Corrosion Control--Chemical Conversion Coatings on Aluminum Alloys

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This article covers two classes of chemical conversion coatings formed by the reaction of chemical conversion materials and the bare surfaces (not alclad) of aluminum alloys. The coatings provide corrosion resistance and provide a surface for better adhesion of primers and paints than bare aluminum. These are not intended to be decorative coatings. The clear coatings for exterior aircraft surfaces and Anodizing (a trade name) are not covered either.

Chemical conversion coatings can be used for touch up of scrapes or bare spots from various causes during fabrication. I recommend that you do not immerse structures after they have been assembled because cleaning agents and coating chemicals can be trapped in between parts and hasten corrosion.

Do the words above sound familiar to some of you.? Some of them were taken directly from MIL-C-5541 as are some of the following words. (Like any good engineer in industry, I copy other people's words without recognition, unless they are copyrighted.)

Classes of Coatings

There are two classes of coatings to specify: Class 1A is a thick film and Class 3 is a thin film. In aircraft design contracts these have definite film thickness requirements. I use the names here because they do properly infer certain characteristics with which I am familiar (and what else would I call them?).

Class 1A coatings are intended to provide corrosion prevention when left unpainted as well as to improve adhesion of paint finish systems on aluminum alloys. Coatings of this type are used on fuel tanks, tubing, and component structures where paint finishes are not required on interior surfaces but are required for exterior surfaces. This can be referred to as a thick film.

Class 3 (there is no Class 2) coatings are intended for use as a corrosion preventative film for electrical and electronic applications where lower electrical resistance contacts, relative to Class 1A coatings and anodic coatings (MIL-A-8625 not discussed here) are required. The primary difference between Class 1A and Class 3 is thickness. Coating thickness is varied by immersion time, therefore the same chemical can be used for both classes.

Because Class 3 coatings are thinner, they are more susceptible to corrosion than Class 1A coatings. If it is required to paint areas surrounding electrical contacts, Class 3 coatings will improve paint adhesion.

Abrasion Resistance

The abrasion resistance of chemical coatings is relatively low. Coatings are reasonably durable when subjected only to moderate handling, but are readily removed by severe wear or erosion. However, cold forming operations (i.e. bending in a brake), when performed with care, can generally be performed on treated metals without appreciable damage to the coatings. They will not hold up on wing leading edges or the lower trailing edge surfaces on flaps.

Selecting Chemicals

The use of a particular manufacturer's coating material is usually based upon availability of the product. Aircraft Spruce has Alodine 1201 (Amchem, Inc, for brushing) listed in their catalog. Alodine 1200 and Iridite 14-2 (Allied Research Products) are equivalent and can be brushed. Either can be used for Class 1A or Class 3 by varying the dwell time. Some people use Alodine 600 for Class 3.

The various products listed on QPL (Qualified Products List) -5541 or QPL-81706 will provide equivalent coatings, but the coatings are not interchangeable from a chemical standpoint. The material from one supplier should not be mixed or used to strengthen an existing solution from another material supplier. (I noticed that Aircraft Spruce only carries one manufacturer.) If you start with one product and it works, stick with it.

Chemical coating materials are proprietary products. The ingredients, processes, the method of application (spray, brush, or immersion), and the equipment required for application of coating may vary.

Coating Procedure

Brushing "vs" Immersion "vs" Spraying - Before I say anything more, whether to brush, dip, or spray is for each person to decide. Since Charlie Wagner promoted the good points of immersion, I will promote the good points of brushing.

For brushing you don't need big tanks, however you do need an area similar to that required for painting. Shelf life of chemicals is critical to doing a good job and a gallon can be refreshed cheaper than a large tank. I am used to swabbing and brushing. And maybe the main reason--I don't like large amounts of chemicals around the house (I have a dog and a cat).

Masking - Mask electrical wiring, fabric, and other non-metallic materials using masking tape and plastic or rubber sheeting

Personal Protective Equipment - Rubber gloves should be worn when mixing chemicals or during plating. Cotton gloves can be used to prevent fingerprints on the cleaned part. Fingerprints will prevent proper chemical coverage.

Mix chemicals - Mix chemicals according to the manufacturer's instructions for brushing. Check the shelf life after mixing, it may be only 21 days. I recommend that the container be labeled with the expiration date. Check your label, but sources say one quart will cover 100 to 125 square feet.

Cleaning and Removing Oxides - Prior to application of coating, the base metal shall be mechanically and/or chemically *cleaned so that a water break-free surface is obtained after rinsing*.

Use of a **non-etch cleaner is preferred.** If an etch cleaner is to be used, read the Appendix - Etch Cleaner.

Scrub all surfaces with nylon abrasive pads wet with water, to remove oxides. (Scotchbrite, Type I, Grade A is a non-metallic mat made of nylon fiber and covered with aluminum oxide grit size 280 to 400. According to a commercial item description aluminum oxide Scotchbrite pads should be color coded maroon.) ***Do not use steel wool!***

Without allowing the part to dry, rinse the part with cold running water. Wipe the surface of the part with wet, clean cheesecloth to remove loose oxides and residue from nylon abrasive pads. Continue wiping until a new section of wet cheesecloth comes up clean. (If you don't use chemicals, you can let the water run down the drain.)

