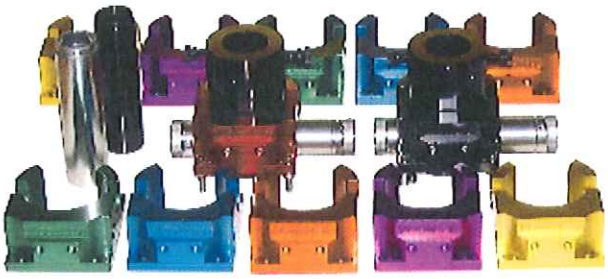
MoonLite Anodizing

A Practical Guide to Anodizing Aluminum at Home

By Ron Newman



"Disclaimer"

The information contained in this booklet is based solely on my experience and opinion. I take no responsibility for the methods described herein. All necessary safety precautions should be made when using the following procedures.

2011

AN OVERVIEW OF ANODIZING

Anodizing gives aluminum parts a hard durable surface that can be dyed a myriad of colors. Today's multicolor techniques can make ordinary parts look spectacular. A home brew anodizing setup or "anodizing line" can be very simple or elaborate depending on ones needs. I will share with you the bare bones method and professional ways to do Type II (room temperature) anodizing.

First, a short overview of the benefits of anodizing and a practical explanation of what anodizing is. Anodizing grows aluminum oxide that then becomes aluminum hydrate into and out of the raw aluminum base metal surface making it extremely hard. The thickness of a type II anodized coating is only about .001" thick, so it can be breached. The anodized surface is still very tough and can withstand weather and other abrasive pounding such as road debris. Additionally, the color will never come off due to the anodized color being part of the surface. The dye penetrates into the parts coating due to the porous anodized layer. Once dyed, the color is locked into the pores by sealing them, making the part weather and solvent-proof. If outdoor UV-rated dyes are used, the color will last a very long time without fading even in direct sunlight. It is the durability and ability to color aluminum parts in this manner that gives anodizing such value.

Type II anodizing adds about .0005" to your finished part (it is important to account for this change in dimension if size is critical). It is best to determine what your particular anodizing setup adds to the parts dimensions by physically measuring the finished part. The coating may be one thousands of an inch thick but half of that is grown into the base metal and half is grown out of the base metal.

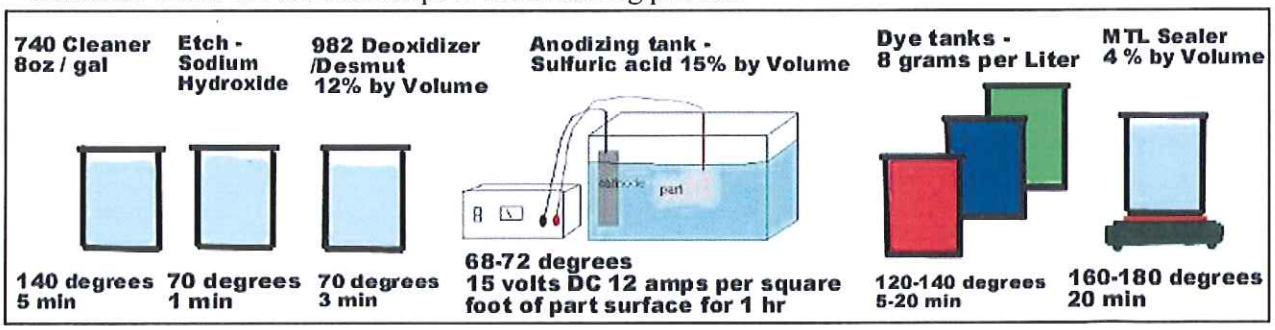
The following steps are required/recommended to anodize aluminum parts correctly - giving the phrase "anodizing line" some meaning:

1) Prep the part (surface finish – matte, gloss / stripping & re-anodizing)
2) Hang the part on an aluminum wire
3) Clean the part
4) Etch the part if a matte finish is desired
5) Deoxidize /Desmut the part
6) Anodize the part
7) Dye the anodized part (optional)
8) Seal the part (Nickel Acetate sealer)

Basic parts/supplies needed to anodize are:

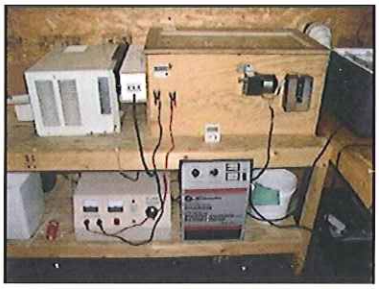
1) Plastic containers (buckets, etc.)
2) Power supply (battery charger, or professional power supply)
3) Sulfuric acid (battery acid)
4) Aluminum hanging wire
5) Cathode of 6061 or 6063 series thin aluminum plate
6) Anodizing dye (included in basic & advanced anodizing kit)
7) Deox/Desmut (included in advanced anodizing kit)
8) "Lye" crystal type drain cleaner (for caustic "sodium hydroxide" solution) used as stripper/etch
9) Nickel Acetate sealer (included in basic & advanced anodizing kit)
10) Aluminum cleaner (included in basic & advanced anodizing kit)
11) Hot plate/ fish tank heaters/ immersion heater
12) Aquarium air pumps
13) Temperature gauge

Illustrated below are the basic steps in the anodizing process.



- Prep the surface finish, matte, gloss. Etc.
- Submerse the part in 140 degree cleaner for 5 minutes, then rinse well.
- Submerse the part in room temperature caustic solution/Sodium Hydroxide ("Lye") for a few minutes to etch. Longer if a matte finish is desired, then rinse well. Skip the etch step if the part is polished to protect the gloss surface finish.
- Deoxidize/Desmut the part at room temperature approximately 3 minutes, then rinse well.
- Anodize the part(s) at a temperature of 68-72 degrees at current density of 12 amps per square foot (ASF) of surface area for the calculated duration. Duration is 1 hour at a current density of 12 ASF. Adjust time longer for lower current densities. For example, a rate of 9 ASF would require duration of 90 minutes and 6 ASF amps would require 120 minutes. The 12 ASF per hour duration standard is based on a Sulfuric Acid ratio of 15%, cathode to part ratio of at least 1:1, and an acid temp of 70 degrees. Rinse the part very well after being in the anodizing bath. Remember that sulfuric acid is a very oily type liquid that will cling to the part if not rinsed very well. Poor rinsing will cause poor anodizing results.
- Dye the part in 120-140 degree dye for 5-20 minutes depending on the shade desired. Rinse the part.
- Seal the part in 180 degree Mid Temp Nickel Acetate sealer for 20 minutes. Rinse the part and hang to dry.
- Never let the parts dry between steps, sag marks or other discoloration can result.

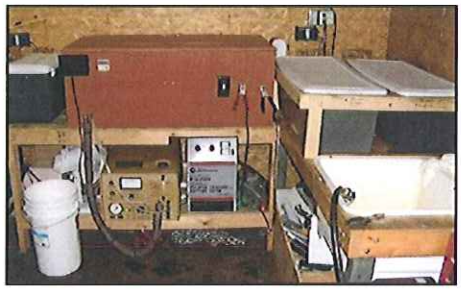
The photo below shows a 15-gallon anodizing station setup.



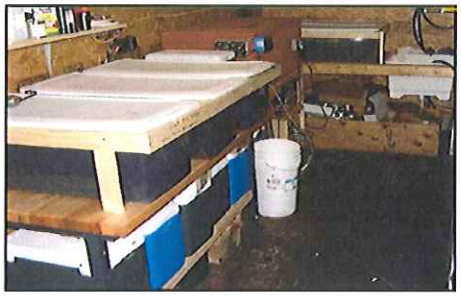
The station consists of a plastic tank to hold the sulfuric acid inside a sealed vented wood box, power supply, and optional air conditioning unit. The air conditioner is helpful to cool the acid back down to room temperature after a run of large parts; however, cooling is typically not a requirement for home brew anodizing at room temperature. Professional systems use chiller units to maintain the acid tank temperature.

A container is needed for each step of the process and each color of dye (five-gallon coolers work well for small anodizing lines). A sink for rinsing the parts is very handy, or you can use the professional method--a rinse tank with constant water overflow supplying clean rinse water.

The following two photos show my current 20-gallon anodizing station setup.



I use 20-gallon plastic tanks with an optional chiller unit. This professional setup can do large volumes of parts continuously. The alcohol based chiller unit with heat exchanger can maintain the acid at room temperature. There is no need to stop and let the acid cool down before starting the next batch of parts. A hobby style setup would not run parts continuously, so a chiller unit is not needed.



Tank material can be as follows:
Cleaner tank - mild steel, stainless steel, or polyethylene
Etch/stripper tank - PVC or polyethylene
Deoxidizer/desmut tank - PVC or polyethylene
Anodizing tank - PVC or polyethylene.
Dye tanks - stainless steel, plastic or fiberglass (never copper or steel)
Sealer tank - stainless steel or other acid resistant material that is stable to 180 F. Professional shops use polypropylene or stainless for the sealer tank.

A beginner anodizing line can be based on 5-gallon buckets. It is inexpensive and works well. On the other hand, coolers cost a little more but provide great insulation that helps maintain the correct temperature for the involved steps. It is a good idea to try and keep your tanks all the same size. If a rack system is used and is the same size, the parts can be easily placed in and out of each cooler/bucket without touching each other. The spacing would always be the same with uniform size tanks

PREPARATION OF THE ALUMINUM PART

Anodizing does not fix the problem of a poor surface, like paint or other coatings can. The quality of the anodized surface is dependent on the existing surface. If the surface has scratches or other blemishes, anodizing it will not hide the imperfections. If anything, anodizing tends to slightly magnify the surface texture. It is therefore important to consider whether the part needs prepped before anodizing it.

There are many ways to prepare aluminum parts prior to anodizing them. For a matte surface, the part can be sanded with either steel wool or emery cloth, or just a simple scotch bright pad will give the part a nice brushed looking surface. Some people like bead blasting the parts prior to anodizing them; however, a polished surface produces the best result when anodized. Colors are more vibrant and deeper shades can be produced if the part has a smooth, polished surface before anodizing it. To achieve a very dark black anodized surface, the part almost always needs to be polished. For instance, a bead-blasted part anodized and dyed black will typically turn out a dark gray/black most times. Beware that bead blasting can contaminate the surface of the part due to particles of media getting imbedded into the aluminum surface. This can cause the part to anodize poorly. Test your sandblasting media (sand, aluminum oxide, glass bead) to see how the media will affect the anodizing quality. Consider a chemical etch to give the part a matte uniform finish prior to anodizing.

Polishing: From my experience, I know of three ways to produce a polished surface for anodizing. They are by buffing the part by hand, using vibratory tumblers, or using an electro-chemical polish step.

