ProblemSolvingForum

Amy Forsgren
Swedish Corrosion Institute
Stockholm, Sweden:

If all three coats are exactly the same paint, go ahead and make up the difference in the next two coats. Otherwise, no.

The coating adjacent to the metal is the only coating that can offer active corrosion protection. For this reason, the primer is the only coat that contains anti-corrosion pigments (zinc dust, zinc phosphate, aluminium triphosphate, etc.). Most active anti-corrosion pigments must be in the layer bonded to the metal in order for their protective mechanisms to work. Therefore, these pigments are not found in most intermediate coat and topcoat formulations, since their existence in these layers would be rather pointless.

If the primer, for example, contains aluminium triphosphate (a good anti-corrosion pigment) and only half the amount recommended by the coating manufacturer is applied, it will do no good at all to make up the difference with an intermediate coat whose pigment is titanium dioxide (an inert pigment of many sterling qualities, including opacity and whiteness, but offering no corrosion protection).

Subsequent layers are there to protect the primer from environmental or mechanical damage, and they can help build up a barrier against water and oxygen. In order to build an effective barrier, however, the coating system is usually very thick—a couple hundred microns for an epoxy mastic system, for example. If the manufacturer’s recommended primer thickness is only 50 microns (2 mils), it probably relies on active anti-corrosion pigments rather than merely barrier properties to provide the corrosion protection.

Check with the coating manufacturer about the particular paint system. In the scenario presented, if the primer contains anti-corrosion pigments, half of the specified thickness would not be sufficient. The best thing to do would be to remove and reapply the primer at the full specified thickness.

David Kuniega
Pennsylvania Department of Transportation
Harrisburg, PA, USA:

The answer to this problem is somewhat difficult to pinpoint, since further detail on the components of “a three-coat polyurethane” paint system would be required to determine the proper course of action. The intent of the question seems to indicate that in this three-coat polyurethane paint system, all coats are similar in composition and perform the same function. The stated primer thickness does not seem to be in a range typical for a zinc-rich primer. Thus, I will attempt to answer the question based on when a primer is and is not similar to the remainder of the system.

If the system includes a sacrificial primer (i.e., zinc-rich), then a 50% reduction of this primer could not be made up by additional thickness of the intermediate coat and topcoat. Therefore, more primer would be needed to meet the specification. The protective function of the intermediate coat and topcoat of most three-coat polyurethane paint systems is barrier in nature. These coatings could not be easily substituted (on a mil-per-mil basis) for an equivalent thickness of a sacrificial primer to obtain equivalent field performance. These systems are best used when high levels of cleaning can be achieved (i.e., SSPC-SP 5, White Metal Blast Cleaning [the equivalent of Sa 3], or SSPC-SP 10, Near-White Blast Cleaning [the equivalent of Sa 2 1/2]).

There are, however, examples of three-coat polyurethane systems that do not include sacrificial primers. If the situation described involves a three-coat barrier polyurethane system, where all three coats are equivalent in compositional nature and field performance, then one might be able to accept the substitution of additional dry film thickness to the intermediate coat and topcoat. This option would depend on the fact that the additional thickness of these coats does not exceed the manufacturer’s technical requirements for maximum thickness per coat. Other
wise, extended cure time, blistering, and delamination could result. These systems are traditionally used for maintenance/spot/zone applications over SSPC-SP 6, Commercial Blast Cleaning (the equivalent of Sa 2), or less.

**R.B.L. Agarwal**  
**Grasim Industries Ltd.**  
**Birlagram-Nagda, India:**

A coating system is more than just the material applied. It includes the surface preparation requirement as well as the application of a number of coats, separately applied in a designated order and to specified thickness. The entire coating system, not just one part of it, protects the steel. Normally, each coat contains specified proportions that contribute to the success of the total coating system.

The primer is designated to be the first coat applied to the surface. One of the most important functions of the primer is to provide adhesion to the substrate and binding to the subsequent coat.

Surface preparation helps to remove contaminants that interfere with adhesion, and it creates a surface profile. The profile on an abrasive-blasted surface could vary from 35 microns (1.4 mils) onwards. Hence, a 50-micron (2-mil) primer would be required, rather than the 25 microns (1 mil) applied by the contractor.

**David Carrick**  
**S.G. Pinney & Associates, Inc.**  
**Metairie, LA, USA:**

Although it would be a lot more convenient and quite easy for the contractor to make up the 25-micron (1-mil) difference with the next two coats, it is not the acceptable answer.

In Appendix B of the SSPC Good Painting Practice Manual, the word “primer” is defined as the first complete coat of the painting system applied to a surface. It also points out that the primer is formulated to meet the special requirements of the surface. Primers may be formulated with special anti-corrosive pigments, such as zinc chromate or zinc powder, for substrate protection. This type of formulation may not be found in the intermediate coat or topcoat.

