Effect of Profile Uniformity on Coating Performance

This Month’s Question

Is it necessary to control the uniformity of the surface profile for coating performance (i.e., should the variation be less than 10 percent or 20 percent, etc.)? In addition, how important is it to maintain a constant distance from the surface and an angle of 90 degrees?

From Jerry Truettner, Heresite Protective Coatings Inc., Manitowoc, WI:

It is necessary to control the profile of abrasive-blasted metal surfaces to a degree. But it is not necessary to maintain an exact profile on all surfaces as long as the profile falls within an acceptable range. The acceptable range is usually determined by the type of coating and total dry film thickness (dft) being applied. Generally, the profile should be 20 percent to 25 percent of the total dft. For a typical thin-film coating applied at 5 to 7 mils (100 to 175 microns) dft, the acceptable surface profile range would be from 1 mil (25 microns) to 1.75 mils (44 microns). The deeper the profile, the more coating required to fill it and achieve the required dft. Inadequate surface profile jeopardizes the desired coating adhesion.

It is important that the blast nozzle be maintained at the correct distance (10-30 in. [25-75 cm] from the surface to achieve adequate surface profile. The air pressure at the nozzle, the type of blast nozzle, the size of abrasive grit, and the surface being prepared (rough/smooth, coated/uncoated) will help in determining the required distance from the surface.

The optimal distance from the surface occurs when the best blast pattern is maintained and an acceptable surface profile is achieved. Maintaining the correct distance from the surface will give the best productivity without sacrificing the blast quality. Holding the blast nozzle too close to the surface results in a narrower abrasive blast pattern; thus, it takes longer to cover a given area. Holding the blast nozzle too far from the surface can result in inadequate cleaning of the metal and may jeopardize the desired surface profile.

The angle of the abrasive blast is important as well. Holding the nozzle at the correct angle will improve the productivity of the blast. An angle that is too direct will cause the abrasive to rebound toward the blaster, reducing performance. The quality of the blast can also be altered because the spent
abrasive will build on the surface, thus reducing the effectiveness of the regular blast.

Too indirect of a blasting angle will alter the profile tooth anchor. This alteration will result in reduced surface adhesion. Abrasive blast rebound is sometimes relied on to prepare indirect areas, such as structural channels. In some cases, the rebound will provide a Near White Metal (SSPC-SP 10) blast but not necessarily the desired anchor profile for the coating that will be applied. In this situation, it may be necessary to change the blast nozzle to a 45-degree or 90-degree angle nozzle to achieve the desired profile.

Abrasive blasting has come a long way, and improvements in coating performance and longevity are being realized. For most industrial coatings, the White Metal (SSPC-SP 5) blast is important, but equally important is the correct surface profile obtained in relation to the coating being applied.

From Jimmy W. Fuller, Naval Sea Systems Command, Washington, D.C.:

It is nice to have a uniform surface profile but not absolutely necessary to ensure coating performance. Abrasive blasting is a learned art and not a laboratory science. A surface profile of approximately 2 mils (50 microns) has provided the best coating performance to date.

Many variables in abrasive blasting can have an impact on coating performance. One variable is the type of abrasive (for example, natural garnets, mineral slags, steel grit, and organic abrasives). Other variables include the type of equipment utilized, the dryness of the blasting air and abrasive medium, the actual air pressure, the cleanliness of the blasting air, the presence of surface contamination, and the ambient air.

The art of blasting requires various angles of attack to adequately remove the coating systems used by the U.S. Navy. At times, scouring the surface by holding the nozzle at an angle less than 90 degrees is necessary to remove the coatings. In addition, the blasting medium must have the appropriate particle size mix, or the required cleaning and surface profile will not be obtained.

The blaster will use the best angle to accomplish the job in the most effective manner. Generally, the surface is not examined under a microscope to determine if the profile has a hook or a void.

The distance from the surface is somewhat important, but I believe that the volume and pressure of the blasting air are more important. With adequate air pressure at the nozzle (i.e., 100 psi [690 kPa]) and appropriate metering of the abrasive, the distance from the surface and the angle of attack will be determined by the blaster. Experienced blasters will know when the process is operating correctly.

The coating being removed will also influence the correct distance from the surface. Some extremely hard surface coatings may require that the nozzle
be held within a few inches of the surface and not be moved very rapidly. Other surface coatings may allow sweep blasting with the nozzle a few feet from the surface, and the required profile will still be established. The variables are again the determining factors.

The type of coating system applied and the application system used (e.g., airless, air-assisted airless, high volume-low pressure) may affect the coating performance as well as the surface preparation.

