

Process Specification for PTFE- Impregnated Surface Treatment of Aluminum Alloys

Engineering Directorate

Structural Engineering Division

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REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version	1/22/07
A	Added reference documents and periodic testing requirements	5/08/14
B	Updated the signature page and format. Clarified and rearranged the usage section. Updated to use Type 1 for new design only.	6/20

1.0 **SCOPE**

This process specification establishes the engineering requirements for producing hard anodize on aluminum alloys with a PTFE-impregnated coating on the surface for the control of surface hardness, friction and wear.

2.0 **APPLICABILITY**

This process specification covers the requirements for hard anodize PTFE coatings on aluminum and aluminum alloys, as described in the 3.0 Usage section. It does not cover the requirements for general aluminum anodizing, which is addressed in PRC-5006, or anodizing for the control of optical properties which is addressed in PRC-5008.

This type of treatment produces a hard, wear resistant, self-lubricating surface with a low coefficient of friction that becomes an integral part of the substrate. The surface consists of a hard anodize oxide layer with a controlled infusion of PTFE particles. This resulting surface layer is resistant to chipping, flaking, peeling, corrosion, abrasion/wear, and galling.

Typical applications include designs which require hard, wear-resistant surfaces with controlled coefficient of friction. Examples include: guide rails, impeller blades, valves, molds, and applications which implement rolling or sliding surfaces.

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 type.

This PRC controls the coating process per the AMS 2482 industry standard (Section 6.0), product quality and performance varies significantly from vendor-to- vendor. In addition to call-out of this PRC, the vendor and company process must be specified directly on the engineering drawing. An example drawing note is as follows:

APPLY PTFE-IMPREGNATED ALUMINUM OXIDE COATING PER NASA/JSC PRC 5011 TYPE 1 (*Vendor Name and Vendor Process*) TO THICKNESS 0.002 Inch \pm 0.0005. VERIFY FINISHED COATING THICKNESS VIA EDDY CURRENT IN PRESCRIBED LOCATIONS PER ASTM B244.

Two types of PTFE coatings are available per the AMS 2482 Standard: Type 1

PTFE-impregnated aluminum oxide

Type 2 Co-deposited PTFE and aluminum oxide Only Type 1 shall be used for new design per this PRC.

Thickness measurement is best verified directly by Eddy Current per ASTM B244, as other means of measurement (e.g. micrometer) provides indirect coating thickness measurement. It is recommended to prescribe thickness verification measurement locations directly on the engineering drawing(s).

3.1 Materials Considerations

This process shall be limited to aluminum alloys consisting of less than 5% copper or 8% silicon or a total of 8% of both elements. Note that alloy 2219 contains more than 5% copper. Alloys with higher silicon content like 4045 and 4047 may be coated satisfactorily with proper precautions in processing but must be coordinated with the responsible materials & processes engineer. Careful consideration should be given to the use of this process on highly stressed parts because of the lowered fatigue resistance and on parts with sharp corners or edges where chipping may result.

Unless otherwise specified on the engineering drawing, all parts shall be heat treated to the required temper, final machined, brazed, welded and formed prior to the application of the coating.

3.2 Process Considerations

Part manufacturing operations such as heat treating, forming, joining, and media finishing can affect the condition of the substrate and adversely affect the finished part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification. For critical wear surfaces, the desired surface finish shall be prescribed and verified prior to coating application.

The anodizing process requires electrical contact of the part being coated with an anode in the bath. This contact point may produce small irregularities in the resultant coating. For parts being coated over the entire surface, the location of the contact points shall be considered by the designer, coordinated with the process provider, and acceptable to the customer.

PTFE surface coatings on hard anodized aluminum alloys are controlled by industry AMS 2482 Standard entitled: "Hard Anodic Coating on Aluminum Alloys Polytetrafluoroethylene (PTFE)• Impregnated or Co-deposited." Two examples coating are Tufram H+ or Tufram L-4, which are applied by General Magnaplate. Other examples are Hardtuf X-20 or Hardtuf X-40X, which are applied by Tiodize

Corporation. As this process is very unique to each supplier, a specific vendor and product name shall be specified to assure reproducible coating properties.