If the primer of a three-coat system is applied at less than the required dry film thickness, this can open the door to premature failure and a reduced life of the system as a whole. Coating failure can occur because of insufficient coverage of the steel profile, which allows rusting of the exposed peaks of the substrate prior to the application of the next coat of the system. Depending on the primer formulation, the low dry film thickness may not sufficiently protect the substrate. An
example would be a primer containing zinc powder. It is possible that only half or less of the zinc powder will be applied to the substrate, reducing the anti-corrosive properties of the primer.

Therefore, it is imperative that the specification be followed and that the required film thickness be applied for each of the coats of the three-coat system. If insufficient primer was applied on the first application of the primer and the manufacturer’s data sheet allows sufficient recoat time, then a second application of primer may be applied to meet the specification.

K.E. Haugland
Jotun Paints Flixborough, UK:

The primer coat in a coating system serves more than one purpose, the most obvious ones being to act as a foundation for subsequent coats as well as to constitute the primary link in corrosion protection of the substrate.

For a primer to provide the best foundation for subsequent coats, it is important that it has very good adhesion to the substrate, that the cohesion of the film is good, and that it provides good adhesion for the following coat. Most coating manufacturers will declare a minimum and maximum dry film thickness (DFT) for their products, often combined with a typical or recommended DFT.

DFT that is too low may influence the coating’s ability to flow out across the substrate and penetrate the surface profile, leading to the possibility of reduced adhesion. Certainly in the case of spray application, a DFT that is too low may obstruct the formation of a continuous film, resulting in a film with pores or pinholes and reduced cohesion. The extreme illustration of this is dry spraying, whereby adhesion, cohesion, and bonding with the following coat will be very unsatisfactory (not to say disastrous).

Although not part of the scenario in the question, one should also bear in mind that excessive film thickness (caused by over-application) is also likely to influence the performance of the primer coat. The most common problem in this respect is solvent entrapment in the film, often leading to blisters and/or possible air entrapment during spray application, thereby resulting in reduced cohesion within the film.

Assuming that the physical properties of the primer film remain satisfactory in spite of a low DFT and that the total DFT of the coating system has met specification requirements, we must move on to consider the corrosion-protective abilities of the system. There are three ways a primer may protect the substrate against corrosion: as a barrier, through passivation, and by cathodic protection. Some primers employ only one of these, while others use a combination.

All primers form an important part of a barrier between the substrate and the environment, reducing the amount of aggressive ions, water (humidity), and oxygen that may reach the substrate and lead to corrosion. Incorporating flake-shaped pigments in the film, typically made from aluminium, micaceous iron oxide, or glass, increases this barrier effect. Whether low DFT in a primer can be compensated for by increasing the thickness of the following coat(s) will depend on how similar (or different) the primer and the subsequent coatings are. If their characteristics in terms of permeability are similar, one could argue that such compensation would be adequate in terms of the barrier effect (provided the subsequent coats are not over-applied).

Primers providing a passivating effect on the substrate will typically contain zinc phosphate (or zinc chromate or red lead, if still in use). Moisture penetrating the film will transport corrosion-inhibiting ions to the substrate surface, where they will inhibit the process of corrosion.

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If the amount of available corrosion-inhibiting pigments is considerably reduced due to low DFT, one could expect that the performance of the primer would be affected as well. An increase in the thickness of inert mid-coats would not compensate for this reduction of active corrosion-inhibiting pigment.

Primers containing metallic zinc dust can prevent corrosion by employing the principles of cathodic protection. The zinc dust will protect the steel in the same way that galvanising or sacrificial anodes work, particularly in areas where the coating system has been damaged. However, the galvanic effect is influenced by the size of the anode. A lower DFT of the zinc-containing primer provides less anode material (zinc dust), while a higher DFT provides more anode material. Although the electrochemical potential (volt) between the zinc and steel remains the same, the size of the anode determines the electrochemical capacity (ampere-hours). Increasing the DFT of subsequent mid-coats with no zinc dust content will have no effect on this situation other than extra protection for the reduced amount of zinc dust present.

Primers function in various ways, depending on their generic type and the properties cultivated while developing their composition. An evaluation of the type of exposure and the environment where the coating system will be used is important. In most cases, there are genuine reasons for specifying the DFT of individual coats in a system instead of just identifying the total thickness of the full system. As noted, DFT that is too thin in a primer coat may in theory affect the performance of the coating system. To what extent this will be noticeable in practical aspects will depend on a number of factors. Only an evaluation based on an intimate knowledge of the product itself (e.g., its composition and physical limitations) can point to the answer of the problem in question. It might be possible that the contractor has sufficient information and knowledge to carry out this evaluation. However, my advice would be to contact the manufacturer/supplier of the relevant coatings to clarify the options and consequences.

Mike Alexander
Garneau Inc.
Calgary, Alberta, Canada:
We have to assume that all specifications are written for a particular purpose and that the specification writer knows what he or she is doing. Otherwise, the coating system might fail “by design.”

