Designing an Anodizing Facility*

There are eight major systems in an anodizing plant that require engineering before a new facility is built:

- Tank systems
- Ventilation systems
- Heating systems
- Materials handling
- Cooling systems
- Computer control
- Rectifiers/power sources
- Waste treatment

All About Tanks

Tank Sizes

The longest, widest and thickest parts to be processed, and some idea of the maximum number of parts per shift and load will, in large part, determine the overall tank sizes needed. Additional space is required for racks, splines and coils, and to allow for good solution movement around the parts. In general, the side and bottom clearances should be at least six inches from the sides, and eight to ten inches from the bottom for crane-operated lines. These dimensions can be smaller for hand lines. Large parts may need more space to allow free solution to flow around them.

Tank Materials

There are a number of materials of construction that can be used to build tanks. Each has its advantages and disadvantages.

Mild steel is used only for alkaline baths, can be easily made in any size, and is easy to repair in place, if leaks occur.

Stainless steel offers good resistance to most of the solutions encountered in the anodizing operation and can be built in any size. Should repairs be needed, they are fairly easy to repair in place.

Polypropylene (usually 1/4-in. to one-in. thick) must be reinforced to prevent bulging. Polypropylene is a good insulator and offers good corrosion resistance to most of the baths in the line. Tanks can be built economically only up to 8–10-ft in length and from about 4–6-ft deep. They are difficult to repair in the field.

Fiberglass tanks are economical in the 8–10-ft range and up to about six ft deep. They provide good corrosion resistance and are easily repaired. They tend to crack with age.

Concrete tanks are only used in large systems of 20–40 ft and must be lined with sprayed-on, chopped fiberglass inside and out to provide corrosion protection and dielectric strength. They are difficult to repair and expensive to maintain.

Solution Agitation

Good agitation is required in all tanks in an anodizing line. It is helpful even in rinse tanks. If air agitation is used, it should be either low pressure blower air or well-filtered plant compressed air that is oil-free. It is almost impossible to have too much agitation, as long as streams of bubbles or large bubbles are avoided and the parts are securely racked.

Mechanical agitation can be used, but the stirrer takes up room in the tank, and this must be taken into consideration when sizing the tanks. In tanks that use external heat exchangers, the solution is moved by pumps. This is an excellent way to provide agitation, if the pumps are of the proper size.

Heating Equipment

Heating should be considered for the anodizing tank, particularly in the northern parts of the country, where the temperatures can be low, especially in the winter months. There are three types of heating equipment now in use:

Electric heating is usually preferred for small tanks (6–8 ft). It is the least expensive to purchase and install, but the most costly to operate. It is the most efficient heating source, however.

Immersion, gas-fired burner tubes are mounted in tanks from 6–40 ft in length, but because of their size, may require increasing either the depth or width of the tanks.

Steam (hot water) coils can be used in any tank size down to about 2 ft. The most widely used method today, steam coils can be made of materials resistant to any bath found in any anodizing line and are easy to remove, repair or replace.

Cooling Systems

Cooling is mandatory for almost all anodizing electrolytes and processes, but is especially important for low-temperature, hard coating operations. Small tanks of less than 4 ft and 1000 A can be cooled by pumping a cooling solution, either water or a water-glycol mixture, directly through coils in the tank.

Larger tanks are more efficiently cooled using external heat exchangers. The electrolyte is pumped through one side of the unit and chilled water or glycol through the other. The exchanger must be made of stainless steel and the pumps of either Carpenter 20 or fiber-reinforced plastic. The main and most expensive part of the system is the chiller itself, which is used to remove the total heat generated during the anodizing process.

To calculate the required chiller size: Multiply the maximum operating amperage by the voltage and multiply this by 3.412. This gives the number of BTUs needed to be removed per hr of operation. This number divided by 12,000 will give the tons of chiller capacity required.

Either water or air-cooled chillers can be used, but water-cooled units are more efficient, especially during the summer months or in hot climates. If water-cooled units are located inside, they must be coupled to a cooling tower outside. The water is then pumped to the remote cooling tower. Air-cooled units are usually located outside, eliminating the costs of buying or maintaining the cooling tower and pump. The other parts of the system are the chilled solution pump, the cooling tower pump and the electrolyte pump. All but the electrolyte pump, which must be made of either Carpenter 20 or fiber-reinforced plastic, can be made of cast iron and sized as follows:

Chiller water	2.4 gal/min per ton of chiller capacity
Cooling tower	3.0 gal/min per ton of chiller capacity