Polishing the part by hand with a buffing wheel is the fastest and cheapest way of prepping a part. A flannel or cotton wheel with Tripoli compound mounted on a good buffer works well for aluminum. It will produce a bright shiny surface fairly quickly. Red or white rouge also works well but is a little slower than Tripoli compound. There are other white polishing compounds that also work well with soft metals like aluminum. Buffing wheels and buffing compounds can be found at some hardware stores or mail order places such as www.Grizzly.com. Here is a simple configuration - Grizzly's 8" buffer (part #H4380) for $79.95, 8" buffing wheel (part #H4694) for $10.95, Brown Tripoli compound (part #H0811) for $18.95.

The buffing wheel can be mounted on a simple grinder if you do not have a dedicated polisher. Two of the drawbacks to using a buffing wheel are that it may not allow you to get into the tight corners of the part, and edges of the part can be rolled over by getting too much polishing action when going over the edge. Buffing can and does remove material if pushed too hard. With a little practice, buffing by hand can produce stunning mirror-like surfaces.

Vibratory Tumblers: Another way to polish a part is to use vibratory tumblers. The tumblers work great for mass polishing of parts prior to anodizing and require little attention, unlike hand polishing. The tumblers are slow but can do many parts non-stop, 24 hours a day. I do not suggest using tumblers for the recreational anodizer. Polishing by hand is fine for one off parts; however, tumblers can be a good asset for small production runs or mini manufacturing setups and come in both small and large sizes to fit almost any need. Two tumblers are normally used - one set up for wet coarse media and the other set up to run dry polishing media.

There are different types of vibratory tumblers; large industrial square units and bowl-shaped units. I am just going to talk about the bowl-shaped units due to them being available in smaller hobby sizes. They can produce stunning mirror surfaces on aluminum parts.

The bowl shape is the key; it vibrates the media down toward the center, down around to the outer edge and then up the outside. It is this wave action that slowly turns the part giving equal polish action to all surfaces; however, it is the vibration that does the polishing. The square vibratory tumblers tend to allow the parts to bump a great deal during the process. If the parts bump, they leave marks in the polished surface defeating the whole purpose of polishing the part to begin with and you end up with shiny parts with marks on them, not a nice flat shiny surface. The donut bowl-shaped units create a track that the parts stay in during polishing. They tend not to bump each other and follow each other around, making a train of parts in the media. It is ideal when the parts follow each other without bumping, however; depending on the size and shape of the part, it sometimes does not happen and the parts may bump each other marking up the nice polished surface. Bowl-shaped tumblers come in many sizes and price ranges from $60.00-10,000.00.

Most large and medium size vibratory tumblers can be set up for either wet or dry media. Most small units tend to only be able to run dry polish media. The coarse sanding type media runs wet, and polishing media always runs dry. Media comes in many different sizes and shapes and material. The media chosen depends on the size and shape of the part to be prepped. Finding a good match sometimes requires a little trial and error.

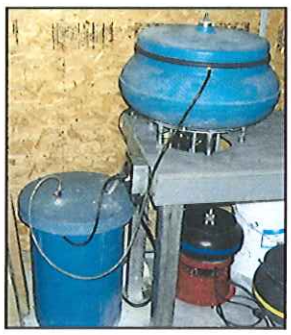
The large ceramic triangles in the photo above are run wet and are one of the most aggressive media types a tumbler can run. This media will debur and sand machine marks off of aluminum parts very quickly. It is so aggressive that it can easily roll off outside corners within an hour or so of run time in the tumbler. The large heavy size of the media makes it a bad choice for fine, smaller, intricate parts. This media is best suited for fast cut down and deburring of larger type parts.

The medium size ceramic polygons (shown above) also run wet and are a less aggressive solution for deburring and sanding machine marks. The smaller size and shape makes them a better choice for medium size parts. Again, they are run wet and are considered a fast cut down debur type of media.

The small plastic ¼" triangles (shown above) come in 3 grades: coarse, medium, and fine. The manufacturer makes them in 3 different colors to help identify the coarseness. The plastic is impregnated with aluminum oxide and is one of the most popular media types for tumblers. It can debur and cut down like the heavier medias given enough time but tends to produce a very fine uniform surface, perfect for anodizing outright or polishing. It is a good match for preparing parts coming off a good quality mill. Slight mill marks can be removed in about 12 hours and the part is ready for additional polishing or can be anodized without going into a 2nd polisher tumbler if a matte surface is desired.

My favorite wet media are synthetic 3/8" plastic domes. They sand medium-sized parts in about six hours, producing a great matte finish. Straight water works well with synthetic as the flow through liquid. A 50 lb bag costs around $100.00 and has reasonable longevity. Wet media of this type wears down and becomes smaller as it is used. Additional media needs to be added to the tumbler to bring the volume back up to normal levels every few runs.

For wet coarse media to work correctly it has to be clean. A flow-through system pumping water through the bowl can be used. The water should be changed each time new parts are put in the tumbler; however, a non re-circulating type system may be more practical in large scale surface processing. The large white tumblers shown on page 6 do not recycle their water. The water simply drains into a drainpipe. A rate of 3 gallon/hour is ideal for a typical setup of this type. A water input regulator limits the trickle of water running into the bowl.



A flow-through system is just a large container with a submersible pump forcing water up into the tumbler bowl. The tumbler bowl then drains the dirty water back out through a drain on the bottom into the re-circulating tank. Low suds detergent is recommended but is not always required for the re-circulating type system. Straight water is all that is required but will wear down the media quicker if detergent is not utilized. A homemade flow-through system is cheaper to build than buying a commercial one. All a system consists of is a submersible pump placed just under the water level that pumps a very small volume of water up into the tumbler. The tumbler drain is located about one inch from the bottom. This keeps a very small amount of water in the tumbler. Sludge will build up in the holding tank and does require cleaning periodically. The bottom blue 30-gallon flow-through unit (photo above) cost about $350.00 to buy. One can be fabricated for much less; however, I still prefer the straight water non re-circulating style setup as it is easy to run and requires no messy clean up. MSC Industrial Supply Co. (www.mscdirect.com) sells vibratory tumblers and the media shown (page 954 of the 2007 catalog for all the different tumblers and media sizes and types).

Once the part is finished in a coarse tumbler, it is ready to be polished. The parts need to be rinsed off and dry before placing them in the polishing tumbler. The typical polishing tumbler can run different types of media - treated corncob or walnut shell treated with red rouge. Treated corncob media is the industrial norm and is the fastest requiring only 6-8 hours to produce a mirror surface on aluminum parts. Red rouge walnut shell media produces a very nice bright mirror surface but takes at least 24 hours to do the same. All polishing medias of this type are run dry.

My favorite tumbling sequence is 7 hours of fine 3/8" wet synthetic domes followed by 8 hours of treated corncob. This produces a good bright polished surface quickly. The polish even gets into small nooks and crannies that a buffing wheel could never reach. Remember, that if the parts bump each other during polishing they will get marked up. Do not overload square-shaped parts because they tend to bump when compared to round-shaped parts. Round-shaped parts can be done in higher quantities. The cheapest media tumbler combinations are the small reloading type tumblers running walnut shell and rouge. They are available more readily from gun shops/ dealers due to the tumblers being used for polishing spent brass cartridges preparing them for reloading.

The small tumblers shown to the left are typical 4 to 8-quart tumblers. They can do both wet and dry tumbling but are limited to parts under 2-3" in size. Tumblers around this size cost between $100.00-500.00. Less media is needed for use in them so they are cheaper to operate than the larger ones.

Industrial size tumblers are rated by cubic feet of displacement. This unit is a 1.5 EB from Royson Industry in Pennsylvania. They cost around $3,300.00. This unit holds about 150 lbs of treated corncob and can process many parts at a time due to its larger 3' bowl size. For more industrial size tumblers and media, please see Royson Industry (www.vibratoryfinishers.com) & Vibra Finish Co. (www.vibrafinish.com). All the large tumblers my manufacturing business uses for production are from the two previously listed dealers.

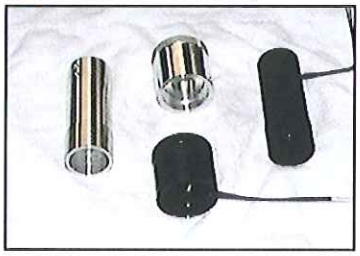
Electro-Chemical: Another non-traditional way to polish parts prior to anodizing them is to use an electro-chemical polishing system. This is sometimes referred to as bright dip and is performed right before anodizing. The electro-chemical polish setup resembles anodizing.

Instead of using sulfuric acid, a special mix of phosphoric and glycolic acid is used in a tank along with a stainless steel cathode. The cathode should go around the entire outside perimeter of the tank. This is a much larger cathode than anodizing tanks use. Just like anodizing, the parts are connected to the positive side of the power supply and suspended on an aluminum wire into the acid. Unlike anodizing, the process requires the acid bath to be heated to 150-160 degrees Fahrenheit. The power supply used is normally the same one used in anodizing. The difference is you run it at a high 30

ASF current density for about 5 minutes, pull the parts quickly, and rinse the acid off immediately. An aquarium air pump or equivalent source must be used with this system. Each part should have an airline positioned directly underneath it. Maximum bubbles should rise up over the part while the polishing is underway.

Five gallons of the chemical is quite expensive at $300.00 plus. See SIC Technologies (www.sictechnologies.com). Depending on your polishing needs, the electro-chemical polish may be a better solution than hand buffing or using tumblers. The polished surface that it produces does not compare to that of tumblers or hand buffing as machine marks and blemishes are not removed but somewhat smoothed over. The end result is a shiny bright part with all the existing marks still there. I do not personally use this method when doing critical parts. I would recommend it being used more as a brightening-type procedure even though it is sold as a polishing solution. Be careful when using such systems as they are extremely dangerous to the operator's health if ventilation requirements are not met. Please follow all manufacturer operating instructions if you are going to use an electro-polishing tank. I do not use them due to the health factors.

Beware of commercial bright dip class cleaners/pre-steps as they contain phosphoric acid that can contaminate your other tanks. Even the smallest trace, as little as 2 parts per million will start affecting your dye bath. Manufacturers that use these brightening products have to replace their dye baths frequently.

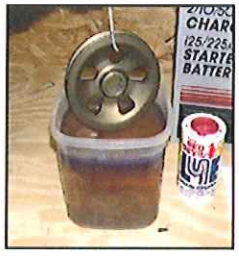


Of course, you may not need to do any prep work prior to anodizing. This photo shows sample parts that were anodized after only being cleaned. They turned out fine, but had good surfaces to begin with. Parts off a good lathe tend to require little to no prep work, unlike parts coming of a mill which tend to have more visible machine marks. Remember, what you see is what you get when anodizing. Anodizing does not fix or fill in any spots on your parts.

STRIPPING OR RESTORING EXISTING ANODIZED PARTS

It is possible to re-anodize any aluminum part, but the existing anodized surface must be stripped off first. Only bare aluminum can be anodized. Beware of clear anodized parts that look like raw aluminum parts. If you attempt to anodize a clear anodized part, nothing at all will happen during the process and the part will not take any dye. If unsure use a multimeter to test the surface of the part to see if it is clear anodized or raw aluminum. An anodized part will show a high impedance or open circuit, raw aluminum will show a low impedance or dead short when measured. Anodized surfaces are aluminum oxide/hydrate and are non-conductive, raw aluminum surfaces are conductive.

