

Process Specification for the Anodizing of Aluminum Alloys

Engineering Directorate

Structural Engineering Division

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Process Specification for the Anodizing of Aluminum Alloys

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REVISIONS		
VERSION	CHANGES	DATE
--	Original version	5/96
A	Reformatted, Type III tight tolerance issue addressed, provisions for addition of glass bead or grit blasting prior to anodizing	3/2/99
B	Added color callout in section 3.0, re-write of definition of "sealing"	7/7/00
C	Changed EM references to ES	6/4/03
D	Significant changes to section 3.0. Added information for Class 1, Class 2, hot water seal, and surface preparation. Added additional Type III design guidance. Added work instructions for JSC hardware and contracted work.	6/2020
E	Clarification increased on sealing and verification requirements.	5/6/2026

1.0 **SCOPE**

This process specification establishes the technical requirements for anodizing aluminum alloys.

2.0 **APPLICABILITY**

This process specification covers the requirements for six types and two classes of electrolytically formed anodic coatings on aluminum and aluminum alloys. It does not cover the requirements for anodic coatings with controlled optical properties in spacecraft external environments.

3.0 **USAGE**

This process specification shall be called out on the engineering drawing by using a drawing note that identifies the process specification and the anodic coating type and class to be used. For example:

ANODIZE PER NASA/JSC PRC-5006, TYPE II, CLASS 1

The following types of anodic coatings are covered by this specification:

Type I	Chromic acid anodizing, conventional coatings produced from a chromic acid bath
Type IB	Chromic acid anodizing, low voltage process, 22 ± 2 volts
Type IC	Non-chromic acid anodizing, for use as a non-chromate alternative for Type I and IB coatings
Type II	Sulfuric acid anodizing, conventional coatings produced from a sulfuric acid bath
Type IIB	Thin sulfuric acid anodizing for use as a non-chromate alternative for Type I and Type IB coatings
Type III	Hard anodic coatings

Sulfuric anodizing is the most commonly performed method of anodizing and produces a thicker, more durable coating. Very few vendors perform chromic acid anodizing. The process is undesirable for vendors due to the health and environmental hazards related to hexavalent chromium used in the process.

The two classes of anodic coatings are:

Class 1 – Non-dyed

Class 2 – Dyed

For Class 2 anodize, the color must be included in the drawing note.

ANODIZE PER NASA/JSC PRC-5006, TYPE II, CLASS 2, COLOR BLUE
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Specific dye colors may be selected from AMS-STD-595. When a specific color and density is required, the dye, concentration, and time shall be included in the drawing note. These details should be discussed with the responsible Materials and Processes organization (M&P) and the vendor.

Type I and II shall be sealed. Class 1 (non-dyed) parts are typically sealed with boiling deionized water. Class 2 (dyed) parts are usually sealed with a commercial sealant containing nickel acetate or cobalt acetate and other proprietary organic sealants to prevent the fading of color in the seal tank. Some metal finishing vendors use acetate sealants for Class 1 parts. Flight hardware that is exposed to ultraviolet light should be sealed using hot water only. Note that acetate sealing may reduce adhesion if subsequent adhesive bonding is required on the anodized surfaces.

Type III coating shall not be sealed where the main function of the coating is to obtain the maximum degree of abrasion or wear resistance. Sealing may reduce the wear resistance and needs prior approval by M&P. If delivering Type III hardware unsealed, the parts shall be rinsed in cold DI water and dried thoroughly with nitrogen.

Anodized surfaces subsequently coated with a dry film lubricant should not be sealed and should be mechanically roughened or grit blasted prior to anodizing to produce a surface that will promote adhesion. Sealing can cause issues with the application of dry film lubricant.

HOT DEINOIZED WATER SEAL

Anodizing is an electrolytic process, and parts must make electrical contact with the rack. The contact point leaves a small void in the coating. If the current is too high, occasionally a “burned” spot results at the contact point. If the location of the contact point is important to a design, it should be coordinated with responsible M&P organization and the vendor. The contact points can be defined on the engineering drawing, or alternatively, surfaces where electrical contact is not allowed, shall be defined on the engineering drawing.

Because of the electrolytic process, unintentional reduction of one or more of the constituents of the alloy may occur during the anodization process resulting in a pitted surface which may not produce a uniform anodic coating. Aluminum alloys with a nominal copper content above 5.0 percent or silicon content above 7.5 percent shall not be anodized without prior approval from the M&P organization.

Verify current version before use.

Surface preparation is critical to the quality of the anodize and the final roughness of the anodized surface. The surface texture is replicated (not leveled) and the roughness is increased during anodizing. Caustic etching, normally used to clean the surface before anodizing, also slightly increases the roughness. To produce a smooth, shiny, or glossy anodized surface, the surface must be extremely smooth to start, requiring mechanical polishing or chemical brightening, and the part would have to be deoxidized, but not etched. To produce an anodized matte finish that is non-reflective, the surface should be roughened after milling by blasting or abrasion.