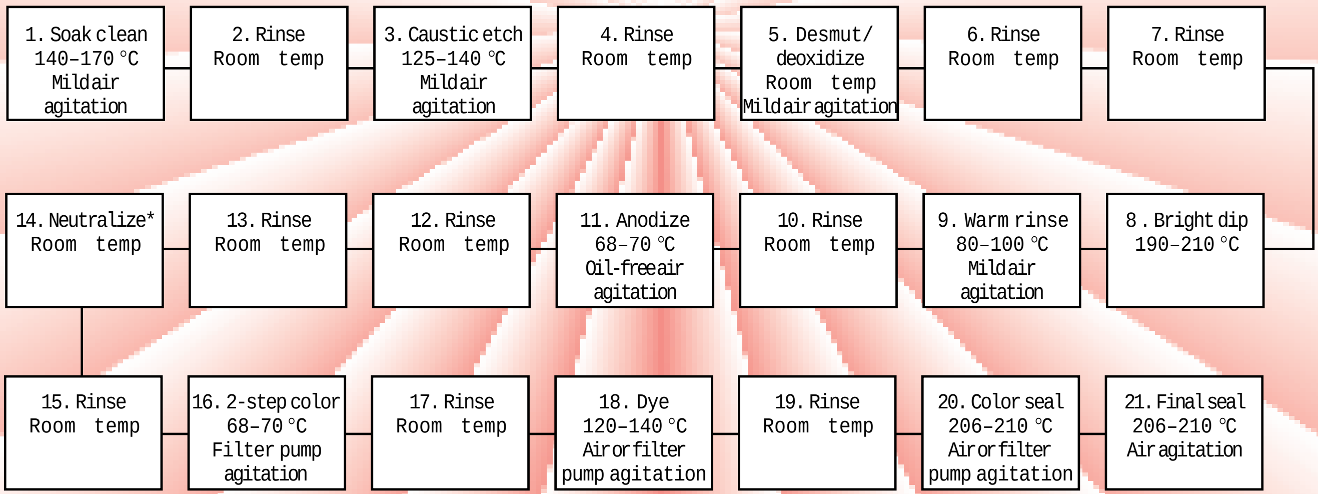
Electrolyte in gal/min = BTU/hr heat removed divided by 3000

The last component is the heat exchanger itself. The only practical choice of material is 316 stainless steel plate type, because of its good corrosion resistance and high heat exchange efficiency. Although other materials can be used (such as graphite, glass or Teflon™) and other styles, such as shell and tube units can be used, the 316 stainless plate type is the one of choice.

Rectifiers/Power Sources

The next area to be considered is the equipment to supply the DC power for the anodizing process and the power source for any possible electrolytic coloring process that might be used in the plant. Care should be taken to see that these units have the proper output of

Typical Tank Layout for an Anodizing Line



*Optional; required only to neutralize entrapped acid (castings or heavy brush finishes)

both current and voltage for the processes to be run.

Typical sulfuric acid processes run from 12–18 A/ft² and usually require 24 V DC maximum.

Typical hard anodizing processes run from 24–36 A/ft² and may need as high as 100 V DC. Some processes require special pulsed power sources.

Typical chromic acid processes run at about 5 A/ft² and require about 40 V. Newer processes require 20 V.

Typical phosphoric acid processes run at about 10 A/ft² and need about 24 V.

The size of the unit is calculated from the current requirements of the process to be run, and the typical load size multiplied by 1.1 to allow for racks, etc. Select a unit with the proper voltage output.

A unit with constant current control is preferred over one with constant voltage control.

Most units in service today use silicon controlled rectifiers (SCRs) for current output regulation and diodes or SCRs for rectification to the required DC voltage. Both water- and air-cooled units are available, with water-cooled preferred because they are completely sealed, thereby protecting the internal parts from fumes, humidity and dust.

Ventilation Equipment

Ventilation is an expensive, major area in the design of a new facility. Tanks requiring ventilation are:

- Soak cleaner
- Caustic etch
- Bright dip (chemical polishing)
- Anodizing
- Sealing

To properly size a ventilating system, one must know the amount of air to be removed per unit time, per open tank surface area. This is usually given in cubic ft/min per ft² (cfm/ft²). These guidelines are published in the *Handbook of Industrial Ventilation*.

Pull-pull Systems

Pull-pull systems need higher exhaust rates than push-pull and require two exhaust hoods instead of one. Because less air is exhausted using the push-pull method, it is less costly to operate.

Ventilating hoods are of two basic designs, updraft or downdraft, either of which may be used, depending on the tank sizes or the material handling system in use. Hoods may be built of mild steel, stainless steel or plastic, depending on the corrosion resistance and the resistance to mechanical damage needed. They must withstand the attack of materials in the tanks, as well as physical abuse from parts falling off racks, and the weight of maintenance personnel working on them from time to time. Hoods should be sized with an area large enough to reduce excessive noise from air velocity. Cross-sectional areas based on 2000 cfm are usually adequate in this regard.