If the part is clear anodized, strip it first using the following "stripping" procedure before re-anodizing it. The photo at left shows clear anodized parts from a RC car and paintball gun. Both need stripped before anodizing. The example part shows a high resistance on the OHM setting of the multimeter indicating it is already anodized.
Strip off the existing anodized layer by placing the part in a caustic solution (Sodium Hydroxide) "Lye," for 5-30 minutes at room temperature. Lye can be found in your local hardware as crystal drain cleaner. Read the label on the back to make sure it says "Sodium Hydroxide".



Wear eye protection and rubber gloves for this procedure!! Mix together one container of Lye (at least 16 oz of powder) in a 5 gallon plastic bucket or container. Stir the crystals in slowly as you stir the solution, which will help them dissolve instead of just falling to the bottom. Place the part in the solution and monitor its progress. The Lye will dissolve the old anodized layer, about .001"

thick. Sodium Hydroxide eats Aluminum!! It takes a while for it to start breaking through the layer. The first minute or so not much action will be seen; however, after a few minutes the part will start to give off bubbles as an indicator of its progress.

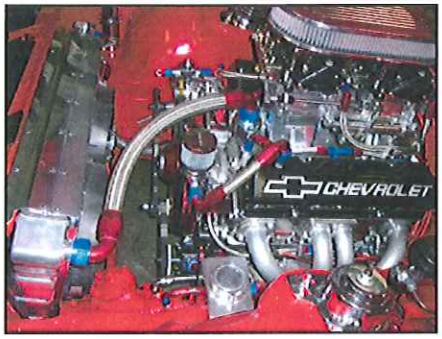
It is sometimes necessary to help the process along if you have a stubborn part by wiping the smut off. Remove the part and rinse it then wipe the smut off the part with a rag then put the part back in the stripper tank. Removing the smut will speed up the stripping process. If you have a deox/desmut tank, just place the smutty part in it for about 1 minute. It will clean the smut right off, visibly in seconds. If there is any trace of the old anodized layer remaining after the deox/desmut tank then place the part back in to the stripper tank and finish removing the last remnants of the old anodized layer. Only bare aluminum should be seen when the part is finished stripping.

NOTE: The caustic solution (Sodium Hydroxide) eats aluminum and leaves other metals on the surface that in turn tarnishes to a dark color. 2024 alloy has 5% copper and will turn black when placed in "Lye." Desmut is the opposite of a caustic solution in this example. Deoxidizer/Desmut (normally ferric acid based) eats the non-aluminum metals in the alloy off the surface presenting a pure aluminum surface to be anodized. (See desmut section in this guide). Make sure there is no oil on the part to be stripped. Oil will retard the stripping action causing uneven stripping on the surface. Remember that the stripping agent will continue to eat raw aluminum while you are trying to strip off any stubborn spots on the surface. If parts are stripped excessively, pits will most likely start to develop on the surface and will show up as dots or blotches on the finished anodized part.

When the part is completely stripped (no remaining spots), rinse it off and buff it back to a shine. Stripping aluminum this way will create a matte finish, sometimes resembling galvanized steel look. Polishing it back to its original surface is up to you. At this point, the part can be re-anodized and dyed any color - just like a freshly machined part.

NOTE: if the aluminum part has other metal or steel parts pressed into it, do not re-anodize the part. Metals other than aluminum will dissolve away during the anodizing process and will contaminate your sulfuric acid tank. The non-aluminum metal areas will need to be removed or masked off before being anodized. In the photo to the left, I show masking the steel parts on a motorcycle head. Regular RTV Silicon was used to protect the non-aluminum parts.

The photo below shows the finished re-anodized part (shown being stripped in photo above) ready for installation along with other anodized parts on the custom 434 aluminum small block in this 92 Camaro project.



Here is a part from a dragster, originally black, stripped and re-anodized violet.

CLEANING THE PART

Cleaning: The aluminum part needs to be clean before anodizing it. Oil from machining, polishing compound or fingerprints from handling the part must be cleaned off.

Normally the 740 cleaner solution provided in the anodizing kit is all that is needed; however, if the parts have heavy grime on them, please scrub the part using dish detergent with hot tap water and use a toothbrush to get into any tight corners if needed. Once the grime is off the part place it in the 740 cleaner tank for 5 minutes at 140 degrees. The "Cleaner 740 from US Specialty Color Corp" is a non-silicated alkaline-based cleaner that will remove oil, grime and polishing compound very quickly. Parts will bubble during the process and take on a pure aluminum look after being cleaned and rinsed. Cleaning parts this way will allow for a nice uniform anodize and dyed surface. The cleaner will not etch the parts if the temperature and bath concentration are correct. Please make sure it is operated at the correct temperature of 140 degrees. The cleaner bath will last for many hundreds of anodizing runs. A year or two is common for the life of the cleaner tank. Remember to not let the parts dry between tanks, so once it is rinsed go right to the next tank.

Heating: Heating the individual tanks in an anodizing line can be a challenge. If metal containers made out of aluminum or stainless steel such as pans are used, then traditional hot plates or a stove will work for a modest hobby setup. If plastic tanks are used then submersible or immersion style heating elements must be used. Remember the cleaner tank runs at 140 F, the dye tanks also run at 140 F and the sealer tank runs at 170 F. My 20-gallon professional anodizing line using plastic for all tanks requires thermostat controlled 1100-watt (part #00090621) and 500-watt (part #00090613) immersion heating elements with thermostat control. They can be found at MSC Industrial Supply Company (www.mscdirect.com) and come in two lengths (6" & 20"). They are for more robust professional lines and cost $150.00 each. A cheaper solution is to look at various cartridge immersion heaters. They are a simple drop in cartridge design with 2 wires coming out and require the user to wire a 110 AC plug on the end. There is no thermostat control built in, so please use them with caution. MSC lists many different lengths and wattage levels (examples: part #00364083 is a 600-Watt unit that is .375" thick and 6" long for $27.15 each, part #00364273 is a 500-Watt unit that is ½" thick and 4" long, Stainless Steel part #37027489 is a 425-Watt unit ½" wide and 6" long for $22.38 each). It is a good idea to have at least 400-500 Watts of heat for a 5-gallon bucket/cooler size line. The higher temperature requirement of the sealer tank would require two heaters to reach the 170 F temperature in a reasonable amount of time.

A cheaper alternative (but not recommended) is to use aquarium fish tank heaters or simply microwave a plastic container of the solution to the desired temperature. Everything from crock-pots to simple metal pans on a hot plate is used by creative anodizors in the "home brew" spirit. Beware, not all brands of fish tank heaters get hot, some only get warm. The "Penn Plax" brand fish tank heaters get very hot and work okay for a small hobby type anodizing line. They are a little slow at the low wattage ratings they come in but can work reasonably in small anodizing tanks.

Air Agitation: NOTE - All tanks should have air agitation. Simple "aquarium" air pumps or other means of blowing air bubbles into the bath (tanks) should be used. At least one air line, preferably multiple air lines should be used in the cleaner, dye, and sealer tanks. The anodizing tank is the most important bath and should have multiple air lines. Some larger systems locate permanent airlines on the bottom sides of the tanks such as long lengths of PVC pipe with multiple holes drilled in it for uniform bubble dispersion. Place the bubbles at the corners of the tanks or along the sides, but never directly underneath the parts. If bubbles hit the parts while anodizing, there is the risk of the bubbles collecting on the part causing an uneven anodized surface that will show ultimately as a discolored spot after dying the part. If you are going to use simple plastic bubble hose lines from an aquarium system then find some way to secure them in the corners of the tank, **do not use aquarium sink stones**—they will dissolve in the acid. It is better to just cable tie some small plastic aquarium air hose to the aluminum cathodes if there is nothing else to hold them in place on a small tank system. Drill some holes in the aluminum cathode to attach the air lines with cable ties. Don't forget the dye tanks—they also require good agitation for uniform color results on your anodized parts. If you are going to skip bubbler lines in any of the tanks, pick the cleaner and deox/desmut tanks, as agitation in those tanks is not really required.

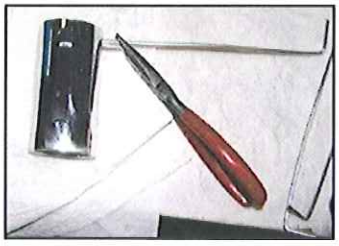
HANGING THE PART

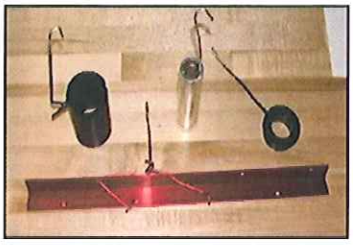
The part to be anodized needs to hang freely, without touching the container or other parts. The hanging wire method requires an aluminum wire be connected to each part. You can buy aluminum 12-gauge wire from MSC Industrial (part #31982929) for this purpose; however, it comes in large rolls and you may not need wire in such bulk quantities. Check with local electrical suppliers for smaller quantities of aluminum wire.

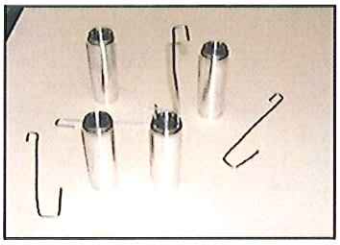
ONLY ALUMINUM OR TITANIUM CAN BE IN THE ACID TANK, NO OTHER METALS SHOULD TOUCH THE ACID. Professional anodizing setups use titanium spring racks designed to hold a certain size/shape part. These racks can be huge, holding thousands of parts at a time or small adjustable style racks for multiple size part runs. Titanium works best because it does not anodize along with the parts and never needs stripped between runs. Aluminum racks would need to be stripped back to raw aluminum each time. Remember an anodized surface conducts no electricity. For the home brew hanging wire method, just discard the anodized aluminum wire when finished, or, it can be stripped and reused. Aluminum knitting needles can be stripped and used as hangers as well. The knitting needles are normally made from a much stronger aluminum alloy. So, if you need something a bit more beefy than the soft 12-gauge wire, stripped knitting needles or aluminum welding 5000 series rods make a good choice. There is some advantage of aluminum over titanium besides the cost factor, aluminum racks or wires have a better current capacity per contact point than the titanium does. So if a very large part were to be held by a small contact point, then aluminum would be a better rack material to hold and support the large current drawing part. Titanium fixtures or racks do not load the anodizing tank as much as an equivalent rack made out of aluminum. Titanium is equal to about 60% of the surface area, when compared to aluminum.

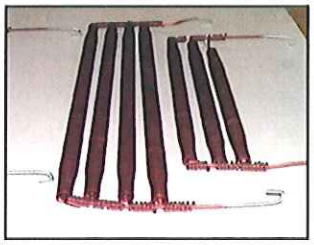
Please see the following sites if you are interested in commercial racks, as they will save much time if anodizing repeat parts frequently - Sequel Corp (www.anodizingracks.com) and Vulcanium (www.vulcanium.com).

