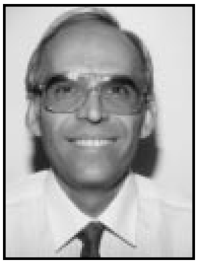

Finishers' Think Tank

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Aluminum: The Lightweight Industry Heavyweight

When it comes to aluminum, metal finishers typically agree this metal has got to be handled and processed using some unique steps and considerations. Because of its light weight, heat capacity, durability, and corrosion resistance, aluminum is the metal of choice for many uses. Are there many types of aluminum parts made for commercial and engineering applications? You bet! Some of these are: Engine parts, screws, fasteners, appliances, medical, aerospace/aircraft and computer parts.

Cycles to finish aluminum may be selected from among: Chromating, electroplating, electroless plating or phosphating. A surface preparation cycle for electroplating or electroless plating generally consists of:

1. Soak clean
2. Etch
3. Desmut
4. Zincate
5. Optional double zincate
6. Strike plate
7. Plate

It may seem relatively easy, but aluminum demands that a quality effort be invested to obtain a quality finish. Let's consider each of these cycle steps, along with some operating tips. Although rinsing is not listed in the given cycle, rest assured thorough rinsing between each step is very important.

1. Soak Clean

Normally, this is considered to be a non-etch, immersion process. The working solution of the liquid or powder concentrate does not attack the base metal. To meet this requirement, the soak cleaner maintains a pH of 8–9.5. It may contain a borax buffer, complexors to control water hardness, polyphosphate, anionic and nonionic surfactants—no caustic or silicate, which cause etching. The soak cleaner will, by displacement or emulsification, remove oily soils and grease. A temperature range of 140–180 °F is common. Immersion time is dependent on the severity of the cleaning demand, although 1–5 min is sufficient for many cycles. Satisfactory cleaning can be confirmed by the absence of water breaks in post rinsing. Or, when running test parts, dip in dilute acid after the cleaner rinse (1% phosphoric or sulfuric acid), followed by rinsing again.

Another soak cleaner is the ultrasonic type. This bath is preferred for the removal of fatty acids, buffing and polishing compounds (animal fats and synthetics). Automotive decorative trim and wheels are prime examples of parts that benefit by ultrasonic cleaning. These baths exhibit a different chemistry, such as containing: High titer soaps, solvents (*e.g.*, propylene or ethylene glycol ethers, pine oil), amines, anionic/nonionic surfactants, borax or inorganic phosphates. Bath pH may range from 9.0–10.0. The components soften and loosen the soils described. Cleaning is facilitated by the application of sound waves, usually 25–80 KHz, or 45–65 watts/gal. This produces low- and high-pressure waves in the bath concurrent with sound waves passing through. Perhaps you have heard of the term "cavitation," which describes this phenomenon. Tiny vapor bubbles form in the low-pressure areas. As the next sound waves pass, the pressure builds up, ultimately imploding the bubble. This released energy "scrubs" the part and helps with soil removal. A transducer forms mechanical motion as sound waves from high-frequency electrical energy. Ultrasonic cleaning is an excellent method to aggressively attack deeply impacted soils (such as in recessed lettering or deep pockets in wheels) and dried compounds. Cleaning times may range from 30 sec to three min. Temperature, however, is important. It shouldn't exceed 165–170 °F. Temperatures in excess will reduce the frequency and magnitude of the all-important cavitation effect. Of course, the ultrasonic cleaner formula can be applied as just a hot soak cleaner. In this case, temperatures up to 210 °F are common to facilitate melting and softening the buffing and polishing compounds. Sometimes, a first ultrasonic cleaner (without ultrasonics) will be followed by the next tank, containing the same cleaner, but with ultrasonics. One item to note is that most ultrasonic cleaner formulations are designed to leave an inhibitor film before etching. In some manual lines that handle parts such as wheels, operators wearing proper protective attire manually wipe the parts with tampico brushes, softening and loosening soils before immersion cleaning.

2. Etch

Because aluminum readily forms an oxide, a thin skin of surface metal must be removed to activate the part for zincating, before it can be plated. Concurrently, etching also provides these process benefits: Scrubs the surface to lift soils and heat treat oxides; produces a matte surface; removes burrs and loosely adherent metal shards; and masks surface scratches and tooling marks. We have two general etchant formulas available—acidic and alkaline (think of the Hall of Fame Tigers outfielder, to remember this one). The most common etch is the alkaline formula (with apologies to Willie, Mickey and the Duke). It consists of caustic soda (low to high concentrations) and may also contain surfactants (for reserve cleaning and controlled etching), scale softeners (to modify the hardness of insoluble aluminate type scales that form during etching—a real work saver when the batch has to be dumped!) and defoamers (to minimize foaming that results from gassing while etching). These etchants are supplied as liquid concentrates and powders. Working bath temperatures may range from 100–180 °F. Concentration, time and temperature must be determined by trial to conform to desired surface treatment. These parameters are critical because they control the etch rate. Increasing one, two or all three increases the etch rate. Many alloys, extrusions, stampings and some castings are effectively alkaline-etched, based on first establishing the etchant operating parameters.