Uniformity of surface profile is nice to have but not necessary. The distance from the surface and the angle of attack are important factors, but an experienced blaster is the most important part of the surface preparation and coating job.

**From Hernan Azocar, Clemco Industries, Washington, MO:**

There is no doubt among coating manufacturers and coating applicators that a precise profile over an entire steel surface area would provide the best possible foundation for coatings. When a profile can be controlled, in conjunction with the proper degree of surface cleanliness, there is a high level of confidence in coating performance. Modern industry’s recognition of the necessity of top quality surface preparation has contributed substantially to the success of many coating systems. There simply is no substitute for a properly prepared surface.

Profile uniformity is a tough goal to reach, especially with air blasting, because of many variables. Some of the factors are nozzle pressure, nozzle distance to the surface, nozzle blast angle, type of surface, and the choice of abrasive.

Types of surface are unlimited in scope. Removing millscale from new steel is one relatively mild consideration, but blasting on countless conditions of coated steel is a major concern. Added to the matrix is the selection of wide varieties of abrasive composition, size, hardness, specific gravity, and shape. The final and most complex part of the equation is the human factor—the person behind the nozzle.

With this set of circumstances, the industry has adopted a logical approach of striving for profile averages. Reasonable levels of screening accuracy on quality abrasive will result in a high percentage of specific particle sizes that will produce acceptable profile averages.

In reference to SSPC’s *Systems and Specifications* (Vol. 2), in Table 8 under the heading of “Surface Profile,” several types and sizes of abrasive are listed. The Table indicates typical maximum profiles and average maximum profiles. Profile readings are taken at several spots within a blasted area. Among those readings, there will be a few very high and very low readings of the peaks and valleys. The higher readings are referred to as “maximum profile.” All high readings are averaged out, and the result becomes the “average maximum profile.” Using the numbers on medium-sized boiler slag, for example, the maximum profile is 4.6 mils (115
microns), whereas the average maximum profile is 3.1 mils (78 microns) with variance factors omitted. The difference between maximum and average maximum is 1.5 mils (38 microns) or, in a percentage comparison, maximum is almost 50 percent higher than average maximum.

Nozzle distance and blast angle are 2 factors that also have an effect on production speed and profile consistency. Maintaining proper distance ensures uniform distribution of abrasive particles in the blast pattern. Too short a distance will create a smaller pattern, causing particles to interfere with each other and affecting the velocity speed required to generate the expected profile. It also slows the production rate because of a smaller blast pattern. Longer distances cause wide dispersement of particles and leave untouched areas in the blast pattern. An added detriment is loss of required particle velocity to produce the desired profile.

The angle of abrasive blasting is often overlooked in blasting applications. Ideally, a blast angle of 80 degrees to 90 degrees to the surface is the most effective in producing defined peak and valley profiles. As the blast angle moves from the perpendicular, abrasive particles will tend to skim the surface, leaving irregular profile shapes that may be too shallow for proper coating adhesion. Severe blast angles may result in complete absence of any profile peaks, and the surface could have the appearance of being cleaned with a grinder.

There are multi-layer coating applications where 45-degree to 60-degree blast angles are required; however, the surface should be re-blasted following coating removal to furnish the necessary roughness.

Profile is a necessary ingredient in the success of coating performance. It provides the means to bond coatings to the surface and ensures that the expected service life will be attained.

From James R. Molnar, Union Tank Car Company, East Chicago, IN:

Control of surface profile uniformity is desirable, if not imperative, to achieve uniform coating film thickness and associated performance. To optimize coating material usage, one must have process control of the abrasive blast operation and the blast profile thereby generated. We would expect the uniformity of profile to be held to a 20 percent spread, so that the sprayer is not expected to compensate for variance in profile by varying the applied coating thickness and so that exceptionally high profile peaks do not penetrate the cured film, especially of a first coat or “shop primer.” We have found that a 10 percent variation is reasonably achieved, as measured with replica tape.

Although the ideal position for the air blast nozzle is 90 degrees to the surface, the shape and size of railcars and the associated available access from existing booths and catwalks do not always permit this angle. The normal approach tends to be less than perpendicular, more like a 45 degree angle, which we have found to be suitable for practical purposes.
Distance from the substrate is certainly a factor in the profile equation, but by far, the major actor is the abrasive work mix. Constant air pressure of 85 psi (590 kPa) or above is also needed. The actual optimum nozzle-to-work distance may vary on a per-job basis, e.g., the removal of various thicknesses and types of old coatings versus the removal of mill or furnace scale from new steel.

November 1992