For the small-scale hobbyist (home brew setup) we will look at simple aluminum wire for holding our parts.

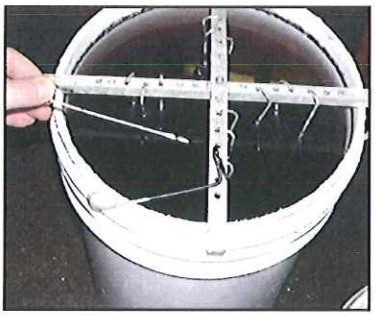








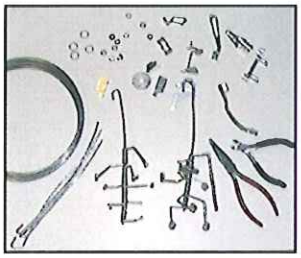
Connect the aluminum hanging wire to the part. This will provide the electrical connection when anodizing and provide a way of suspending the part in the various tanks (cleaner, dye, etc.), plus keep the part from being touched or handled. I force thread the wire into an existing tapped hole. Double the wire up, or pound it to a point to fit in your tapped hole. This connection must be very tight or it will fail during the anodizing process. Use pliers if needed to crank the wire into the hole. The wire is softer than the aluminum alloy and will simply take the shape of the hole without damaging the threads in your part.



Remember, wherever the wire touches the part it will not anodize and will not take any dye. Pick the connection spot so it will not show on the finished part. If the part does not have a tapped hole then you need to get creative by pinching the wire against the aluminum or wrapping it around or through a hole or bending the wire into the shape of a spring to hold your part(s). Just remember, where the wire touches it will not anodize or take any dye.

You can anodize many small parts at a time by rigging up parts holders. Twist pieces of aluminum wire around one main wire to create multiple holders that only take up one hanging position. In the photo below, I had over 1,000 one-inch knurled knobs to

anodize. I made multiple spring holders out of aluminum wire. Each rig held 12 knobs and I had 20 hanging positions in the 20-gallon tank. Of course, I had to strip each wire holder so it could be reused again and again. Bus bar and electrical connections will be covered later in this guide.



DEOXIDIZE/DESMUT THE PART

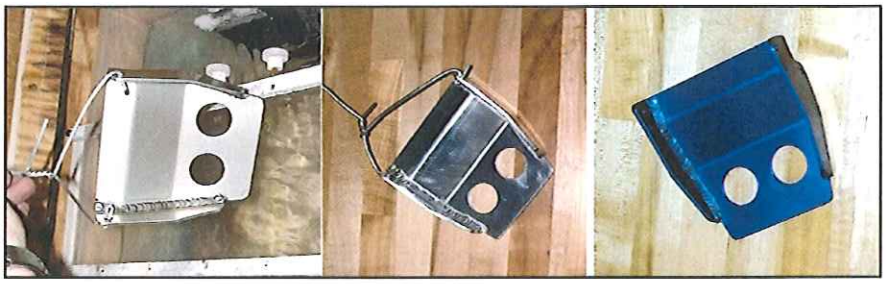
Performing a deoxidation/desmut step is normal procedure to prep aluminum before anodizing. Deox/desmut comes right after the cleaning and or the optional etching step if performed. Deox/desmut is always done right before anodizing as it prepares the alloys surface for anodizing by removing NON-aluminum metals from the surface. For example: 2024 alloy has 5% copper. This alloy along with others should be desmutted before anodizing so a purer aluminum surface is presented to the anodizing tank. When doing 6000 series it is not as important but will help improve the anodizing quality. Deox/desmut is a proprietary mixture of sulfuric and ferric acid. It is mixed with water at 12% by volume and is operated anywhere from room temperature to 90 degrees for 1-5 minutes. Most shops operate it at room temperature. Deox/desmut is also used to remove the smut after stripping parts in Lye (caustic solution).

Deox/desmut is not going to magically allow difficult cast aluminum alloy parts to be anodized. Unknown cast aluminum is very difficult to anodize due to not knowing the amount of silicon or other "non-aluminum" components in it. Making matters worse is the fact that thin wall areas of cast aluminum parts have higher silicon content close to the surface due to rapid cooling in the thin sections. Remember, we are anodizing aluminum and the purer the surface the better it works.

Industry uses the following pre-treatment when doing cast. (*This is for advanced anodizing only – try it at your own risk*). No etch step (leave as much aluminum on the surface as possible). For sand cast use 100% nitric acid and 2 pounds of ammonium bifluoride per gallon. For die cast use 50% nitric acid, 50% water and 1-pound ammonium bifluoride per gallon. Submerse the part until it turns a frothy white color, less than 60 seconds normally. Rinse it immediately and anodize like normal. No anodizing kits ever include chemicals for doing cast. These items must be found at a local chemical supplier.

The desmut photo sequence to the right shows a heavily smutted part after being etched in the caustic lye tank, half dunked into desmut for 30 seconds in the middle photo, and complete desmut, ready for anodizing in the last photo.

Aluminum parts that are welded will have a different anodized color due to the welding rod alloy being different than the main alloy, plus heat applied to the surrounding aluminum can cause some discoloration next to the welded area. A longer duration Deox/Desmut step may help the appearance of the weld area. In the photo below a foot pedal from an aircraft is welded then anodized and dyed blue. The welded areas turned a much darker blue than the regular aluminum areas.



Here is a test part of 3 rings of 6061 aluminum welded together with 3 different welding rod alloys. It was then anodized and dyed black. The top 4043 welding rod alloy area turned gray and looks poor. The middle 5356 rod and bottom 5654 alloy came out much darker than the 4000 series welding rod and looks like a much closer match to the rest of the part.

SETTING UP AN ANODIZING LINE

At this point, you need to start thinking about how large an anodizing line you need for the size of parts you will be doing. Most tanks in an anodizing line are normally the same size (cleaner, desmut, anodizing, dye, sealer and rinse tanks). Size consideration needs to be given to the anodize tank. Making the anodizing tank larger than the other tanks increases the acid volume level. This is a big help when dissipating heat into the bath while anodizing. Twice the volume means only half the temperature rise during a run. Keeping the acid tank temperature around room temperature (68-72 degrees) during anodizing is important. You will read about this later in this section. As for the sealer tank it needs to operate at 170 degrees, so consider this requirement when picking a suitable tank material. Remember to brace thin walled plastic tanks if they are to be heated. They will deform very quickly without bracing.

Two-gallon crock-pots, turkey cookers, simple plastic storage bins, coolers, and 5-gallon buckets, all work well for setting up an anodizing line. Just give heating requirements some consideration when picking your containers. As immersion heaters may cost more than the amount saved on cheap plastic containers.

ACID BATH (Anodizing tank)

Mix together a solution of sulfuric acid and water in a plastic container. The mixture should be between 15-20% sulfuric acid to water ratio; however, if you are using battery acid, it contains 65% water, so mix 50% battery acid to 50% water. This works out to around 19.9% acid by weight not volume, and is within range for anodizing. You may want to add slightly more water than battery acid to get closer to a 15 % mixture. You can source sulfuric battery acid at your local auto parts store, (Napa Auto Parts), or you can mix 165-225 g/l of pure sulfuric acid. 12 fl oz /gal comes out to 15% as well. The lower the acid ratio the better the anodized surface is but the less conductive the bath becomes. **Wear eye protection and rubber gloves when working with sulfuric acid.** Also, keep a box of baking soda around so you can neutralize any acid that spills or comes in contact with your skin. Just sprinkle the baking soda on the affected area and wash with water. When the baking soda stops fizzing the acid is neutralized. REMEMBER: THE 3A'S RULE! ALWAYS ADD ACID! NEVER ADD WATER TO ACID. Put a good amount of water in your tank first, then slowly add the acid to the water. If you add water to pure acid it could boil up. A good amount of heat will be noticed when adding the acid. I have used pure acid in the past. When I first added the acid to get the mixture correct, the tank temperature went from room temperature to 160 degrees, due to the reaction. That will not happen if you use battery acid as it is already diluted. By the way, the acid will last many hundreds of anodizing runs if you are careful about rinsing your parts between tanks. Dragging chemicals over from previous steps can cause contamination of your acid or any of the baths associated with anodizing. Also be very careful not to let any other non-aluminum metal contact the acid, steel or copper will contaminate the tank immediately causing the color to go to a brown or green tint. With a little care this tank can last a very long time. The acid may need changed after heavy use due to high levels of dissolved aluminum in the bath. Dissolved aluminum content should be between 5 and 15 g/l for the system to work well. Every time the system is used, a small amount of dissolved aluminum will get into the acid. That is normal, and it does not hurt anything. Most anodizors leave the aluminum cathodes in the acid all the time to help increase the amount of dissolved aluminum content, especially in a new tank bath. Eventually the acid will need to be changed due to contamination and increased aluminum content. Change your acid if you start to notice that the system requires additional voltage from the power supply to produce the same current density compared to when the acid was new. For example, 15 volts may have

provided a current density of 12 ASF when the acid bath was new. If you note the system requiring voltages greater than 15 volts to produce the same current density, then it needs to be replaced. Remember, a small amount of dissolved aluminum is actually needed in a new system. So a few test runs with some scrap aluminum, or just simply leaving the aluminum cathodes in the bath for a few days will help get the dissolved aluminum content to a nice working point. Please dispose of your acid correctly when the time comes. Neutralize with baking soda or take it to a battery recycling facility in your area. Follow all your local, state and federal guidelines when discarding old chemicals or operating an anodizing line creating wastewater.

CATHODES AND BUS BARS

Next you will need a cathode or cathodes. Multiple cathodes placed on the side of the tank work well. The cathodes are connected to the **negative** side of the power supply. The cathodes should be 6063 aluminum alloy sheet or 6061. Both work well but 6063 is the standard for anodizing. The cathode should stick out of the acid so a heavy gauge wire can be connected from the cathode to the negative side of the power supply. Try and use at least a 12 gauge wire from the power supply to the cathodes. The best cathode is simply a thin aluminum sheet that can be bent if needed. It is the surface area that matters not the thickness; however, thicker cathodes will last longer than thin ones. Multiple cathodes spread out will avoid shadow affects on your part due to uneven anodizing. This is normally never a problem as long as there are at least two cathodes at opposite sides of the tank. The ideal cathode to part surface ratio is at least 1:1 with the limit being 1:3 (1 cathode area to 3 part area). Remember, no other metal should touch the acid!) You should use stainless steel hardware to connect the wire to the aluminum cathode sheet. Just make sure the fastener is above the acid level. Stainless will not corrode up as fast as other metals do when exposed to sulfuric acid vapors for long periods of time.

Remember, nothing but the aluminum of the cathode should be touching the acid. Steel will dissolve away and contaminate your acid. Brown acid indicates iron contamination. Brown indicates copper contamination. Replace the bath if the acid becomes non-clear.

