervisor perception (in regard to speed). I've seen a number of operations that could easily keep up with production and meet film build requirements with a smaller tip orifice, but stay with what they have for those reasons.

Coating Rheology

Characteristics of the coating, specifically viscosity and surface tension, have a significant affect on its ease of application. These characteristics are a function of the ready-to-spray solids content and coating formulation. Although few of us have the ability to determine a coating's surface tension, viscosity is an easy thing to measure. It is also a fairly reliable indicator of how difficult (or easy) it will be to atomize a coating. In general, as a coating's viscosity increases, it becomes less fluid and atomization becomes more challenging. At some point, certain application equipment (such as HVLP spray guns actually used in a compliant manner) may not be able to produce the finish you are looking for because it doesn't provide the atomization energy needed to form the droplet size required (a finer droplet size generally means a smoother finish). At this point, operators typically resort to excessive spray gun setup parameters (leading to high turbulence, poor transfer efficiency and a fog of overspray) or start reducing the coat-

ing with solvent additions (making it easier to apply, but defeating the purpose of high solids coatings).

Application Tool

The type of application tool used in conjunction with characteristics of the coating sprayed also affect the degree of atomization. This is where good judgment in application tool selection may pay off. The best example of how application equipment affects the degree of atomization achieved is to compare HVLP and air-assisted airless under two scenarios. Figure 1 depicts the atomization-fluid output regions you might expect from HVLP and air-assisted airless equipment when spraying a conventional (i.e., low viscosity), solvent-borne coating. The first thing you might notice is that air-assisted airless equipment produces a coarse droplet size in comparison to HVLP equipment (also note the disparity in fluid output for each spray tool). However, upon switching from a conventional solvent-borne coating to a high viscosity - high solids coating, the HVLP region will experience a significant shift (up and to the left of the chart), while the air-assisted airless region remains relatively stable. This is because HVLP, if used in a compliant manner, is much more limited in terms of atomization energy (remember, by definition, HVLP operates at a maximum air cap atomizing pressure of 10 psi). Depending on the coating's characteristics and fluid delivery rate, HVLP's degree of atomization may coarsen to such a degree where

orange peel becomes excessive and thin film builds are difficult to apply. Under these circumstances, conventional air spray or air-assisted airless may be the "tool-of-choice" because of their ability to produce a finer degree of atomization with high solids-high viscosity coatings. Benefits might include a smoother finish and better film build control.

The following example demonstrates the importance of equipment selection. A company in the aerospace industry had problems staying within its specified film build range. HVLP spray guns were used (as directed by the aerospace NESHAP) to apply a high solids coating. However, the applied film build had a tendency to exceed the targeted range (not a good thing—especially in the aerospace industry). The degree of

atomization produced by the HVLP spray equipment was identified as a potential contributor to the high film builds (remember that HVLP is often promoted through its ability to apply higher film builds per pass). Consequently, alternative application methods were investigated. Initially, the focus was on conventional air spray since its greater atomization energy capability would allow it to achieve a finer degree of atomization. However, after weighing in all the demands of the finishing operation (e.g., large target area, large variations in operator working height and film build objectives with a high solids coating), air-assisted airless appeared to offer some definite advantages over air spray. Initial trials with air-assisted airless produced favorable results in terms of finish appearance and film

build control. Additionally, because air-assisted airless is a high fluid pressure system, the fluid delivery rate would be relatively unaffected by changes in the spray operator's working elevation (in contrast to the low fluid pressure system of an air spray process). More extensive in-house testing revealed air-assisted airless technology significantly surpassed their HVLP application process in terms of finish quality, film build efficiency, transfer efficiency and waste reduction.

Finishing Approach

Finally, any article on film build control wouldn't be complete without mentioning the spray operator. In addition to the spray gun setup parameters identified above, a number of other "operator dependent" factors affect film build efficiency. These include the speed of the spray gun stroke, orientation of the spray gun relative to the substrate surface, gun-to-target distance and overlap. Finishing approach (i.e., the manner in which an operator finishes a specific workpiece) is another aspect that may lead to film build problems. Oftentimes, certain areas of a part will receive a greater or lesser number of spray passes during the finishing process simply because the operator is not cognizant of his or her finishing approach. Like any well-managed program, competent direction, good communication, training and quality control feedback (i.e., DFT monitoring results) does wonders in the area of problem recognition and correction.

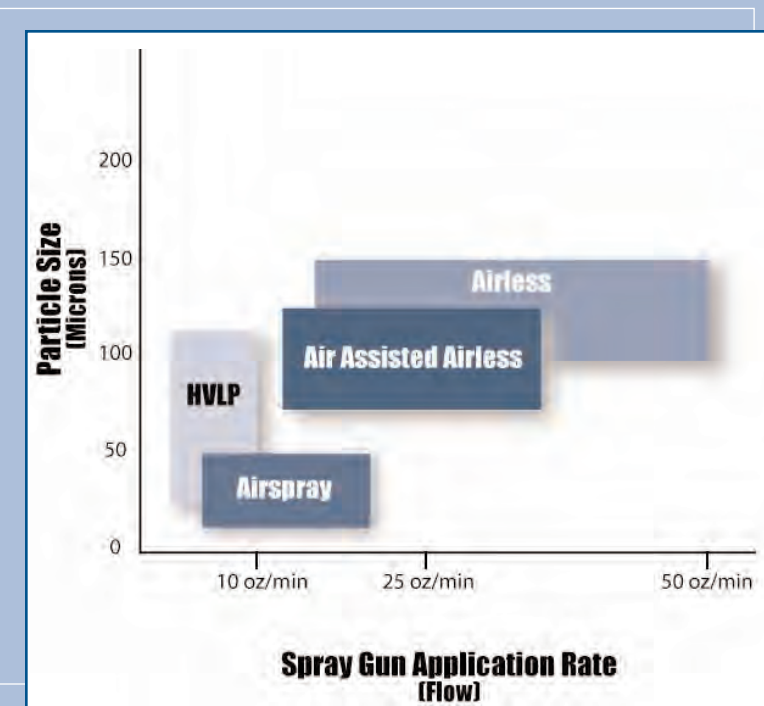


Figure 1. Degree-of-atomization / fluid delivery rate regions for liquid application tools applying a conventional solvent-borne coating. Courtesy of Glen Muir, Graco Incorporated.