# Anodizing Considerations for Medical Devices Machined from Aluminum

The purpose of this article is to familiarize the reader with the process of anodizing as it relates to the many medical devices and instruments made from aluminum alloys and commonly found in the doctor's office, medical suites and hospital operating rooms. General considerations regarding material selection, properties, finishing and processing pitfalls are discussed. It is hoped this treatise will further the understanding of this process which provides such benefits as corrosion protection, durability, cosmetic appeal, functionality and versatility. Aluminum is selected because of its availability, inexpensive cost and ease of manufacturing.

**What is Anodizing?**

Anodizing is the creation of an oxide layer at the surface of the material through an electrochemical conversion of the base material. An electrolyte, typically a sulfuric acid bath, is used in conjunction with applied voltage to the parts as the "anode". When electricity is passed through the anodizing solution via the parts in process, water is hydrolyzed (broken down into its basic components of hydrogen and oxygen).

The hydrogen migrates to the tank wall, the "cathode " or negative terminal, where it is released to the atmosphere. Oxygen travels to the aluminum part (the "anode", or positive terminal). The oxygen combines with the aluminum creating aluminum oxide. The millions of anodic cells created in the process form the coating that is hard, corrosion resistant and accepting of dyes that can be applied overall or selectively to create the desired "look" of the end product.

Anodizing may be simply classified as type II or sulfuric anodize, or type III, commonly called hard anodize. The particular process selected will be determined in the design of the part and its end use.

Typically the parts show up at the anodizing shop as a handle, a collar, a sleeve, a housing, a shaft, a retractor and a myriad of other descriptions detailed on a blueprint. The anodizer utilizes the information on the print or other instructions to determine what is required to do the job? As much information as possible should be provided on the prints and in supporting documentation to allow the anodizer to be successful in providing the desired end result. Some important considerations include:

- Information on alloy and temper…an example would be 6061-T6.
- The finish as received and as desired in the anodized product.
- Establishment of the sample finishes and colors to match if available.
- Relevant processing details not otherwise documented.
- Development of a technical process sheet to detail the finishing process.

**Some Notes on Specific Alloy Considerations**

**2011**

Selected for machinability and cost. High lead content in this alloy causes difficulties in the anodize process. Generally OK with type II finishes. Type III very susceptible to burning. The savings in material cost in selection of 2011 may be offset by a noticeably inferior looking part when anodized.

**2024**

Easy to work with, susceptible to corrosion. Must not be left wet when in process. Anodizes well with type II finishes. Type III very susceptible to burning. Must be concerned with sharp edges.

**6061**

One of the easiest of materials to anodize. Some of the problems encountered with parts include:

- Not enough material removed in machining to fully remove the mill scale or surface contaminants imbedded during cold working or extrusion. Can result in a pitted anodized finish…usually caused by corrosion.
- Apparent differences in the cooling rate of extruded stock may cause variation in the microstructure. This is evident as an "alloy pattern" or mosaic, "splotchy look" after anodize.
- Inconsistent temper, even within the same designation may show up in anodized parts as a variation in color due to the range of tensile properties for a given temper…noted most often with clear anodize.

**7075**

Many of the same concerns as with 6061 as detailed above are applicable to 7000 series alloys. In addition, the anodizer must be more concerned about coating thickness than with 6061. 7075 is highly susceptible to corrosion. It will blister if left in the dye too long when hard anodized. Also, an "orange peel" phenomenon occurs when you go from the cold anodize tank to the hot dye tank without a proper cycle through the room temp rinse tank to stabilize and outgas the parts. Another process defect can be seen as crazing or cracking.

**Die Cast Parts**

Die-castings do not generally anodize well because of the high silicon content of the material. Best results (cosmetically) are attained by light bead blasting then type II, class 1 (clear) or class 2, dyed black.

**Other Concerns**

1. Surface finish incoming may look worse after anodizing
2. Sharp edges can cause problems…burning
3. Machining marks left by dull tooling are more noticeable after anodizing
4. Uneven finishing from bead blasting or graining becomes more apparent after anodizing
5. Poor tumbling or vibratory deburring techniques can leave soap residue or other contaminants on parts. Parts packed or left wet may cause corrosion
6. Part on part impingement may result in nicks and dings
7. Polished, grained or blasted parts from the customer often exhibit damage in transit or from normal handling.
8. Metal chips in blind holes from the machining operation
9. Oil residue in deep, blind holes
10. Parts washers contaminated or inadequate, incomplete drying of parts
11. Parts shipped in newspaper packing can "etch" material

**Corrosion and Anodizing**

It may be to your amazement, but not all corrosion is caused during the anodizing process. Although the chemicals used during anodizing can cause corrosion, it is not the only source of this problem.

The aluminum used in sheet metal forming and/or machining is alloyed with metals such as iron, copper, magnesium, manganese, zinc, chromium, and other trace elements. Aluminum alloys, in the presence of water, set up galvanic cells where electrical currents cause pitting of the surface. Some of these elements are very active in the presence of moisture.

Some of the problems which surface during anodizing are directly related to corrosion related issues. Most are entirely preventable during the storage and handling of aluminum prior to and during fabrication/machining:

**1. Problem:** Water…anytime it is allowed to remain in contact with bare aluminum, sets up the conditions for corrosion. Discoloration, white chalky residue or even pitting may show up in close examination.

**Solution:** Keep it dry.

**2. Problem:** Water soluble coolants used during machining may also carry contaminants from other jobs.

**Solution:** Change coolant frequently, dry the parts, at a minimum do not allow parts to lay together wet or hold the coolant in pools. Corrosion can begin very quickly, especially on die-castings or 7075 (high zinc alloys). Again, do not allow parts to remain wet.