Both round and rectangle ductwork is used. Round is generally preferred, because it is easier to install and needs no internal bracing. Ducts should be sized to keep the internal velocity below 2000 cfm to reduce noise levels. Almost any material can be used in building ducts, but because it is easy to install and fabricate, PVC is most often used.

There are at least 10 different types of fume scrubber designs available, all of which are capable of adequately handling the soluble fumes from the etch and anodizing tanks. Scrubbers are usually made from PVC or fiberglass. A large enough cross-sectional area must be provided to allow the vapors to condense on the packing of the unit. The correct packing thickness and density are also required to have an efficiently operating unit. Bright dip tanks need special consideration because of the need to control the oxides of nitrogen generated by such processes.

Typical Rates of Air Exhaustion

	Pull-pull	*Push-pull*
Soak cleaner	150 cfm/ft²	75 cfm/ft²
Etch	200 cfm/ft²	85 cfm/ft²
Bright dip	250 cfm/ft²	95 cfm/ft²
Anodize	250 cfm/ft²	95 cfm/ft²
Seal	175 cfm/ft²	80 cfm/ft²

Material Handling Equipment

This may well be the most important of all the systems in the plant, because the choice of handling equipment can affect the throughput of the plant and the quality of the final product. There are two main types—manual or automatic.

Manually operated includes monorail hoists, and bridge cranes, as well as hand lines.

Manually operated monorail hoists are used with tanks up to 8 ft in length and work bar load of 1000 lb. Bridge cranes are initially more costly than a monorail, but are more productive, and they can be used with tanks up to 50 ft long.

Automatically operated systems, side-arm cranes, overhead hoists and return-type equipment all offer the same advantages over manual systems:

- Reduction in number of operators
- Increases in productivity
- Improvement in quality
- Decrease in chemical usage

The side-arm unit can be fully programmable and handle loads of up to 5000 lb and can work over tanks about 6 ft long. This type of equipment is easy to set up and operate on a line with a number of varying process cycles. It is the least costly to purchase and install.

Overhead cranes offer the same flexibility in the types of cycles that the side-arm system offers. This type of unit can handle loads from 1,000 to 12,000 lb and can work over tanks as small as 4 ft to those more than 40 ft in length. They can use variable speed motors to insure smooth starts and stops, thereby reducing rack swaying. This is the most widely used hoist system in anodizing plants today.

The return-type machine is a fixed-cycle unit, offering little flexibility. It is, however, a high production unit. It can handle rack weights of about 200 lb and process 120 racks/hr. It needs less space than other systems and is easiest to maintain because there are fewer parts. A wide variety of hoist controllers is available—from simple drum types to fully programmable logic units.

Computer Controls

The last major area to engineer in a new facility is the possible integration of computers to operate, monitor, document and control the entire plant. As in most industries, computers are now being used more and more widely in the finishing industry. Each plant needs to be looked at carefully to determine the degree of computer control needed or desired and the cost benefits to be derived.

It is possible today to build fully integrated computer-controlled plants. A programmable logic controller (PLC) can operate the hoists and actuate the rectifiers. Another PLC could be included to monitor the various tank parameters. A computer can be provided to automatically analyze and replenish the various baths. The information from the hoist controller and the automatic chemical analyzer can be gathered by another computer and the data can be used to produce reports, such as part status, process line status, part set-up and processing, work scheduling, maintenance scheduling, chemical usage, inventory levels, and statistical process control data.

All information can be displayed, printed out, stored or passed along to the plant mainframe computer for other uses.

An automatic solution analyzer can be programmed to draw a sample from each tank on a regular basis, prepare the sample and deliver it to the proper system for analysis. After the analysis is completed, if a bath constituent is found to be out of the proper range, a report can be generated for the addition of dry chemicals or a pump- or valve-actuated to add liquids. After the addition is made, a second sample is drawn and the bath re-analyzed to insure that it is operating within the limits established for it. **P&SF**

* This is an edited version of a chapter excerpted from the *Light Metals Finishing Process Manual*, an extensive reference manual developed by the AESF Light Metals Finishing Committee. The manual covers aluminum and its various alloys, as well as other commonly used light metals (magnesium, titanium and zinc). Simple "recipes" are used to describe mechanical and chemical processes, each described in conjunction with the most common alternatives or refinements, using both characteristics and trade designations. Coloring processes, application of organic finishes, porcelain enameling, troubleshooting, safety inspection and appropriate waste treatment are covered. Information is based on current practices that may be adapted to any plant or operation. An appendix contains a table of conversion factors, plus a list of sources of additional information. The manual is 170 pages in looseleaf format for easy updating. Price is $39.95 for AESF members; $60.00 for non-members. Call AESF Publications Sales toll-free (1-800/334-2052) and ask for Order Number 20-99.