In this case, it is extremely important for the engineer to specify the primer thickness and the anchor pattern depth, to give the tolerances in the primer thickness, and to specify the accepted

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tool and method to determine the primer thickness. At such low thicknesses as 25 or 50 microns (1 or 2 mils), the primer coat is extremely hard to measure, especially over blasted steel. The numbers shown by different measuring instruments can be quite deceiving.

There is usually a huge difference in performance of the coating system depending on the primer thickness, especially in wet, elevated temperature tests. Higher thickness of the topcoat cannot and will not compensate for the thinness of the primer. Therefore, another layer of primer is needed to achieve the specified thickness.

It is acceptable for the contractor to suggest changes to the specification before the beginning of the job as part of regular negotiations aimed at reducing costs or improving quality. However, after the job is started, the contractor should neither deviate from the specification nor suggest changes to cover up poor work. In other words, what is the point of writing the specification if we do not intend to adhere to it?

Alan Rawson
New Hampshire Department of Transportation
Concord, NH, USA:
Contractually, the contractor only furnished half of the specified primer. This fact begs the question of how the project was completely primed without the contractor’s own quality control recognising and addressing this problem. And where was the inspector?

With all of that aside, if the owner is considering letting the contractor off the hook, then we need to assess whether there is a difference in long-term performance if the shortfall in primer is made up with the topcoats. There are a couple of factors that would influence the outcome: the primer material and how the film thickness was specified.

From the information provided, we know that the primer is an organic polyurethane. We do not know if this resin is loaded with zinc, for cathodic protection, or other corrosion inhibitors. If it is a zinc-rich primer, then there will be a significant loss to the owner in long-term protection if the last 25 microns (1 mil) of primer are not applied. Conversely, if the primer is a typical penetrating sealer or a straight urethane barrier coat, then making up the film thickness with the topcoats would be an acceptable solution.

If the owner is still having difficulty making a decision and the primer contains a corrosion-resisting material, then we need to look at how the film thickness was specified. Does the coating specification say that the dry film thickness will be measured from the profile peaks? If it does not, the original performance intent for the primer may be even further from realisation.

Most new steel has a specified profile in the range of 25 to 75 microns (1 to 3 mils). The Type 2 magnetic film gauge measures from an imaginary plane located between the peaks and valleys of the surface profile. On a typical abra-
sive-blasted surface of 70 microns (2.8 mils), the imaginary plane might be down 13 microns (0.52 mil) from the peaks. With this scenario, if the film gauge is reading 25 microns (1 mil) of primer, there would only be 12 microns (0.48 mil) of primer above the profile peaks.

The actual coverage achieved is further complicated by other issues. A Type 2 gauge in good condition has a variability of 10% to 15%. If this variance is coupled with the statistical variation that is inherent with profile development and coating application, there will very likely be profile peaks protruding through the primer coat. These uncoated peaks would be the expected points of early failure (rust bloom).

With all this said, I think the owner needs to take a hard look at how he or she ended up with this situation. The contractor has virtually no quality control, was motivated by the material cost differential to skimp on the primer, or both. Regardless of the reason, I suggest that the contractor be required to furnish another 25 microns (1 mil) of primer. And for the next contract, I recommend to the owner that the specified primer film thickness be increased to a more typical 75 microns (3 mils). This thickness will help ensure adequate coverage over the profile peaks and sharp edges.

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**Upcoming Questions**

- Is it cost-effective to pressure wash a bridge or other structure before abrasive blasting? What pressures, flow rates, and procedures are recommended?
- A specification requires Proprietary Paint A, but the application contractor says that Proprietary Paint B is just as good. The manufacturer of Proprietary Paint B says that his material is the same as the specified product except that the resin in Paint B is slightly modified. How should the specifier respond?
- What causes static electricity during abrasive blasting and shot peening? What risk does it pose and how can it be controlled?
- When using coatings with a solids content of 95% or greater, what kinds of defects, such as holidays or micropores, are possible or likely to occur in the applied film?
- I am the maintenance engineer of an inland oil refinery and wish to upgrade my painting system. I am aware that salt spray testing does not accurately predict performance of a coating and that several accelerated cyclic tests are now being used. What is the best accelerated test for screening candidate coating systems?
- To comply with clean air regulations, I am going to begin using water-borne rather than solvent-borne coatings in my shop. What changes in operations (e.g., workflow, training, equipment, QA/QC) are necessary to assure success?
- High-pressure water cleaning and abrasive blasting are recommended to remove mildew from concrete. Do these methods allow residual organisms to reinfect the surface and, if so, what can be done to prevent reinfection?
- What techniques can be used to meet a specification requirement that limits chloride content to 5 micrograms or less per square centimetre inside ships' ballast tanks prior to recoating? Is the requirement derived from an industry norm? Is it reasonable?
- What coating problems are likely to be encountered in storage tanks that have dissimilar metal sides and floors?

Responses should be 1-2 typed, double-spaced pages and sent along with your name, address, and telephone and fax numbers to:

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