**3. Problem:** Mass de-burring equipment is usually a "wet" operation that holds the material removed from the parts in suspension, then by nature a mix of many different metallic elements.

**Solution:** DO NOT allow parts to sit in a wet tumbling or vibrating tub. Remove immediately, rinse, blow out any blind/ deep holes and joints, and make sure the parts are not touching each other while drying. Parts can be packed when totally dry.

**Conclusion:** Finishing operations such as polishing, graining, or blasting will not necessarily remove existing corrosion and may hide it until the anodizing process. Since the anodize coating combines with the base aluminum, it will expose these flaws in the material if the pre-processing steps do not cut deep enough to remove them.

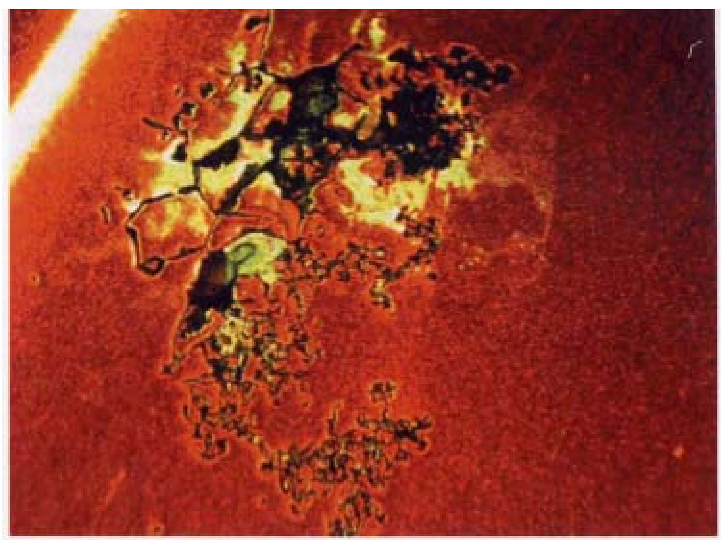

*Exhibit 1. A polished aluminum part, anodized and dyed red shows corrosion that was hidden by the smearing action of the polishing only to appear after anodizing.*

**Deburring Considerations in Anodizing**

Many parts are subjected to various deburring treatments prior to anodizing. One problem encountered is caused by material from the de-burring wheel being left on the part as a result of aggressive finishing. The result is a deposit that has been melted or smeared onto the part and acts as a masking agent during anodizing, leaving a bare spot or uncoated area.

Two of the most common brand names include "Bear-TexÓ and "3M" or "Scotch-Brite™" wheels and include product in many forms. The generic makeup is nylon based abrasive media.

**Convolute Wheels** are constructed of non-woven nylon impregnated with abrasive grain and wrapped in layers around a core and bonded together to produce a uniform wheel. Convolute wheels are available in a wide range of diameters and can be broadly classified into cleaning and finishing wheels and deburring/blending/polishing wheels.

**Unitized Wheels** are constructed of compressed, non-woven, tough abrasive fibers bonded together with an adhesive system under heat. The hardness, abrasive material, (silicon carbide or aluminum oxide), and grit size...medium, fine, or very fine are variables in the manufacturing process. The intended purpose and specific deburring or polishing need will dictate the optimum choice.

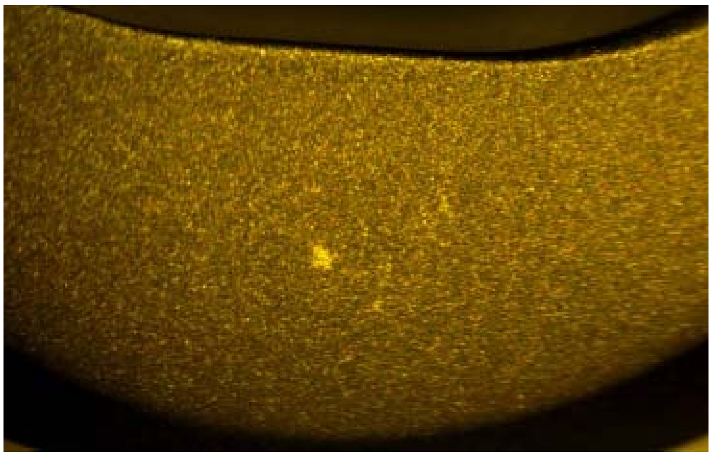

*Exhibit 2. Residue "melted" onto part.*

Material from the wheel can be deposited on the work piece because temperatures at the grinding interface may exceed 400°F. If the wheel is wrong for the application, too much pressure is applied or the speed of the operation is excessive, material from the wheel can be melted onto the part. Commonly referred to as a "smear", the deposit is typically one or more of the components of the material used to manufacture nylon based wheels. Titanium parts are particularly susceptible to smears because the high heat generated in the deburring process can quickly melt the matrix of the wheel if not properly controlled.

Compounding this problem is the fact that the material smear may not be visible to the operator. Nylon and/or fibers along with the abrasive can withstand normal cleaning and anodizing, then become easily visible after the processing is complete.

**In conclusion**, it is extremely important to choose the correct deburring wheel for the job and then use it according to manufacturer's recommendations. The Internet provides a wealth of technical information on these products through the manufacturer's web sites and will direct you to technical service representatives. These specialists will have the knowledge and experience with your materials or products to guide you in determining the appropriate deburring solution.

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*There are other factors which may affect the application of anodized coatings or the base product after anodizing. Please consult with our technical support staff.*