A 6061-aluminum plate is used as cathodes in this configuration. It is recommended that the cathodes be removed when not in use; however, I don't bother. The aluminum ones here are turning black after about 4 months in the acid without being removed. You can remove them and rinse any dark smut off the cathode that may have built up. NOTE: In the photo on the below, all 4 cathode sheets are wired together to the negative side of the power supply. This tank has about 6 square feet of cathode surface area so it is capable of anodizing up to 18 square feet of part area, if that much could fit in the tank.

Bus bars are used to suspend multiple parts into the acid and provide a positive electrical connection to all parts. The bus bar is simply a bar of aluminum or stainless connected to the positive side of your power supply. The bus bar has holes for the hanging wire drilled into it. Again, use a 12-gauge wire between the power supply and bus bars. A bolt hole is drilled and tapped into the side of the bus bar so a bolt or knob can be used to clamp the hanging wire tightly to it. As you can see in the photo on the previous page, the medium size tank has two bars with four boltholes each allowing 8 hanging stations. The photo above is of a larger 20-gallon tank that has 20 hanging stations. Aluminum electrical bus bars can be purchased at Lowe's or Home Depot. Check the electrical department for grounding bus bars; however, they are short. If you want long bus bars you will need to make them yourself. You may notice the large coil in this tank; this is because cooling starts to become an issue when doing large numbers of parts. My 20-gallon system has an alcohol based chiller unit with aluminum tubing running into the bath. I will get into cooling considerations later in this section. I just want to explain the aluminum coil in the photo. Also, note the 4 air bubble lines located in each corner of the tank by the cathodes. Agitation using bubble lines in each of the 4 corners is a good idea for the anodizing tank.

POWER SUPPLY

Type II anodizing requires about 15 volts to produce a 12 ASF of current density rate. This is assuming a 15 % acid ratio, 70-degree bath temp, a 1:1 cathode to part

ratio, 6061 alloy cathodes being used, and the system is broke in with some dissolved aluminum content in the acid. The ideal power supply should be adjustable in voltage from 0-15 DC and have enough current capacity for your size anodizing line. It should also provide a fixed current or voltage mode and have both current and voltage meters so you can monitor and adjust the power level. With that said, a variable DC 15 volt power supply with enough current capacity to anodize the largest part(s) is required. The rated current capacity of the power supply should exceed the largest current demand that will be made. If the system will be anodizing 3 square foot of part surface area then the power supply should be able to handle around 36 amps, 3 square feet at 12 ASF equals 36 amps. If the largest part or parts add up to 1 square foot of surface area then a 12-amp supply is required. I carry Astron power supplies that are 0-15 volt DC and come in 5 current capacities: 12, 20, 35, 50, and 70-amp versions. But first lets talk about other solutions and the pros and cons.

In the photo above is a plating rectifier on the left good for up to 50 amps at 15 volts. They are expensive at about $600.00, and are adjustable and work well, but don't give the most current capacity for the money. To the right is battery charger rated at about 50 amps continuous. Using a battery charger is not a good adjustable way to anodize, however it can work for small part loads.

In the "home brew spirit" a battery charger can be used but is not recommended. A small setup can use a manual 12 volt 40/50 amp charger/starter. DO NOT try and use an automatic battery charger. The anodizing process fools automatic battery chargers and they in turn ramp down the current. Automatic battery chargers simply do not work! The manual battery charger shown on the previous page puts out about 17 volts on the highest "start" setting, and about 15 volts on the 50 amp charge setting. This model will provide up to 30 amps before over heating. Battery chargers are over rated when it comes to current capacity. For example, if the battery charger is rated at 40 amps continuous, then it really can only handle about 20 amps, ½ of what the rating is. If the battery charger is pushed close to its max rating it will simply over heat and turn off in the middle of your anodizing run. The adjustability is very poor, plus the amp meter on them is not very accurate. There is no good way to measure the real current draw while anodizing.

Another drawback to using a battery charger is there is no way to ramp the voltage up slowly. With professional power supplies there is an adjustable voltage/ current knob that can be turned up slowly over a 20 second period. This avoids the sudden short circuit condition that exists in the first 5-10 seconds of anodizing an aluminum part. The ability to slowly ramp the power up will keep the power supply from "pegging" and going in to shut off protection mode. A battery charger would simply shut off if the load were too great when the power is first applied.

A professional variable 0-15 volt DC power supply or larger variable range is ideal due to it being adjustable and having the ability to be ramped up slowly when first applying the power. Surge current can be avoided by starting at zero voltage and slowly ramping up the voltage over a 20 second period until the correct current draw is displayed on the meter. Surging or spiking the system can sometimes cause the electrical connection to be lost where the aluminum wire touches or contacts with the part. Ramping the voltage/current draw up slowly helps avoid that problem.

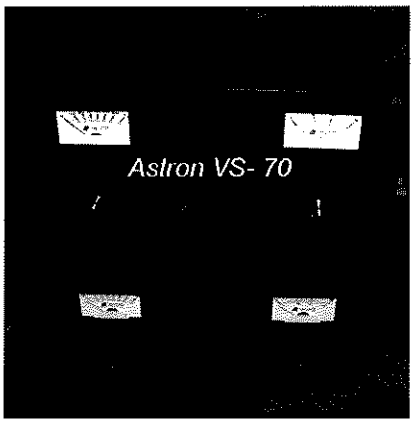
Shown below are adjustable 0-15 volt power supplies that operate in fixed voltage and fixed current mode. These units work very well for anodizing. They can simply be set to a specific current or voltage and the supply will maintain the current or voltage setting very accurately. The Astron VS-12 on the left can handle up to 12 amps and is a good choice for small 2 gallon anodizing lines, the one on the right is a 35 amp version and is a good pick for a 5 gallon bucket to 10 gallon cooler style anodizing line.


Astron VS- 12


Astron VS- 35

In general, the larger the current draw, the faster the part will anodize but too much current can burn the part or burn off the hanging hookup wire. High current anodizing also causes higher temperatures in the tank that can cause the parts to pit. Localized heat around the part in the acid can cause pitting! Again, use air bubble lines in the tank to keep things

stirred up and temperatures consistent. Aquarium air pumps work great for this purpose. Don't try anodizing too many parts at a time at high current levels unless you have some experience with the process. Follow the current density/time guideline below on the next page.



Here is a photo of my personal power supply configuration running my 20-gallon line. I use 2 Astron 70-amp units in master/ slave mode providing up to 140 amps total. The large 70-amp Astron version can be stacked and inter connected with a cable allowing one unit to be the master controller while the others are just slaves. This power supply configuration can grow along with your tank size. This will avoid the user buying a new power supply if the system is scaled up. 140 amps can anodize over 10 square feet of part surface area in 1 hour; however, there are some heat considerations running at this high of current capacity. A chiller unit is required to keep thing cool while running at that high of a rate.

CURRENT DENSITY

A current density of 12 ASF of part area is recommended, and is the standard for Type II mil spec anodizing. Best results are obtained when staying between 6-12 ASF of part area. Anodizing at 12 ASF only requires 1-hour duration for a full thickness coating. Anodizing at a lower density – such as 6 ASF will require twice the duration to grow the same thickness coating. The higher the current density, the smaller the pore size but the harder the anodized coating. The lower the current density the larger the pore size and softer the anodized coating. NOTE: If the anodized pore size is too large or too small, the part may not take dye well. The particle size of the dye is designed to match the anodized pore size. Also, sealing will be difficult if the pore size is too large due to a low current density value.

Figure out the total surface area your parts will have including a small amount for the hanging wire. Count all surfaces that touch the acid. For example, 3 test parts are to be anodized having .6 square feet of surface area each. .6 X 3 equals 1.8 square feet. 1.8 X 12ASF = 21.6 amps (on the meter) for a 1 hour duration. Or you could anodize them at a lesser current density---say 8ASF for a longer duration (95 min). 1.8 X 8ASF= 14.4 amps (on the meter) for a 95 minute duration.

NOTE: The required voltage to produce the standard 12 ASF may not be the standard 15 volts DC as normally noted. There are many variables that can affect the impedance of your system. Power supply, acid ratio, cathode to part ratio, cathode material, cathode placement, acid temperature, dissolved aluminum content. So the 15-volt rule producing 12 ASF is a guideline and for the most part will work well in almost all situations. In other words - if you simply ramp the voltage up to 15 volts and anodize for 1 hour it will work out fine. There is no need to figure the parts area. This is assuming that all the other variables are within reason.

An important fact to learn about your particular system is the "noted voltage" that produces 12 ASF of current density. Once you find the "noted voltage" that produces 12 ASF of density then you can simply ramp your power supply up to the "noted voltage" instead of calculating part area to figure out the current draw. To find the "noted voltage" anodize a test part that has exactly 1 square foot of surface area. A 12x6" sheet of aluminum will work nicely. Start ramping up the power until 12 ASF or 12 amps in this case is displayed on the current meter of the power supply. Check the voltage with a voltmeter and document the voltage. That is the noted voltage that produces 12 ASF on your system. During future anodizing runs, all you have to do is turn up the power supply to the "noted voltage" and the part(s) will automatically draw current at a density of 12 ASF. There are some limitations to this trick. Part(s) being anodized must be somewhat close to your test part in size. Plus the anodizing system will drift over time due to the dissolved aluminum content rising. This will require a periodic test to see if the "noted voltage" may have changed.

If you are using a battery charger, note that the amp meter is not very accurate on most units, so some error in current draw may be read. Better to err on the low side than to over anodize a part and risk burning it.

Remember that the battery charger can only provide so much current and if exceeded will overheat and turn off. Don't expect to draw 50 amps continually from a 50 amp rated battery charger. A more practical expectation would be 30 amps from a 50 amp rated unit.

ANODIZE TIME

Calculate the duration by the following rule: 1-hour duration at 12 ASF.

You must know the current density that you are anodizing at---not the current draw, but the current density: 12 ASF = 1 hour duration, 9 ASF= 90 minutes duration, 6 ASF= 120 minutes duration.

If a full durability Type II surface is required then anodize for the full duration. If a brighter finish with a light color is desired, cut the anodizing time or current density by about 1/3 (decorative anodizing). When dying black, anodize the full time. Otherwise you risk ending up with a dark blue or brown color instead of dark black.

For example, I have a 1-square foot area part drawing 6 amps on the meter. If I want it to be fully anodized it would need to run for 2 hours (12/6 = 2) or half of that time (approximately 1.5 hour) for regular brighter colors (decorative anodizing). Obviously, a higher current density rate shortens the overall anodizing time required.

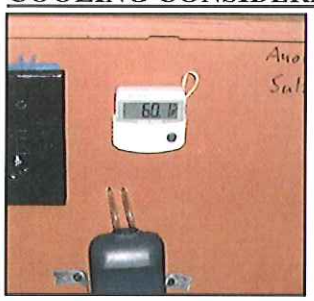
Below is the voltage chart (provided by **US Specialty Color Corp**) for producing 12 ASF with 15%/wt acid at 70 F with a 1:1 cathode ratio using 6063 sheet as cathode material. With a tank having at least 5 g/l dissolved aluminum content. As you can see, higher voltages than 15 volts can be required when doing other non-typical aluminum alloys.