If glass bead or grit blasting is required by the design prior to the anodize process, it shall be included in the drawing note. For example:

BEAD BLAST WITH SIZE 13 GLASS BEADS PRIOR TO ANODIZING

Or

GRIT BLAST WITH 180 GRIT ALUMINUM OXIDE PRIOR TO ANODIZING

If the anodize is required to be a matte finish, this shall be specified in the drawing note, see example below. Glossy finishes may also be specified.

MATTE FINISH ALL SURFACES

3.1 SPECIFIC DESIGN INFORMATION ON TYPE III COATINGS

When no thickness is specified on the engineering drawing, the default thickness shall be 0.0020". When no tolerance is indicated, the coating shall not vary by more than $\pm 20\%$ across the part, and no greater than ± 0.0004 " regardless of the coating thickness. When an alternate thickness is required, it shall be specified on the engineering drawing, along with the tolerance. If coating thickness measurement is required at critical locations of the part, it shall be specified on the drawing.

Corners shall have a radius, and not a chamfer or broken edge, to obtain a uniform coating. Since the coating grows perpendicular to the surface of the part, sharp outside and inside corners can produce dimensional irregularities. The recommended radii in MIL-A-8625 are as follows:

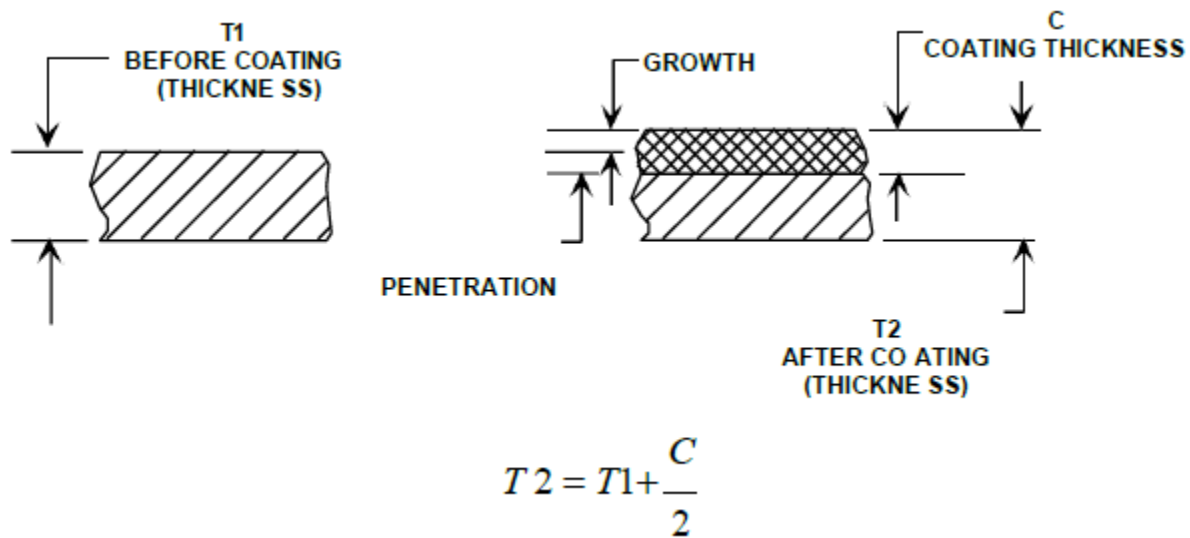
Coating Thickness	Recommended Radius
0.001"	0.03"
0.002"	0.06"
0.003"	0.09"

The engineering drawing shall specify coating thickness or ensure that all anodized

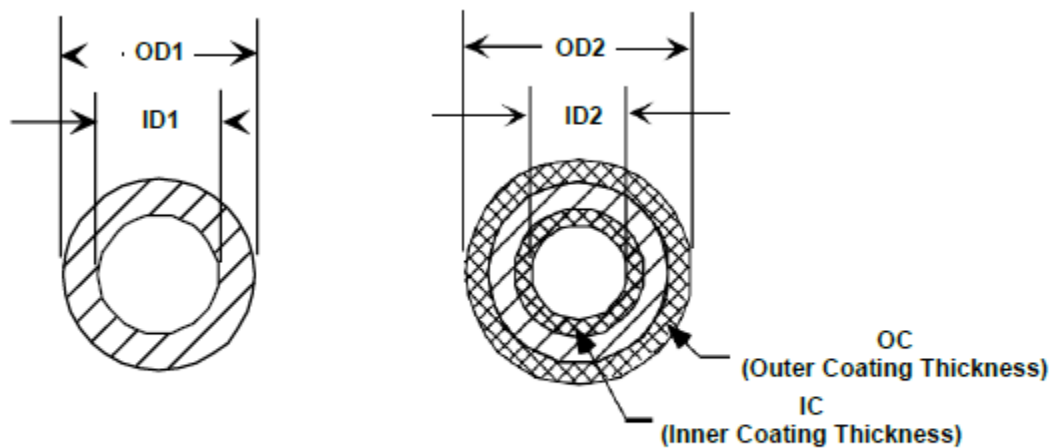
Verify current version before use.

edges are minimum 0.06" radius. Smaller radii may be used by the designer; however, this increases the chance that dimensional irregularities or appearance issues will result.

