

Anodizing by Constant Current Density

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Today, the modern anodizer is faced with challenges never before considered. The quest for Quality and reproducibility has become the by-word of many of their customers. SPC, Quality, Computer Controlled lines, Auto-analyzed process tanks and many other advances have pushed many of the anodizers into the "high-tech" world of finishing whether he likes it or not. This is not all bad though. Some of the advances, properly implemented, can save the anodizer a lot of time and money.

However, even with these advances, many "old-time" finishers hold on to the old, out-dated methods of doing things. Of these methods, the use of **CONSTANT VOLTAGE** for anodizing stands out. Some anodizers will not consider the many disadvantages of anodizing by constant voltage rather than the more preferred way of using constant current.

One of the most commonly used excuses is **"I run a job shop and the parts I receive are too complex to be measured"**. The reality is that in most job shops, at least 70-80% of the parts received can be measured, but it is easier to "do it the old way"; a "cop out". Another way an anodizer can help himself is to get the customer to give him the surface area of the parts from his auto-cad program. But, he will have to ask!

There are some anodizing jobs that will not require this type of control. "Commercial" finishes only require evidence of an anodic oxide and would not be considered as a quality anodize – only a necessity!

CONSTANT VOLTAGE

Anodizing by constant voltage can be compared to driving your car blindfolded. Because the voltage is only the **driving force** (much like the car's accelerator pedal) in a very dynamic system, other methods of control must be employed. The best method is the use of **CONSTANT CURRENT DENSITY ANODIZING**.

CONSTANT CURRENT

Let us again refer to the above automobile analogy. If we consider the accelerator as the voltage and the current as the Cruise Control, we can see how constant current is a more controllable system of finishing.

As you are aware, when using cruise control on your automobile, you set the desired speed (amperage). You then allow the accelerator pedal (voltage) to accelerate or decelerate as needed to maintain this speed. This is the same thing that happens in an anodizing tank. The voltage will fluctuate according to the needs of the system being anodized, while maintaining the required amperage. Bath temperature, acid concentration, aluminum content, aluminum alloy, temper resistance and many other variables will change the voltage necessary to give you a good, consistent

anodic oxide.

THE ANODIC OXIDE

The anodic oxide is an extremely good resistor. As its thickness increases, the more resistant to passage of electrical current it becomes. Therefore, a constant voltage level, applied in the anodizing bath, will only be able to overcome a certain level of resistance. This means the current density will decay as the anodizing process continues, producing an anodic oxide that will be less and less abrasion resistant. Conversely, an anodic oxide, formed at a constant current, will be consistent throughout, regardless of the changing conditions.

SAVINGS

Another advantage to using constant current is the time saving. Because of the current decay when using constant voltage, it takes longer to form the necessary oxide thickness. With constant current, you can accurately predict the time necessary to form a given oxide thickness (**720 Rule** - see below). This means that the parts being anodized will spend less time in the sulfuric acid bath and will have less outer surface oxide dissolution due to the proximity of the oxide to the acid.

No matter the makeup of the anodizing electrolyte, the sulfuric acid in the bath will dissolve and soften the oxide to some extent (a function of time and temperature). The higher the electrolyte temperature, the higher the dissolution rate. If a combination of high temperature and low current density are employed (as might be the case with constant voltage), the resulting oxide will have low abrasion resistance and will most likely offer high resistance to adequate sealing.

Many anodizers who employ constant voltage anodizing would be astounded at the production increases they could realize if they were to control the current instead of the voltage. As stated above, the anodizing time and the oxide thickness can be predicted very accurately when aluminum alloys are anodized at constant current.

The 720 Rule

We know, for instance, that it takes **720 amp-minutes per square foot to produce 1.0 mil of oxide** (except in the case of the 2xxx and some casting alloys). Therefore, if we want to know how long it will take to anodize a part to 0.7-mil oxide thickness (Class I Architectural finish) at 15 asf, we simply plug the knowns into the formula and solve for the unknown.

Therefore:

$$720 \div 15 \times 0.7 = 33.6 \text{ minutes.}$$

Many anodizers have to keep the parts in the anodize tank for 50-60 minutes to attain 0.7 mil oxide thickness. This is because they are anodizing at constant voltage and having to allow for current density decay. If, on the other hand, they anodize by constant current, a considerable timesavings will be realized (in this case, 16-26 minutes).

Therefore a typical anodizer who anodizes by voltage can, in many instances, double his production and produce a more acceptable part at the same time.

As an example, alloys 5005 and 1100 were anodized under various controlled conditions and the

parameters recorded (see Table I). From these data, you can see the value of anodizing by constant current, namely:

1. The oxide thickness was well within the predictable range on the parts anodized using constant current, whereas the parts anodized by constant voltage had a wide oxide thickness variance.

2. As the temperature was lowered, the oxide thickness variation was greater.

RAMPING

Another anodizing consideration, which must be taken into account, is the ramp speed: "How long do I take to reach full current?"

There is no hard & fast rule to follow. If the ramp speed is too fast, burning of the parts can occur; if too slow, soft, mossy oxides will be formed due to the low current densities employed during ramping and the solution effect of the electrolyte because of prolonged anodizing times.

In the case of **Type II (68-72°F)**, a ramp speed of 15-30 seconds is usually sufficient if the parts are correctly & tightly racked.

For **"pseudo" hardcoating [45-55°F]**, (with appropriate anodizing additives), the ramp speed will be in the range of 45 seconds to 1 1/4 minutes.

Type III, hardcoat anodizing (30-45° F) requires a somewhat slower ramp, usually 1-2 minutes, to guard against the possibility of burning.

If the ramp time is extended much beyond these times, the anodic oxide quality can be grossly affected. Soft oxides will be formed which will accept dyestuffs readily, but will also allow these same dyes to leach very rapidly during both rinsing and sealing. This type of anodic oxide structure is difficult, if not impossible to seal due to the very "open" pore structure formed. Obviously, the formation of a softer oxide will give negative results to any abrasion tests run on the anodized part's surface.

There are a few alloys that will not lend themselves to "fast" ramp speeds. The 2XXX alloys and some casting alloys exhibit a greater tendency toward burning when the current is applied too rapidly. However, even these "problem" alloys will react positively to a moderate ramp speed (2-3 min).

Over the years ramping times have ranged from **10-60 minutes!** In these cases, the anodizer was dismayed that he could not pass a simple seal test, or a salt spray test, or an abrasion test, or understand why his dye leached so badly in his rinse and seal tanks. It was not until he decided to anodize by constant current and to control his ramp speed that these tests were passed & the dye and seal chemical usage was greatly reduced.

EDUCATION

None of the facts presented here are **new**. Mostly, they are common sense items that have been overlooked or forgotten for some reason. Maybe we did not train new anodizers correctly. The rush to do a "fast" job may have gotten in the way of doing a "quality" job. Competition could have lured us into forgetting our basics and we accepted the "easy" way as the "correct" way.

For whatever reason(s), we should look at how we are anodizing and determine if we want to stay in this business or be replaced by other coatings which **DO** use forethought and quality to gain a foothold and market share in our customer base.....the choice is **OURS!!!**

Table I
Oxide Thickness Variations

Alloy	Temp. Deg F	Anod. Conditions	Oxide Thickness (mils)
5005	70	Current Density	1.19
5005	70	Voltage	0.96
5005	63	Current Density	1.23
5005	63	Voltage	0.78
1100	70	Current Density	1.22
1100	70	Voltage	0.96
1100	63	Current Density	1.21
1100	63	Voltage	0.78

Anodizing Conditions: 60 min; 185 G/l sulfuric acid