Alloy	Voltage	Alloy	Voltage
1100	15.0	5056	16.0
2011	20.0	5357	15.0
2014	21.0	6053	15.5
2017	21.0	6061	15.0
2024	21.0	6062	15.0
2117	16.5	6063	15.0
3003	16.5	6151	15.0
3004	15.0	7075	15.0
5005	15.0	Cast	
5050	15.0	356	19.0
5051	14.5	380	23.0

Dissolution Point - As the part anodizes and the coating grows to (.001) it reaches a point called dissolution. At that point in time, the thickness of the coating cannot grow any thicker and the acid is dissolving the aluminum at the same rate the coating is growing into and out of the parts surface. So if you keep anodizing after the calculated time, the fully anodized part starts to get smaller as the dissolution affect starts (called burning the part). Current draw will almost be the same as it was during the regular anodizing process. Just a very small or subtle change or flattening in current draw will be noted. The detection of this subtle change of impedance can be masked by other factors such as heat rising in the tank during the process. I don't recommend trying to detect the subtle current change to know when to stop anodizing and instead recommend using the calculated duration formula for knowing when to stop anodizing.

Hard Coat Anodizing Type III is really the same as Type II anodizing except the dissolution point is moved by lowering the acid temperature. This allows a thicker coating .002" thus the phrase "hard coat". Early anodizing methods required the acid to be at 32 degrees and the current density to be at 24 ASF or higher. Modern hard coat additives (Glycolic Acid / Glycerin) allows hard coat to be done at an easier to maintain 50 degrees. If you think you are going to try hard coating be aware that the voltage needs to be ramped up over a specific time frame fairly high to keep a steady 24 amps per square foot draw during the end of the process. The additive keeps the parts from burning at the high current density levels. Just remember, hard coat can only be dyed black or dark green due to the smaller pore size. Hard coat Type III anodizing is not a home brew method and is not covered in this guide.

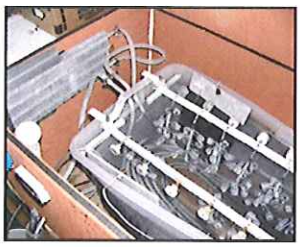
COOLING CONSIDERATION



My anodizing tank has an electronic temperature gauge to provide a means of monitoring the temperature of the acid, ensuring it does not exceed more than 74 degrees Fahrenheit while anodizing. You can use a simple outdoor thermometer by taping the probe to the side of the plastic tank that holds the acid. Insulate the probe with some foam and duck tape it fast to the side.

Heat is generated and dissipated into the acid during the anodizing process. The larger the tank of acid, the slower the temperature will rise. Small tanks may only be able to do one run at a time before being forced to wait for the acid to cool back down. The ideal temperature range is between 68-72 degrees for Type II anodizing. If the temperature gets too high while anodizing the parts may start to pit or the hanging wire may burn off at the acid to air boundary layer. Portable IR point and shoot temperature gauges from Radio Shack work very well for dye and sealer tanks temperature reading.

An air conditioning unit can be used to blow cold air into the sealed box to cool the acid down to 65 degrees before starting an anodizing run. It can then maintain a normal temperature range with the air conditioning unit running while anodizing. You do not need to have an air conditioning unit if you are only doing a few parts. Most people would do one run and then wait for the acid temperature to cool back down before starting the next. An air conditioning unit used in this manner is not very efficient as well, but does help on a hot summer day.



For large cooling needs a chiller unit can be used. In the photo at left, the 20-gallon tank has a 50' coil of plastic tubing running through the tank. It uses isolated coolant that is a mix of alcohol and water pumped through the tubing. Beware - typical thin wall aluminum tubing will develop pinholes after sitting in the acid tank for a few months. You may be able to use a titanium coil or very thick aluminum heat sink to pump your coolant through for limited time; however, most shops just use plastic PVC as it holds up for a very long time. PVC it is not a very effective heat transfer material so a large number of PVC pipe surface area needs to be in the tank to make up for the inefficiencies.

The chiller unit can remove a large amount of heat. This enables large batches of parts to be done at a very high current draw. The system can maintain a specific temperature during the duration of an anodizing run. Only professionals would use large chiller units of this size due to their cost. Used chiller units such as the one in the photo at left, can sometimes be found on EBay. Small aquarium chiller units cost between $400.00-1,000.00 and would be of help as well. Some folks have modified water fountain assemblies as chiller units. I think a little creativity is the name of the game when it comes to maintaining the acid bath temperature. Solutions for a home brew system can be as simple as floating a bag of ice cubes in the acid before starting the anodizing run. If you want to do large parts or larger quantities of parts without adding additional cooling, just make up a larger volume of acid. That way the heat is dissipated over a larger area and will be less of an issue.

Here is a way to calculate approximately how much heat will be dissipated into the acid during anodizing. Take the measured voltage of the power supply times the current drawn. For example, if my system is drawing 30 amps of current at 15 volts, then the amount of heat produced is approximately 450 watts (voltage x current = watts).

ANODIZING

Suspend the aluminum part in the acid using the attached aluminum hanging wire. Connect the **positive** terminal of the power supply to the wire holding the part and turn on the charger. The part should not touch the plastic container or be placed too close to the cathodes in the tank. Remember the negative side is connected to the aluminum cathodes.

If the electrical connection to the part is not tight, the connection can fail during the process and only the aluminum hook up wire will be anodized, not the part. The current should rise then level off in the first few minutes of anodizing. As the anodized layer builds on the part you may notice a small change in the amount of current. This is normal; however, if the current drops suddenly during the process this indicates that the connection to the part has failed. If the current is too high, the connection wire may burn off. Use a 12-gauge wire when possible for the hanging wire. If the current keeps rising as the part anodizes then check the temperature. The

hotter the acid gets the more current will be drawn. Remember, the temperature has to be kept within limits or your part may become pitted or burned.

NOTE: When using a small tank, the drop in current (when approaching the dissolution point) may not be seen due to the rise in heat causing the current to actually increase during the anodizing process. The higher the temperature, the more current will be drawn. This masks the fact that as the part becomes fully anodized it conducts a little less current. A large tank with a large volume of acid would disperse the heat better and would show a more characteristic drop in current as the part becomes fully anodized. This is not so with small home brew size tanks.

A small amount of bubbles (oxygen and hydrogen) will start foaming off both the cathodes and a very small amount from the part. I would advise not breathing the fumes and suggest some way of venting them away from your work area. I placed the plastic anodizing tank in a sealed wooden box with a fan to vent the fumes out a nearby window using a simple dryer hose.

Obviously a build up of flammable gases could be dangerous. Please anodize in an open area or provide ventilation for the small amount of gases that are produced.

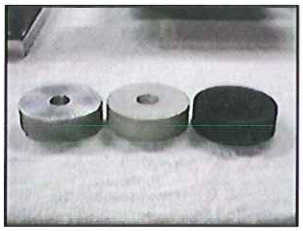
Current Density / Duration Time Guideline:

Figure out how long to anodize the part using the following 720 rule: 720 amps per minute per square foot of part for 1 hour, or 12 amp hours per square foot for 1 hour. You need to know the area of your parts, and the current being drawn to know what the current density is. Once you know the current density that you are anodizing at then the duration can simply be calculated----12 ASF rate =1 hour duration, 6 ASF rate would require 2 hour duration, a 9 ASF rate would require a 90 minutes duration.

Remember the current being drawn on the amp meter is just the total current draw of all the parts. To figure current density, which is an anodizing rate, figure the total square foot of part surface area into the total current draw. For example, 3 parts have a combined area of 3 sq feet and the amp meter on the power supply reads 30 amps. That means that the current density rate is 10 ASF, and the duration would be around 80 minutes. Each part is drawing 10 amps for a total of 30 amps.

Example below: The aluminum tube has 42.4 sq inch or .29 square foot of surface and is drawing 2 amps according to the meter on the power supply. That means the systems current density is running at 6.89 amps. To calculate the time take 720/2 = 360 amp min, and 42.4/144 = .294 sq'. 360 times .294 = 105 minutes in the tank.

This part should have been anodizing at a higher 12 ASF rate. Remember time is money for an anodizing shop, plus the coating is harder if anodized at the higher current density. Notice the surface color/texture of the finish anodized part. Different alloys will show slight changes in the color after they are anodized. It may have a pale lemon tint or a chalky white looking color depending on the alloy type and the voltage/current density it was anodized at. Note: parts anodized at lower current densities tend to be silver in color. You should be able to see a difference in the parts texture as well.



The photo to the left shows the color of three 2024-alloy samples:
Natural aluminum, anodized aluminum, and dyed black aluminum

Can you tell which part in the photo to the right lost its electrical connection during anodizing by looking at the color? The 2nd part from top failed during anodizing. See the lighter shade, unlike the others, which are fully anodized. These parts are 6061 aluminum alloy anodized at 7 amps per square foot of current density for a little less than 2 hours. Rinse the part after removing it from the acid tank and rinse it again. Rinsing methods can be as simple as using hose pressured water over a sink. Professional lines use a dedicated rinse tank or two to dip the

parts in between baths, just make sure the tank has an adequate overflow rate as to keep a clean supply of water. Most anodizing quality problems are due to rinsing problems. Sulfuric acid is sticky/slimy in nature and requires a good amount of rinsing to be sure it is removed. Constant "drag over" of acid into the dye tanks will shorten the life span of the dye baths. Make sure parts with blind holes or other odd features are rinsed very well; if traces of acid are still present it will leech out during the dye process and show up as discoloration around a blind tapped hole.

Never let the parts dry between tanks and rinsing. Anodizing needs to be done from start to finish with no pauses. If parts are let hanging to dry after being rinsed coming out of the anodizing tank they will most likely have a sag mark on the bottom of the part when finished. The discoloration is due to the acid not really being rinsed off 100% and when the water sags and dries at the bottom of the part the dry sulfuric acid residue will discolor the part. It shows up once the part is dyed and sealed. The problem does not happen if the parts are kept wet the entire way through the process. The 140-degree dye tanks will remove any remaining acid residue that may have been missed from the rinse tank. Of course that is what eventually kills the dye tanks over time.

DYE THE ANODIZED PART

Now that the part has an anodized porous layer, it can be dyed a variety of colors. Use real anodizing dye if you want your parts to have UV protection otherwise they will fade in direct sunlight. I use and sell dye manufactured by US Specialty Color Corp. Real anodizing dyes with good UV rating cost around $16.00 (some colors cost more) and make two gallons of solution. The particle size of the dye matches the pour size of the aluminum oxide coating. If you use RIT clothing dye as some folk's suggest, you may have some trouble. RIT is not as forgiving as the good stuff and it fades badly in just a few months time due to no UV rating. The particle size of fabric dye is not a good match for the anodized pour size. RIT tends to barely go into the anodized surface and will lay shallow on the top of the pour structure. Please see my web page to order dyes as they are not very expensive – www.focuser.com/anodize.html or contact me at (570) 275-7935, MoonLite Telescope and Anodizing.