Acidic etchants contain a backbone of inorganic acids, such as hydrochloric, hydrofluoric, phosphoric and sulfuric. Usually, phosphoric and sulfuric acids are the main acids, with lower levels of hydrofluoric and hydrochloric acids. The bath may also contain organic acids, such as citric or gluconic, which are effective complexors, and surfactants to provide secondary cleaning. Because of the ingredient profile, acid etches are predominantly liquid concentrates. Concentration and time are dependent on the surface treatment requirements. Bath temperatures range from ambient to 130 °F. Mechanically polished parts are best suited to acid etching. This is because acid etching is generally mild, and does not distort or lower the desired luster or leveling. Parts to be electroless nickel-plated are also preferably acid etched. The grain and structure of the aluminum surface produced in this etchant is better suited to adhesion of the EN deposit. Some alloys, and especially castings, generate heavy metallic smuts if alkaline etched. In this case, acid etching is preferred to facilitate removal of the smut in the appropriate desmutter. Scratches, tooling marks and burrs may also be removed in acidic etchants.

Series 380		Series 413	
Element	**Assay %**	**Element**	**Assay %**
Magnesium	0.10 max.	Magnesium	0.10 max.
Zinc	3.0 max.	Zinc	0.50 max.
Manganese	0.50 max.	Manganese	0.35 max.
Silicon	7.5-9.5	Silicon	11.0-13.0
Copper	3.0-4.0	Copper	0.60 max.
Iron	1.0 max.	Iron	0.80-1.1
Nickel	0.50 max.	Nickel	0.50 max.
Titanium	—	Titanium	—
Chromium	0.35 max.	Chromium	—
Tin	—	Tin	0.15 max.
Lead	—	Lead	—
Cadmium	—	Cadmium	—
Other	0.50 max.	Other	0.20 max.

3. Desmut

The best way to approach this step is to know the alloy designation. In the previous etching step, the metal surface was attacked, removing a thin coating of aluminum, while exposing an aggregate of insoluble metal oxides. This material, commonly referred to as a smut, must be chemically dissolved before the next process step. Aluminum alloys have been designated in groups for handy reference (see below).

Aluminum Alloy Designations

Aluminum Alloy Type	No. Group
99% minimum & greater	1XXX
Copper	2XXX
Manganese	3XXX
Silicon	4XXX
Magnesium	5XXX
Magnesium & Silicon	6XXX
Zinc	7XXX
Other element	8XXX
Unused series	9XXX

First Digit .... Alloy Type
Second Digit .... Alloy Modification
Third & Fourth Digit .... Aluminum Purity of Alloy

Examples of suggested desmutters based on alloy type are:

- For high silicon - sulfuric acid + fluorides
- For high copper - nitric acid + fluorides
- For low Alloys - sulfuric acid + oxidizers

Other available desmutter baths for consideration include:

- Nitric acid, typically 50-100% v/v
- Nitric acid + sulfuric acid
- Iron salts
- Iron salts + sulfuric acid
- Nitric acid +sulfuric acid + fluorides. Also referred to as the Universal Tri-acid. Consists of 50% v/v nitric acid (42 deg Be), 25% v/v sulfuric acid (66 deg Be), 25% water and 1-2 lb/gal of ammonium bifluoride.

Aluminum die cast alloys are based on six major elements: Silicon, copper, magnesium, iron, manganese and zinc. An example of applying the correct desmutting bath is illustrated by the casting comparison shown in the chart at the top of this page.

General Tips

- The Universal Tri-acid is best suited to desmut both of these castings. However, the formula containing 2 lb/gal of ammonium bifluoride is recommended for the Series 413 casting. That’s because of its greater silicon content (~41% more silicon).
- Usually the aluminum part will exit the desmut bath white and smut free. Close inspection may also indicate a very fine surface etch, which is actually beneficial for zincating or chromating. If the part is smutty (wipe with a white paper towel), chances are slim that subsequent processing will be successful.
- If the part gasses while immersed in the zincate, there is a good

probability it hasn't been properly desmutted.

- If the desmut bath contains nitric acid, be certain that good operating, compliant exhaust is in use to safely vent off nitric oxide gas fumes.

I have dedicated more space to reviewing the desmut step because my experience has indicated this step is very critical compared to the other ones in the process cycle.

In addition, the importance of quality rinsing cannot be understated. Some examples are:

- Dragging residual soak cleaner into the etch bath—excessive foaming will occur.
- Alkaline etch dragged into the desmut bath will reduce its service life.
- Failure to adequately rinse off trace chemicals may cause them to react with the constituents of the next bath—a typical source of cross-contamination.

Analysis Tips

- The soak cleaner of choice is adequately controlled by titration, to regulate maintenance product additions.
- Alkaline etchants are tricky, but can be accurately controlled by analysis. A simple method is to measure the specific gravity by hydrometer. As the bath ages, it becomes heavier and more viscous. For each application, there will be a specific gravity range corresponding to dumping the bath. A direct titration is not so simple. As the bath is used, reacted aluminum forms aluminum hydroxide and sodium aluminate, which are alkaline compounds. Therefore, the direct titration to neutralize actual product alkalinity is accurate only for a newly prepared, never-used bath. The correct method is to titrate for alkalinity based on total and corresponding to the aluminum content. Correction factors, along with plugging in the titration values, provide actual product alkalinity in the bath and aluminum content.
- Based on the desmut bath used, many suppliers offer specialized titration procedures to determine the values of mixed acids in baths. Handbooks and several metal finishing texts also detail equipment and methods.

Aluminum certainly needs special care and attention to processing. That's why next month's review will continue with zincating, the optional double zincate, strike and plate.

Finishing Trivia
Getting the Lead Out

- Tin/zinc alloy is a very popular replacement for tin/lead for two reasons—it eliminates deposit whiskers and the use of lead.
- The use of lead in plumbing solder in the U.S. was discontinued in 1990.

Coming soon …*The Mailbag.* P&SF