If strict control of lubricity/wear and/or coating thickness is necessary, pre- production process qualification is recommended. Pre-production verification articles and or coupons article shall be fabricated from the same alloy, temper, and form as the production hardware, with representative machining, tolerances, and surface preparation methods planned for the production hardware. The parts should be processed by the vendor to the same requirements as the production parts. Parts can be installed in development assemblies and tested. Coupons can be evaluated by M&P for hardness or sent to a laboratory for friction, or wear life testing.

3.3 Design Considerations

This process incorporates a hard anodize oxide layer of a specified thickness which is impregnated with PTFE. The hard anodize is similar to the thicker Type III anodize specified in the NASA/JSC PRC 5006 "Process Specification for the Anodizing of Aluminum Alloys.

The desired thickness and tolerance shall be specified on the engineering drawing. Per the AMS SAE 2482 standard, the default thickness is 0.0020 +/- 0.0005 inches; however, the thickness of the coating can be specified from 0.0011 - 0.003 inches. Tolerances shall be +/- 0.0005 in. Coating application normally results in 50% growth and 50% penetration per surface. The thickness requirements do not apply to blind holes and recesses with depth greater than twice the diameter or in open holes with depth greater than seven times the diameter unless a specific coating thickness is specified in those areas. Typically, holes and slots are masked and then chemical conversion coated per NASA/JSC PRC 5005 "Chemical Conversion Coating of Aluminum Alloys."

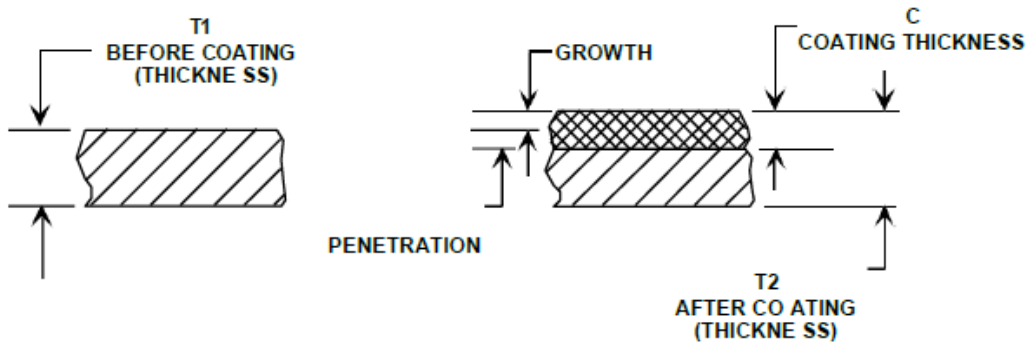
Corners shall have a radius, and not a chamfer or broken edge, to obtain a uniform coating. Since the coating grows perpendicular to the surface of the part, sharp outside and inside corners can produce dimensional irregularities. The recommended radii in MIL-A-8625 are as follows:

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

Smaller radii may be used by the designer; however, this increases the chance that dimensional irregularities or appearance issues will result.

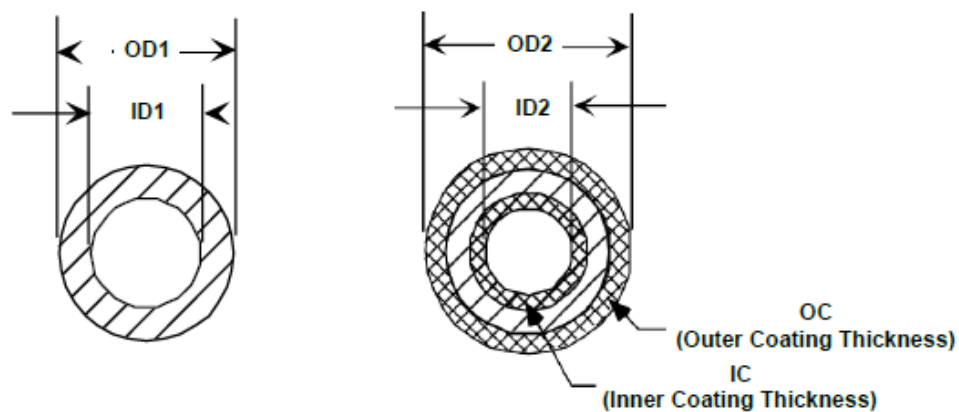
Type III hard anodizing associated with this coating process has a large impact on design dimension due to the much thicker oxide coating than other anodize types.