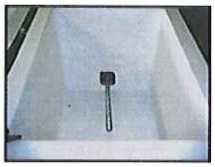
Mix the concentrated powder dye with distilled or DI water following the instructions. Most kits include dye to make 2-gallon dye baths. Heat the dye to about 140 degrees Fahrenheit. Hang the anodized part in the dye bath from between 30 seconds to 20 minutes, depending on the desired shade. If you want a light pastel shade of color, keep the time short. If a deep solid color is what you are after, let the part in the dye for the full 20 minutes.

The dye bath will last years if you are careful not to cross contaminate it with sulfuric acid from the anodizing step. Remember to rinse well between tanks. Also, do not forget to seal the dye container when it is not in use. This will prevent evaporation and keep oxygen from growing algae in your bath. NOTE: Just add water to the dye bath, sulfuric acid bath, cleaner bath, and all other baths as needed due to evaporation of the water content.
Note: the first thing an anodizing shop does each morning is top off the water level in the tanks they will use that day.

Here is a 5-gallon blue dye tank with a MSC Industrial 1100-Watt heater pulled out and an aluminum hanging rack installed. You can simply use a plastic container and microwave it to heat up the dye if needed. It does not have to be anything fancy. Remember, aquarium heaters may work for small systems and are inexpensive. Don't rule out crock-pots, they are great for a 2-gallon setup. The low setting is about 130-140 degrees and the high setting is about 160-170 degrees—perfect for the sealer tank.

At left are two large 20-gallon dye tanks with 20 position racks and 1100-watt heaters all set to go. If using plastic tubs, reinforce them with a wood or metal frame. The heat will deform the container if not supported. Polyethylene plastic is good for 140 degrees while polypropylene is stable up to 190 degrees.

NOTE: Aquarium air pumps are used in all tanks to blow air into the solution to keep the parts agitated. This includes the dye tanks as well.



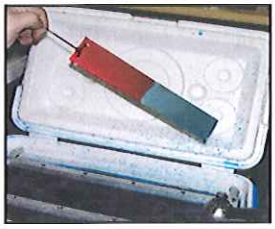
Water heater tank elements can be used for larger more professional anodizing lines. They come in 1000W and 1400W 110-volt versions. Just make sure the element is installed so it does not contact the plastic and will be watertight.

Rinse the parts after removing them from the dye tank. If you do not want to dye the part and just want to seal the natural anodized color, skip the dying step all together and seal it as outlined later. The natural anodized color will change slightly, but you will produce what is called a clear anodized part.

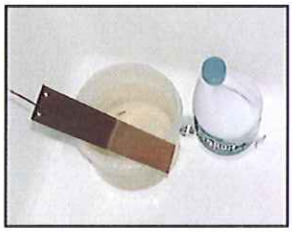
MULTI COLOR ANODIZING (SPLASH/FADE/MASK) TECHNIQUES

All kinds of special effects can be achieved when it comes to multi color anodizing. Fade anodizing can give one part many colors with unlimited shades. Stripping dye back off a dyed part can give it a unique look plus provides an opportunity to be dyed a 2nd color. Splash or masking the part allows artistic designs to be made in the dyed part. Masking techniques are varied and create stunning effects in the metallic patina of anodized parts. Like any anodized part, the final finish is sealed and the color is locked into the surface for the life of the aluminum part.

Fade anodizing is just what the name implies, colors fade from one to the other. To fade anodize you place the anodized part in the first dye for a short period of time, maybe only half of the part is held in the dye tank. The part is then rinsed off and placed in the next color dye tank (turning the part or dying over a portion of the first color). A good rule of thumb is to start with lighter colors first as darker colors will always be dominant. Remember coloring Easter eggs when you were a kid, well it's the same thing! Once the color is the way you want it, just rinse the part one final time and lock in the dye by sealing the part. Remember to rinse between dye tanks as well. The dye won't rinse off like one would think!

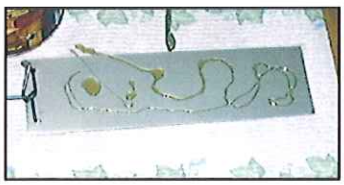


Dunking and overlapping fade points is normally done by hand. Draw the part out gradually to get a nice transition fade.



Stripping dye back off is done by placing the dyed part in sulfuric battery acid for a little while. It will bleach out the color allowing the part to be re-dyed a different color. Remember to rinse the sulfuric acid off well before placing the part in the next dye tank! Again, seal like normal once the colors are to your liking. NOTE: Bleached areas tend to retard dye absorption a small amount. The color may shift and not match the other non-bleached surfaces.

Splash or mask anodizing is my personal favorite. Splash anodizing is done by splashing dye onto chosen areas of the surface and letting it set or by splashing on bleach or acid to remove or lighten existing dye. You can also dab on bleach or sulfuric acid with steel wool or other fibrous items to give a fine random-etched look. This can be repeated with multiple colors. In the following example, I'm masking the part with some rubber cement before dying it. The rubber cement will take a while to set (about 20 minutes). Allowing drying time makes this technique a little time consuming but the results are very striking. Here I have already dyed 2 parts a light shade of color and then masked over the dyed color with rubber cement. Once the glue is dry, I placed the part in another dye tank, pulled out the part and rinsed it off once the desired shade was reached.




Wait a while for the glue to cool back down and then roll it off with your fingers, removing it completely from the part. The part will have the original non-dyed anodized look where the glue was or the original dyed base color. At this point you could seal it and call it done or dye the entire part again in another color. Remember, the original color will be affected by the second color so think of how the colors combine if double coloring is done. Stencils can be used to make sharp-edged patterns on your work or electric tape to make sharp edges in your patterns. Vinyl logos and lettering can be made and applied as a mask. This provides unlimited graphic ability for your parts.

For controlled splash or "splotch" coloring, mix some Corn Starch and water with concentrated dye to make a paste. This paste can then be applied to desired areas and allowed to set (at least 30 minutes). The paste not only dyes the area it was applied to but also provides limited masking properties. Note: The paste will start dissolving quickly when placed in the next color dye. Gently place the masked part in the second dye color. Keep the dye time as short as possible (2-3 minutes). I use room temperature dye baths for this procedure, as the paste does not dissolve as quickly at room temperature; however, this paste is a poor true masking agent and will only last a few minutes. Pull the part out and rinse off the paste in running water before sealing the part.

The paintball gun (photo below) was done with orange paste first then hot pink as the bath color.

The same results could have been achieved by first dying the parts completely in orange dye and then rubber cementing over the areas you want to keep ("splotch"). The rubber cement would need to dry and then the parts stripped in bleach (removing the non-masked orange dyed areas). The parts would next be rinsed and placed in the pink dye bath to complete the pattern. The parts would then be removed, allowed to dry, rubber cement removed, rinsed and sealed like normal, achieving the same result but by a different method.

Engraving anodized surfaces with a CNC mill after they are anodized can produce dramatic looking graphics. The photo to the left shows a mustang shield that was engraved by cutting through the blue anodized layer exposing the raw aluminum under the anodized layer.

SEALING THE PART

Once the part is dyed to your liking it is time to seal the pores and lock in the dye by sealing the part. Sealing using a Nickel Acetate sealer designed for color anodizing will give the part maximum hardness, stain resistance to the surface, and allow the dye to meet its UV rating. Do not use the low temp Nickel Fluoride based sealers. They tend to leech the dye out of the parts. Use that type sealer for clear anodizing only.

All anodizing dye manufacturers recommend a nickel acetate sealer step. There are two types of Nickel Acetate sealer - boiling or mid-temperature. The boiling type requires the parts to be boiled in the sealer for 20 minutes, then rinsed and hung until dry. The drawback to using this is the requirement of boiling the solution. This can be a problem if your tanks are large. The 20-gallon sealer tank shown to the left is wrapped in insulation and a wood box reinforces the plastic container. It can reach near boiling temperature in about four hours. A better sealer type is the mid-temperature sealer that operates the same way as the boiling sealer does but only requires heating to 170 degrees for a duration of 20 minutes. With this sealer, you have less evaporation and maintenance.

If your parts are not sealed properly then fingerprints and the like can stain the anodized surface over time. Plus, the UV rating of the dyes will be affected by not sealing the part.

That's it! Anodizing has a small learning curve so practice on scrap pieces of aluminum before dunking your good parts in the tanks. **Remember eye protection, gloves when needed and protective clothing are necessary**. You are working with acid! Safety first!

If you need to dispose of the sulfuric acid, neutralize it with baking soda before handling it. Follow all Federal, State and Local regulations when disposing of any chemicals.

Please see my anodizing site at http://www.focuser.com/anodize.html to order kits, Astron power supply, heaters, or individual chemicals. You may also place an order by calling (570) 437-2232 MoonLite Telescope and Anodizing. I recommend placing the order by phone if you are interested in larger quantities. Kits do not ship outside the U.S. (2 Gallon ***Basic*** Kit can be shipped outside the U.S. as it does not include Deox/Desmut or Etch - $154.00). Guide sold separately.

2 Gallon Kit - $196.00 (S&H not included)
Includes Cleaner, MTL Sealant, Deox/Desmut, Etch
Black Dye, Blue Dye, Gold Dye, Violet Dye, Red Dye
Grey Dye, Green Dye & Yellow Dye

Color Samples

Astron Power Supply


Astron VS- 35

0-15 volt DC high current power supplies that feature amp and volt meters, dual adjustment by current or voltage. The adjustable current control is perfect for anodizing. Plus the larger units can be stacked to increase capacity making one become the master and others to work as slaves.

When picking your power supply, keep in mind you should have 12 amps for every square foot of part surface being anodized. A little extra capacity is a good idea so as not to run the units at the max rating. Please use a fan to help cool the power supply if you do tend to run them at full power all the time.

2 Models to choose from- (shipping & handling is not included in price below)

VS-35M	$258.95	(Good match for 5 to 10 gallon bucket/ cooler size tanks)
VS-70M	$411.95	(Stackable for expanding professional anodizing lines)

Here are some helpful sites for containers, power supplies, tumblers, racks, etc.

http://groups.yahoo.com/group/anodizing101
http://www.usspecialty.com
http://www.gravescompany.com/tumbling.htm
http://www.multimeterwarehouse.com/hy3020D.htm
http://www.sictechnologies.com
http://www.anodizingracks.com
http://www.grizzly.com
http://www.vibratoryfinishers.com
http://www.servisure.com
http://www.ishor.com/VibratoryFinish.htm
http://www.russamer.com
http://www.process-technology.com
http://www.mscdirect.com 1-800-645-7270
http://www.vulcanium.com
http://www.vibrafinish.com

TROUBLE SHOOTING SECTION

? Part will not take the dye.