Type III hard anodizing has a large impact on design dimension due to the much thicker oxide coating than other anodize Types. The oxide coating thickness grows at approximately twice the thickness of the converted metal. When the Type III anodic coating is applied, typically half of the coating thickness is comprised of the penetration into the "before coating thickness" and the other half consists of the coating growth "coating thickness". The net effect is the surface of the part grows about half the thickness of the new coating, as shown below:



This process is complicated even more for intricate geometries, such as the tube shown below. It should be noted that the Inner Coating Thickness (IC) does not necessarily equal the Outer Coating Thickness (OC). The resulting dimensions and tolerances are determined as a function of part geometry and anodize bath conditions (i.e. uniformity of the supplied current density). The more complex the geometry, the more difficult it becomes to hold tight tolerances. Normally for tubing, the current density is such that $IC < OC$.



$$OD2 = OD1 + OC$$

It is recommended that for such Type III applications, both the final dimensions and the “machine to” dimensions should be specified on the engineering drawing.

Inside surfaces of narrow holes or tubing will not achieve the same thickness as outside surfaces. The coating thickness will also decrease with the depth of the hole or length of tubing. In some configurations, an auxiliary cathode can be used to improve anodizing thickness and consistency on the inside of a cavity. Other design solutions include not requiring a uniform thickness in the hole, reaming, or polishing the hole to a uniform thickness after anodizing and masking the hole. If holes are masked, they should be conversion coated instead to ensure corrosion protection.

Anodizing, especially hard anodizing, is not recommended on threads. Threads are commonly masked from the anodize process and subsequently chromate conversion coated. The slight thickness increase, even from Type 1 or Type 2 anodize can interfere with the installation of helical inserts and has occasionally resulted in high running torque when the final fasteners are installed.

The color of hard anodize will vary, depending on the composition of the alloy, from gray to black to dark brown. Castings and high copper aluminum alloys may have an unacceptable appearance in some applications. Special procedures can sometimes be used to improve the surface appearance of hard anodize on these alloys.

3.2 WORK INSTRUCTIONS

Work instructions shall be generated for implementing this process specification. The work instructions shall contain sufficient detail to ensure that the manufacturing process produces consistent, repeatable products that comply with this specification.

For work performed at JSC facilities, these work procedures shall consist of Detailed Process Instructions (DPI's).

For contracted work, the contractor shall be responsible for preparing and maintaining, and certifying written work procedures that meet the requirements of this specification.

4.0 REFERENCES

All documents listed are assumed to be the current revision unless a specific revision is listed.

JPR 8500.4

Engineering Drawing System Requirements

MIL-A-8625

Military Specification, *Anodic Coatings for Aluminum and*

Verify current version before use.

SAE AMS-STD-595	<i>Aluminum Alloys</i> Colors Used in Government Procurement
SOP-007.1	Preparation and Revision of Process Specifications
NASA-STD-6012	Corrosion Protection for Spaceflight Hardware

5.0 MATERIAL REQUIREMENTS

None

6.0 PROCESS REQUIREMENTS

All anodizing of aluminum alloys shall be conducted in accordance with the technical requirements of MIL-A-8625. Type III anodize coatings formed at room temperature are prohibited.

If a coating thickness is not specified on the engineering drawing, the thickness for Type III coatings shall be 0.002" +/- 0.0004".

7.0 PROCESS QUALIFICATION

None

8.0 PROCESS VERIFICATION

Process verification shall be in compliance with MIL-A-8625. Flight hardware that provides mission-critical functions shall meet additional verification for corrosion protection stated in NASA-STD-6012 which may exceed the capabilities of anodize alone. Finishes for mission-critical hardware should be coordinated with the relevant M&P organization.

Monthly corrosion testing per MIL-A-8625 is required. For contracted work, proof of this testing shall be submitted along with the certificate of conformance.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

All anodizing of aluminum alloys shall be performed by personnel qualified to conduct the process through training or experience. If these processes are to be performed by an outside vendor, the development of an appropriate training program shall be the responsibility of the vendor.

10.0 **DEFINITIONS**

Anodizing Process	Electrochemical procedure by which aluminum and aluminum alloys are treated electrolytically in a bath containing chromic or sulfuric acid to produce a uniform oxide coating on the metallic surface
Chemical Conversion Coating	A protective coating that is formed on the surface of a part by a chemical reaction that occurs with the surface of the alloy. Chemical conversion coating is also known as Alodining, chem flim, or chromate conversion.
Hard Anodize	Type III anodic coating, also known as hardcoat, that is formed using a low temperature sulfuric acid bath. It is an extremely hard, abrasion resistant, porous oxide.
Sealing	Process by which the chemically treated aluminum is immersed in boiling, deionized water for 15-30 minutes; partially converts the alumina of the anodic coating to aluminum monohydroxide. Nickel acetate and sodium dichromate solutions may also be used as anodic coating seals.