TECHNICAL BULLETIN

Aluminum Anodizers Council™

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"Sulfuric Acid Anodizing with Aluminum Cathodes"

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Sulfuric Acid Anodizing With Aluminum Cathodes

Today's quality-conscious finishing shops are concerned with saving money, producing more quality products, and reducing the emissions of toxic materials to the environment. Energy conservation and general cost effectiveness are strongly emphasized principles in today's finishing circles. In sulfuric acid anodizing, savings in both energy and capital costs can be realized through the employment of aluminum (AI) cathodes in place of traditional lead (Pb) cathodes.

Relative Conductivity of Select Metals (IACS)*

Copper	100.0 %
Aluminum	60.0 %
Lead	7.8 %
Titanium	4.0 %

*Kirk-Othmer Encyclopedia of Chemical Technology

Table 1

Used for years as the cathode material in anodizing systems, lead has only 8 to 10 percent the conductivity of copper (see Table 1). On the other hand, extruded aluminum bars or sheet products have 50 to 60 percent the conductivity of copper, and conserve 40 to 50 percent of the energy wasted by the generation of heat in an anodizing bath. In fact, many large and small installations using aluminum cathodes report very successful results. Most anodizers report significant savings in refrigeration costs, as well as reduction in anodizing time at a given current density. More importantly, they observe the absence of lead in their effluent!

One concern of potential users is the dissolution of aluminum cathodes during idle or "non-anodizing" periods. However, it has been reported that the accompanying slight increase in the concentration of aluminum is not measurable. Normal decanting methods made the small amount of additional aluminum buildup insignificant. An anecdotal report based on four years of experience with a two-shift operation noted a cathode loss of just 1.0 mm/yr. (0.039 in/yr.)

Cathode Material

Several aluminum alloys are suitable as cathode materials. Because of their availability, extrusion alloy 6063 and sheet alloys 1100 or 1350 are among the alloys most often used. Alloys in the 2xxx, 4xxx, and 7xxx series are not candidates because of their relatively low conductivity and high dissolution rates in acidic environments. All tempers should be "Full Hard" for optimum conductivity, e.g., 6063-T6.

It is important that the correct temper of the chosen alloy be used. T6 or T5 tempers in the extrusion alloys should be the ONLY tempers used. Under NO condition should the overaged temper (T52) be used. Although the sheet alloy temper appears to be of less importance, the harder tempers are the most popular.

Anode/Cathode Ratio

An anode-to-cathode area ratio of 3:1 is acceptable. A ratio of 5:1 also has been used with success under special conditions, e.g., to maintain a uniform oxide thickness on all surfaces when it is necessary to anodize blind areas or deep crevices. This "starving cathode" mechanism gives better and more even throwing power throughout a densely loaded rack of parts than do other cathode materials.

Although the easiest material for fabricating cathodes is flat stock (see Figure 1), it is sometimes necessary to provide a greater amount of cathode area in a small space. When parts with large surface areas, such as automotive trim, are anodized in each load, it may be difficult to provide the desired cathode area. For this reason, a fluted extrusion can be used (see Figure 2). This design provides more surface area in a small space and the desired ratio of anode/cathode area can be maintained.

Typical Flat Aluminum Cathode

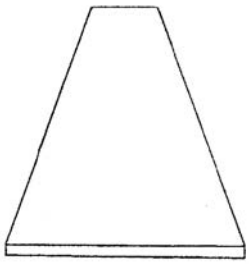


Figure 1

How to Determine Optimum Cathode Area

Typical Fluted Aluminum Cathode

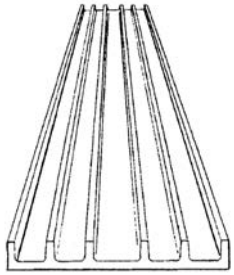


Figure 2

Determining the optimum cathode area for your particular anodizing system can be somewhat confusing when you first look at it. How many square feet do I need? How do I figure the area? These are the most common questions asked when someone is first deciding to install aluminum cathodes.

The answer is a simple one. Use the mathematics of your anodizing system to help you! For example, suppose you have a 15,000 amp rectifier and you anodize at 15 amps per square foot. Simple mathematics tells us that your can anodize 1,000 square feet of material; therefore, your total square footage of cathode area would be 1,000+3 or 333 square feet. This total area should be divided in half (333+2 =166.5 sq. ft.) and the 166.5 square feet of cathode placed on one side of the tank while the remaining 166.5 square feet of cathode is placed on the opposite side of the tank.