If the part does not take the dye, it means it is not anodized fully. Dying is the moment of truth. The lack of a part taking the dye indicates problems with your anodizing setup/method, not the dye bath. Check the surface with a meter to see if it is anodized. Look for: failed electrical connections, too little current draw, too short anodizing time, to small cathode size, an automatic battery charger or too weak acid. Ask your self these questions- what was the current density? How long did it anodize? Did the wire anodize and take the dye, but not the part. In the photo at left, the middle part failed to take the black dye due to not being fully anodized. The electrical connection was at fault. The part was returned to the anodizing tank BEFORE sealing it. The wire was replaced with a new one. The part was anodized fully and re-dyed.

? Hanging wire burned off.

Make sure the anodizing tank is agitated with an air line blowing bubbles. If hot spots or warmer layers occur then the wire can burn off (usually at the air to acid boundary). Too much current can cause this when anodizing only one part in the tank or too high of a current density is being used. Is the acid ratio correct and is there a 1:1 part to cathode ratio? Check the current to see if it is excessive. Don't fully trust a battery chargers amp meter; they tend to be off a good amount. Check your current density rate; it should be between 6-12 amps per square foot of part.

? Part turns black while anodizing and does not take dye well, or color is not uniform, poor quality - spots.

Do the deox/desmut step for a much longer duration. The aluminum alloy has other metals in it that are not aluminum. They sometimes show up as tarnished smut on the part when anodizing or placed in Lye. For example, place a piece of 2024 alloy in Lye. Note the part will turn black. The Lye is dissolving the aluminum but the 5% copper is left on the surface and tarnishes to a dark color. Cast aluminum has a high silicone content and sometimes depending on the alloy will not anodize well regardless of whether a desmut step or deoxidizing step is used.

? Parts won't draw much current during anodizing.

Check the battery charger. Automatic chargers don't work. Get a professional power supply so you can be sure of proper current and voltage settings. Increase the cathode size/area. Check the electrical connection to both the cathodes and the parts. Acid is too cold or is too low a ratio of acid to water (low temperatures will cause low current draw). Keep the temperature between 68-72 degrees.

? Parts come out with a fuzzy texture.

The heat may have been too high when anodizing, check the tank temperature. The part could have anodized for too long a period, shorten the anodizing time. Use a good Nickel Acetate sealer instead of boiling or steaming. Too high of current density, reduce current and test with scrap parts. Check to make sure your sealer tank is not running too hot. If the sealer is too hot it can make a fuzzy residue on your parts. Lower the temp to 160 –170 and try another test part.

? Parts are pitted.

The acid temp may have been too high while anodizing; check the tank temperature and make sure air lines are agitating the bath. Make sure parts are clean before anodizing. DO NOT LET the parts set in the acid before or after anodizing.

? Testing your system for the first time.

It you are using a battery charger it is helpful to measure the DC voltage produced at different settings under load (when anodizing). Voltage for a typical setup should be between 13-15 volts, being ideal to produce a current density between 6-12 amps per square foot of part. If no current or little current is being drawn but the voltage is within range, check both the cathode and all electrical connections to the part. If the electrical connections are good, then add more acid and increase the cathode size until the current density is within limits. 15 volts should produce 12 ASF of current density if the acid ratio, cathode ratio, and acid temp are within range.

? Parts have small white dots on them after dyed & sealed.

You probably didn't even see them until the sealer dried 100%. Sulfate (sulfuric acid) was probably dragged into the dye tanks contaminating it. Change the dye. Rinse much better in the future coming out of the sulfuric acid tank. Check water quality as well. Poor water (hardness) can cause white spots due to high calcium content.

? Parts have black or dark spots.

Possible (non aluminum) metals are contaminating your sulfuric acid tank. Remember nothing but aluminum or titanium can touch the acid. Try anodizing some scrap aluminum parts to try and plate the contaminated metals out of the bath on to the scrap part. Once your test parts come out clear, continue to anodize your good parts like normal. Check cathode material - Is it 6063 or 6061 alloy or some other alloy that is contaminating your acid?

? Parts have areas around holes or other features that didn't take the dye.

Poor rinsing can cause discoloration around tapped holes. If there are any traces of acid leeching out during the dyeing step it will cause the dye to not take around those effected areas. Rinse the part much better next time. Blind tapped holes will tend to do this if not rinsed very well.

? Parts have white marks on corners.

Acid may be too strong, dilute with water. Is the acid ratio 15 to 20 %?

? Part has strip of lighter color in middle of part

The acid tank may not be agitated enough or is too warm. The difference in heat generated from the part dissipating it at different rates will cause discoloration due to sections of the part anodizing at different rates. The dye is then absorbed darker on the edges and lighter in the middle. Let the tank cool back down or provide a way of cooling the tank better. The problem tends to show up with blue and gold color dyes more than other colors.

? Part has unevenly dyed/ colored surfaces.

Your part may not have been 100% clean. Use a good cleaner prior to anodizing. Poor cleaning and rinsing is the number one cause of unevenly dyed parts.

? Parts change color shade from one side to the other.

There was probably too little cathode area or poor part to cathode position. Shadow effects can be a problem when running to small of cathode ratio or too many parts for the size tank. Check for at least a 1:1 cathode to part ratio, and make sure multiple cathodes are used.

? Sharp edges chip off after anodizing.

Don't leave sharp edges on your parts. Always debur or round over 90 degree edges before anodizing. This eliminates or reduces fractures of the aluminum anodized coating on corners. You should always have a radius instead of a sharp corner if the part is to be anodized. Anodizing grows the coating at a right angle to the surface, sharp corners will sometimes show a void like area where the anodizing is not as pronounced as the rest of the surface.

? Parts have a white residue film after drying coming out of the sealer tank.

The sealer is spent or damaged, replace the bath. The whitish residue will wipe off the part, but the problem will get worse until the sealer is replaced. This is how you know when to replace the mid temperature sealer bath, normally in about 6 weeks of use if used every day. Also the sealer can be damaged if it is over heated above 180 degrees. There is a smut inhibitor in suspension that will drop out of the sealer solution if it is inadvertently over heated. Over heating will prematurely limit the longevity of the sealer bath. If the color of the residue is not white but the color of the dye, then it is not the sealer that is at fault but the part most likely was burned in the anodizing tank.

Anodizing Dyes

Description: Water-soluble powder dyes used for coloring anodic coatings on aluminum. Chrome-free design. Light fastness is typically 6 to 7 on (1 to 8) scale.

Oxide thickness	.20-.5 mils
Concentration	2 g/l (black is mixed at 8 g/l)
PH	5 to 6
Temperature	140 F
Duration	15 seconds to 15 minutes Preferred sealing MTL sealer

Conditions: Tank must be stainless steel, plastic, or fiberglass. Never copper or steel.

PH: To raise pH, sodium hydroxide should be used.
To lower pH, acetic acid should be used.

Agitation: Agitation of the dye solution, either by air or by means of mechanical stirring device, is usually of value in obtaining uniformity of color and increased dye absorption.

Rinses: Rinse thoroughly after anodizing. Use good quality water and over flow at an adequate rate to maintain low ion concentrations for maximum tank life and optimum color quality. (Two rinses recommended)

Specialty 982 Deoxidizer/ Desmut

Description: Liquid designed to deoxidize and desmut aluminum prior to anodizing.

Concentration	12% by volume
Duration	1-3 minutes
Temperature	70-110 F

Conditions: Tank should be PVC or polyethylene reinforced with steel. Mix with deionized or good quality tap water.

Agitation: Continuous air agitation is recommended to increase effectiveness.

Specialty 740 Cleaner

Description: Powder mixed with water that makes a non-etch, non silicated, alkaline cleaner designed for aluminum surfaces.

Concentration	8 oz/gal
Duration	Immerse 1-10 minutes
Temperature	140 F

Conditions: Tank should be made of mild steel, stainless steel or polyethylene. Use deionized or good quality tap water. NOTE: if used at lower then 8 oz/gallon ratio or operated at less then 130 degrees F or ran at too long of a duration, it can start to impart a mild etch to the aluminum surface.

Specialty MTL Sealant

Description: Mid temp nickel acetate sealer for dyed and clear anodized surfaces with a smut suppressant.

Concentration	3-4% by volume
Duration	Immerse 5-20 minutes (2-3 minutes per .0001" oxide coating thickness)
Temperature	180-190 F

Conditions: Tank should be stainless steel or other acid-resistant material that is stable to 190 F.

PH: pH 5.5-6.0. Mix with deionized water. Lower the pH with acetic acid. Raise pH with ammonium hydroxide.

Agitation: Agitation of the sealant tank by using a circulation pump is recommended to maintain uniform sealant solution temperature. NOTE: overheating (boiling) the sealant will shorten the longevity of the bath. Life span is 6 weeks.

Specialty 835 Etch

Description: Alkaline material, which uniformly etches aluminum alloys. It contains an ingredient that minimizes the formation of aluminum scale in solution tanks and on heating elements normally associated with most alkaline etch solutions.

Concentration	4-6 oz/gal
Duration	10 seconds - 10 minutes
Temperature	130-150 F

Conditions: Tank and associated equipment should be constructed of stainless steel.

MoonLite Telescope & Anodizing / Ron Newman
755 Preserve Road
Danville, PA 17821-7909
http://www.focuser.com/anodize.html

Price Sheet effective April 2011

Guide and Anodizing Kits

Add to Cart Anodizing Guide $28.00 + shipping and handling (32 US, 39 Canada, 40 International)
Add to Cart Basic 2 Gallon Anodizing Kit $154.00 + shipping/handling
Add to Cart Advanced 2 Gallon Anodizing Kit $196.00 + shipping/handling (cannot ship outside US)

2 Gallon Individual Supplies

Add to Cart 2 Gallon Individual Dye $16.00 + shipping/handling
Available Colors: *Blue SE, Gold EAN, Green AEN, Grey BL, Bordeaux R, Violet 3D, Yellow D Brown GL, Deep Red L, Olive Drab, Orange 3A, Turquoise PLWN*
Add to Cart 2 Gallon Black Dye $42.00 + shipping/handling
Add to Cart 2 Gallon Sealer $25.00 + shipping/handling
Add to Cart 2 Gallon Deox/Desmut $36.00 + shipping/handling (cannot ship outside US)
Add to Cart 2 Gallon Cleaner $20.00 + shipping/handling
Add to Cart 2 Gallon Etch $22.00 + shipping/handling (cannot ship outside US)

5 Gallon Individual Supplies

Add to Cart 5 Gallon Individual Dyes $37.00 + shipping/handling
Available Colors: *Blue SE, Gold EAN, Green AEN, Grey BL, Bordeaux R, Violet 3D, Yellow D Brown GL, Deep Red L, Olive Drab, Orange 3A, Turquoise PLWN*
Add to Cart 5 Gallon Black Dye $90.00 + shipping/handling
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Add to Cart 5 Gallon Etch $46.00 + shipping/handling (cannot ship outside US)

Astron Power Supplies, Heaters, Coil & Cathode/Wire kit

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All kits ship using UPS Ground or Priority Mail International