Hands On

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Chromate Conversions

Teamwork is something for which there's simply no substitute. Sure, you may feel as though you work harder than anybody else, but the fact remains that the accomplishments of the group would be difficult to achieve by yourself. The same is true of the parts that you plate, and then coat with a chromate conversion coating. Although I've never heard them argue, a zinc coating is not much good without the chromate that goes on it, and the chromate isn't any help without the zinc under it. A piece of 6061-T6 benefits from a close relationship with a little chromium, too.

Chromate conversion coatings can take on many characteristics, some of which can be seen, and some that really can't be seen. There are some general rules, however, that govern how almost all of them operate. Once you know how they work, you might be a better finisher ... get that big raise ... buy a summer home by the ocean ... have a garage full of classic cars ... the possibilities are endless!

So let's first discuss why they're called "conversion" coatings—not necessarily the best name for them. They do, however, "convert" the exposed surface from whatever is under it to a layer of chromium-bearing stuff. Perhaps it would be better if they were called "fungus-like parasitic globs on a metal-that-they-once-tried-to-eat" coatings. Let me explain.

You see, the first thing that conversion coatings attempt to do is to chew up some of the surface onto which they are going to deposit. In the process, they begin to let some chromium come out of solution, forming a thin layer of the metal chromate on the surface. In reality, it is just an organized way of corroding the part! The layer of metal chromate constitutes the "conversion" of the surface from bare metal to something else.

The initial layer is predominantly trivalent chromium, combined with the metal onto which it is coated. Once the reaction has begun, more chromium tends to be attracted to the surface, and the thickness of the coating builds. As it does, more and more hexavalent chromium accumulates in the deposit, because there is less and less base metal with which to react. That isn't bad, though, because the hexavalent chromium will stay there after the part is dried, acting as a reserve in case any metal becomes available with which the hexavalent chromium can react. In practice, this means that the part will resist corrosion for a longer period of time if a heavier chromate is deposited on it.

Appearance vs. Durability

How thick is thick? That depends—like everything else in this business—on several factors. If a shiney, chromium-plated simulation is needed, then a *blue-bright* or *clear* chromate is used. It appears clear or blue because the coating is relatively thin, containing about four times as much trivalent as hexavalent chromium. Trivalent chromium is blue, so the coatings have a pleasant blue hue. If the coating becomes too thick, however, it will begin to entrap more hexavalent chromium, and turn yellow. If long-term corrosion resistance is desired, then appearance should be sacrificed (I have learned to appreciate a nicely done yellow, even olive-drab, chromate), because the parts will last much longer. Yellow chromates are much thicker than blue-brights, and it is worth noting that the yellow color is imparted from the increased amount of hexavalent chromium reserve available. Olive-drab chromates last even longer, primarily because they're about as thick as ... well, they're *real* thick.

In a salt-spray chamber (or "salt box"), a clear chromate on zinc plate is supposed to last about 24 hr. A yellow chromate will withstand 96 hr nominally, and an olive-drab will go more than 100 hr before red rust. A plain piece of zinc-plated steel will only last about six to eight hr under salt spray.

A salt-spray cabinet, by the way, as specified by ASTM B117, contains a five-percent mixture of salt (NaCl) in water at pH 7-ish, sprayed in a fog-like mist at 95 °F. Parts are hung in the chamber at a 15–30-degree angle to vertical, and observed periodically to see how they're doing.

Chromating on aluminum is a rather special case, although it still follows the rules of thickness and color. A yellow chromate on the most difficult-to-chromate wrought alloy (usually 2024 T3) is supposed to withstand 168 hr of exposure to salt spray before it is officially pronounced corroded. That is a requirement of MIL C 5541. Of course, one reason why it is required is because it really is pushing the limit of yellow chromate, and everything has to be right for the parts (five must be tested) to pass the test.

Speaking of chromating aluminum, there is one other unique property of chromates as corrosion-preventive coatings. *When properly applied*, they will exhibit very low electrical resistance, which to an electronics manufacturer means that parts can be assembled after they have been coated, simplifying the task. Of course, there is a requirement in MIL C 5541 for that, as well.

It should also be mentioned that many vendors now offer chromates for doing clear work that don't contain any hexavalent chromium. The idea is that the waste will be easier to treat. Some of them do look very good, and exhibit a pleasing blue color *when properly applied*.

Chromates are very economical to use, considering the value they add. Providing parts with improved corrosion resistance is an important aspect of surface finishing. I wouldn't make reservations for the island cruise yet, though ... I haven't said anything about the *when properly applied* part of chromating. Next time .... ❑