Do not allow surface to dry before proceeding to chemical application or the oxide will reform.

For other approaches and comments on cleaning see Appendix - Other Comments on Cleaning.

Chemical Application - Apply brush conversion coat solution to the wet surface with an acid-resistant brush, cheesecloth pad, swab or synthetic sponge using a light pressure and continuous motion.

On curved or inclined surfaces, begin the application at the lower surface and work up to minimize streaking. Keep the surface wet with the solution for a dwell time sufficient to obtain desired color.

The dwell time for aluminum is 1 to 5 minutes depending on the strength of the mixture, temperature and film thickness desired. Did I say, "the longer the dwell time, the thicker the film"? (You will have to experiment to get your version of Class 3 or Class 1A.) I do like Charlie Wagner's 3-minute egg timer for a standard. The best part about it is, unlike a digital clock, you don't have to remember when you started it.

You may wish to dip your small parts such as clips and brackets in a small plastic bucket or pan.

Visual Appearance - The simplest way to evaluate a conversion coating is to observe color, uniformity of appearance, smoothness, adhesion to the base metal and to be sure there are no powder spots. Visual examination is performed to assure that proper cleaning and coating procedures were used such that a coating with sufficient protection exists over the entire part. Coating color may range in color from a light green or golden, to iridescent yellow, to a dull brown. It should be a continuous film but color may be different between different surfaces. Streaks are not a cause for re-coating.

Different alloys will have different colors. See Appendix - I remember.

Note: Visual examination will not reveal if the protective value of the coating has been impaired by contamination or by overheating during drying.

Rinse - Rinse the surface thoroughly with running water. Maintain the rinse water pressure at a low level to prevent removing the coating. A squirt bottle may be used to rinse small areas. Catch the rinse water. (Small parts can be rinsed in a bucket of water first to get most of the chemical quickly. Be sure the water does not get too much chemical and lower the rinse efficiency.)

The newly formed conversion coating is soft and easily removed if rubbed. Do not swab the surface with cheesecloth during rinsing. Do not disturb the coated surface until it is completely dry.

Drying - Air dry the treated surface for at least one hour before priming. I also recommend waiting more than an hour before priming. I recommend that no heat, or blown air be used. You can, but if the air pressure is too high or the temperature too hot, it is possible to damage the coating with no visual indication of the damage.

Disposal of Rinse Water and Out-of-date Solutions - The rinse water will have chromates which the EPA dislikes very much. With brushing, the amount rinse water you have to dispose of will be less than if you used immersion. Catch the rinse water in plastic buckets (such as pickle buckets from a local fast food place) and use when you next mix concrete. Out-of date solutions should be treated likewise. I had originally thought the chromates would leach out of the concrete until I was told otherwise. Manufacturing plants use concrete pits to trap the chromates.

Appendix - Etch Cleaner

Some industrial processes require an etch type cleaner (certain adhesive systems for better adhesion) but chemical conversion coating does not.

If you do use an etch-type cleaner, extreme caution should be taken to prevent pitting or intergranular attack. With alkaline etch the aluminum tends to be more soluble than the alloying elements. The existing intermetallics, such as copper in 2024, may be further exposed.

Using an etch cleaner will produce a thin black film on the aluminum surface. This film must be removed using a deoxidizer prior to application of the chemical conversion coating.

Both the etch solution and deoxidizer solutions etch the aluminum surface resulting in metal removal. Typically the etch solution will remove .0004 to .0007 inches in 10 minutes. The deoxidizer solution will remove .00015 to .00040 inches per hour. The aluminum surface will have a bright non-oxidized surface from the deoxidizer. **The surface must remain wet until the application of the chemical conversion coating to prevent the formation of new oxides on the aluminum surface.**

Appendix - Comments on Cleaning

Abrasives containing iron such as steel wool, iron oxide, rouge, are prohibited for all aluminum cleaning operations as particles from them may become embedded in the metal and accelerate corrosion.

Remember that the purpose of using an abrasive pad is to clean, not scuff the surface. In painting you scuff the previous coat for better adhesion of the new coat.. Conversion coatings do not require scuffing.

Charles Wagner (Oct-Nov 96 ***The Leading Edge***) uses Dawn dishwashing detergent for cleaning. Industry stays away from commercial detergents and soaps for manufacturing. I remember years ago when a manufacturing engineer told me how he periodically changed formulations of Tide so there would not be long term buildup of a sediment ("soap film"). The changes in formulations could cause undesirable results.

Using MEK (Methylethylketone) is good if you have good ventilation and no gas water heater or clothes dryer or space heater. MEK and Solvasol were the two all purpose cleaners I was taught to use. I stayed away from MEK because of its flammability like acetone. Solvasol was for cleaning greasy parts and was a trade name. (*Note: Since this was originally written, Lee has found a better solvent that he now recommends. This biodegradable cleaner was covered in last months newsletter, with an addendum in the next article -- ed*)

Appendix - I Remember

I remember seeing an F2H-3 Banshee at the McDonnell gun butts. It had only chemical conversion coating on the skin (and access panels). Each piece of skin and panel had a different color. It looked like a patchwork quilt.

Thanks

Thanks to Ron Yarbrough, Steve Mitchell, and Bob Urban for helping me on the stuff I could not find in MIL-C-5541.