Proper Cathode Placement

Cathodes must be properly positioned in an anodizing tank to realize maximum effectiveness. This is especially true when aluminum, with its higher conductivity, is used as the cathode material. The cathode must provide a relatively even flow of current to the anodes (workpieces) in order to obtain consistent anodizing on all surfaces. The minimum anode-to-cathode distance is 25cm (10 in.). It is important to position the cathodes with respect to the work so that areas of current concentration are avoided, or at least minimized.

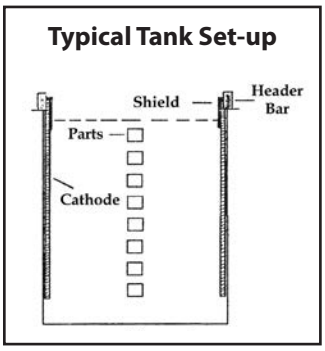


Figure 3

The vertical depth of the cathodes in the anodizing tank should not extend below the bottom of the workpieces. The top of the cathode, below the surface of the electrolyte, should be masked with plastic covering to a depth equal to the top of the workpiece. Cathodes placed along the side of the tank should not exceed the length of the longest material being anodized. When short workpieces are anodized in a tank outfitted for longer objects, plastic cathode shields should be installed to block the excessive cathode areas (see Figure 3). Alternatively, plastic anode shields can be placed on the work rack at right angles to the cathodes and at the ends and bottoms of workpieces to improve the uniformity of current distribution. Shielding will reduce the possibility of unusually thick buildup of oxide on the end, top, or bottom of the work and produce more uniformly anodized material.

Attachment and Maintenance

The aluminum cathodes should be cleaned, deoxidized, clamped tightly and welded to an aluminum header bar. All welds should be located above the electrolyte level. The weld should be continuous along the sides, top, bottom, and back of the cathode where it is attached to the header (see Figure 4). There should be no voids in which sulfuric acid might be trapped. Use only 5356 alloy welding wire. Other alloys can cause undue corrosion of the joints.

The header bar should be attached to the cathode bus conductor as far away from the tank as possible to avoid contamination of this joint from sulfuric acid mist, spillage, or drippage.

To ensure the electrical integrity of all-aluminum bus systems, connections should be welded rather than bolted. If bolted connections must be made, however, stainless steel bolts (type 316 or 316L), pressure plates, and Belleville spring washers should be employed. The mating surfaces should be clean and a joint compound* applied prior to tightening. Maintenance inspections should be scheduled to ensure that the joint is tight and not overheating.

Because of their light weight, aluminum cathodes can be removed easily when maintenance of the anodizing tank is required. Pick-up rings can be welded to the header, corresponding in location to the hooks of a crane to make removal and reinstallation relatively simple (see Figure 4).

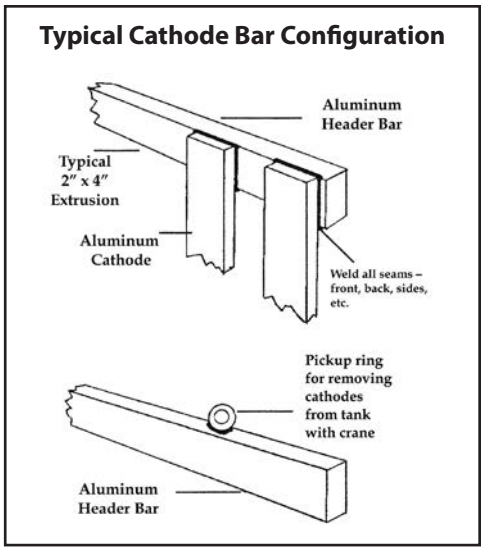


Figure 4

Energy Savings

With properly installed aluminum cathodes, a 1- to 2-volt reduction in cell voltage during the anodizing cycle can be achieved, as compared with a standard lead-cathode system. For example, a lead setup consumes 10 to 30 kW more electrical energy than an aluminum-cathode system when a 10,000 amp rectifier is used at full capacity. This wasted energy generates heat in the anodizing tank. With aluminum cathodes, a saving of electrical power also will be realized as a reduced load on the refrigeration system. Because more of the energy is used for anodizing, less heat is generated, the system is more energy efficient, and more oxide growth per unit time is realized.

In summary, the increased efficiency and associated energy savings offered by aluminum cathodes should be of substantial benefit to prudent, quality-minded sulfuric acid anodizers.

*For example, NO-OX-ID (or equivalent); Sanchem, Inc., 16 S. Canal Street, Chicago, IL 60616