The oxide coating thickness grows at approximately twice the thickness of the converted metal. When the hard 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:



$$T2 = T1 + \frac{C}{2}$$

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 $IC < OC$.



$$OD2 = OD1 + OC$$

$$ID2 = ID1 - IC$$

It is recommended that for such 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.

This coating process is generally not recommended for use on threads.

4.0 REFERENCES

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

ASTM B117	American Society for Testing and Materials Specification, Standard Test Method for Operating Salt Spray (Fog) Testing Apparatus
ASTM B1193	American Society for Testing and Materials Specification, Reagent Water
ASTM D1894	Static and Kinetic Coefficients of Friction of Plastic Film and Sheeting
ASTM B244	American Society for Testing and Materials Specification, Standard Test Method for Measurement of Thickness of Anodic Coatings on Aluminum and of Other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
ASTM D4060	American Society for Testing and Materials Specification, Standard Test Method for Measurement of Abrasion Resistance of Organic Coatings by the Taber Abrader
ASTM B487	American Society for Testing and Materials Specification, Standard Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopic Examination of a Cross Section
JPR 8500.4	Engineering Drawing System Requirements

MIL-A-8625	Military Specification, Anodic Coatings for Aluminum and Aluminum Alloys
PRC 5005	Chemical Conversion Coating of Aluminum Alloys
PRC 5006	Process Specification for the Anodizing of Aluminum Alloys
SAE AMS 2482F	Society of Automotive Engineers, Inc., Aerospace Material Specification: Hard Anodic Coating on Aluminum Alloys Polytetrafluoroethylene (PTFE)• Impregnated of Co-deposited

The following references were used in developing this process specification:

SOP-007.1 Preparation and Revision of Process Specifications

5.0 MATERIAL REQUIREMENTS

None.

6.0 PROCESS REQUIREMENTS

All hard anodize PTFE-Impregnated aluminum alloys shall be processed in accordance with the AMS 2482 standard.

The periodic friction tests in AMS 2482 are not required, unless specifically requested by the procuring authority.

If a coating thickness is not specified on the engineering drawing, the total coating thickness shall be 0.0020" +/- 0.0005".

6.1 Work Instructions

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

7.0 PROCESS QUALIFICATION

No formal process or vendor qualification is required per this standard, unless specifically required by the procuring authority. If pre-production testing is necessary for strict control of properties, then property verification testing per Section 3.3 of the 2482 standard shall be performed prior to coating treatment of the production parts.

8.0 PROCESS VERIFICATION

Process verification shall be in accordance with AMS 2482.

When parts are to be tested for process verification, such parts shall be supplied by the purchaser. Otherwise, the vendor shall supply all samples for process verification testing. The purchaser reserves the right to sample and perform any confirmatory testing necessary to ensure that the coating conforms to the requirements.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

All PTFE coated parts used on flight hardware shall be coated by a qualified company or certified operators.

10.0 DEFINITIONS

Material Lot A single batch (bar, forging, extrusion, etc.) of material that is produced by the vendor and is documented by a certificate of compliance.

PTFE Polytetrafluoroethylene (PTFE) is a strong, tough, waxy, nonflammable synthetic resin produced by the polymerization of tetrafluoroethylene. PTFE is commonly known by trade names such as Teflon.