



Anodic Oxidation Coating on Aluminum

1 Scope

This specification covers basic requirements for anodic coatings on aluminum and aluminum alloys.

1.1 Material Description. The anodic coating is an oxide layer produced by an electrolytic oxidation process. The oxide layer provides improved corrosion protection. This coating can be transparent or colored. Anodic coatings must be either sealed or painted to maintain their appearance.

1.2 Symbols. Not applicable.

1.3 Applicability. Anodic coatings are used for:

1.3.1 Decorative Parts For:

1.3.1.1 Interior Applications.

1.3.1.2 Exterior Applications. Exterior parts, whether clear or colored, are further classified for chemical resistance and application as follows:

- **Class A** – Extreme alkaline resistance to pH 13.5. For Class A, a supplemental coating is mandatory. Refer to GMW16209 (inorganic topcoat) or GMW16929 (organic topcoat) for requirements.
- **Class B** – High alkaline resistance to pH 13.0.
- **Class C** – Alkaline resistance to pH 12.0.

This performance level may be usable in emerging markets or other areas where environments are known to be mild. It is only usable via special drawing note for parts that are not shared among other regions.

Note: If no decorative exterior class is listed on the drawing, Class B is assumed.

Exterior applications should be limited to above beltline. Applications below beltline are subject to a special release and specific requirements of a higher level must be defined. The corrosion severity in that area is much higher than above beltline because of copper (etc.) containing brake dust.

Exterior colored anodized parts are required to be Class A.

1.3.2 Functional Parts For:

1.3.2.1 Interior Applications.

1.3.2.2 Exterior Applications. Exterior Applications including painted aluminum parts and hard anodized layers. Hard anodized coatings are characterized by their hardness and a thickness of more than 25 µm. For applications that need minor corrosion protection and also high wear protection, the hard-anodic layer may not be sealed. For applications that need a very high corrosion protection, but only moderate wear protection, the hard-anodic layer has to be sealed. Anodized coatings used as a paint substrate (designation FETu (see Section 8)) are used unsealed or partially sealed (e.g.; 5 minutes in hot water) to provide the best paint adhesion.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM B136	ISO 1463	ISO 4892-2	SAE J1545
ASTM B137	ISO 2360	ISO 6507	SAE J1976
ASTM B680	ISO 3497	ISO 18314-1	SAE J2527
ASTM D7869	ISO 4892-1	ISO 20566	

2.2 GM Standards/Specifications.

GMW3059	GMW14444	GMW14865	GMW16929
GMW3286	GMW14458	GMW14873	GMW17103
GMW3417	GMW14669	GMW16209	
GMW14270	GMW14729	GMW16853	

2.3 Additional References.

- American Association of Textile Chemists and Colorists (AATCC) can be found @ <https://www.aatcc.org/>

3 Requirements

3.1 Appearance Requirements. Decorative anodic coatings must be either sealed or supplemental coated to maintain their appearance. To achieve consistent appearance, the same system of sealing and coating must be applied to all adjacent parts. It is further expected that all adjacent parts be produced by the same supplier using a common process.

The anodized coating can be created in different gloss levels ranging from bright to dull (satin). The required appearance (gloss level and/or appearance code (see Section 8)) must be indicated on the relevant engineering drawing.

To achieve the required surface finish (decorative appearance, gloss level, etc.), polishing, brightening, etching, brushing, etc., processes shall be performed prior to anodizing. Defects of the substrate surface (cavities, scratches, etc.) become more visible after anodizing. The process used, especially for semi-bright or satin, must not influence the corrosion resistance. It is essential that decorative extruded parts be buffed prior to anodization to ensure consistent appearance.

3.2 Appearance and Decorative Effects. Parts shall demonstrate no defects or discontinuities such as pores, cracks or any other types of damage. The brightness, color and structure shall be identical to the appearance master.

Colored anodized coatings for exterior decorative use may only be produced in electrolytic coloring processes or in a combined electrolytic and dyeing process. Chemical dyeing is allowed only for decorative interior parts or non-decorative exterior parts because chemical dyed layers are less resistant to environmental influences than electrolytic colors.

Functional exterior parts unsealed for painting need to have a smooth surface.

3.3. Coating.

3.3.1 Anodization. The particular requirements for prepared components shall be met using a suitable anodizing process.

3.3.2 Rinsing Prior to Sealing. Anodized aluminum surfaces are porous and have no corrosion or staining resistance. To achieve the designated corrosion resistance, the pores have to be sealed. Therefore, all electrolyte residues have to be removed from the pores by rinsing the components, subsequently, in flowing, non-aggressive cold water. For decorative applications, it is strongly recommended that the rinsing period shall be at least as long as the duration of the anodizing process.

3.3.3 Sealing. Sealing consists of treatment with hot or gently boiling water which shall be clean, pure, and not contaminated with traces of electrolyte.

For decorative exterior anodizing, minimum two-step sealing is required.

Hard anodized coatings should not be sealed when wear resistance is required. For applications where the main emphasis is on a very high corrosion protection, the hard-anodized coating is also to be sealed. Wear resistance is decreased because of the sealing.

Hot water sealing only may qualify as "unsealed" for use as a paint base.

3.3.4 Thickness. Minimum anodize thickness, as specified in Appendix A, Table A1 and Table A2, is applicable to all significant surfaces as specified on appropriate part drawings. Minimum thickness, other than those listed in Appendix A, Table A1 and Table A2, may be specified on the engineering drawing or math model if required.

3.3.5 Post Treatment/Additional Top Coating. Except for Decorative Exterior Class A anodize, any kind of post-treatment (e.g., additional coatings/layers before or after sealing) is not allowed. That includes Sol-Gel applications, paints, nanoparticles, physical vapor deposits, or similar applications.

3.4 Test Requirements.

3.4.1 Coating Thickness. Film thickness shall be determined by microscopic method (see ISO 1463), x-ray method (see ISO 3497), or by eddy current method (see ISO 2360). In case of disagreements between purchaser and supplier, the microscopic method shall be the preferred method.

3.4.2 Neutral Salt Spray (NSS) Test. The test shall be done according to GMW3286. The test duration depends on the application and is specified in Appendix A, Table A1 and Table A2. After testing, the parts shall show no base metal corrosion.

3.4.3 Copper Accelerated Acetic Acid Salt Spray (CASS) Test. The test shall be performed according to GMW14458. The test duration depends on the application and is specified in Appendix A, Table A1 and Table A2. After testing, the parts shall show no base metal corrosion.

3.4.4 High Humidity Environments. The test shall be done according to GMW14729, Option B (wet bottom). The test duration depends on the application and is specified in Appendix A, Table A1 and Table A2. After testing, the parts shall show no base metal corrosion and no change of surface appearance.

3.4.5 Absorbance of a Colorant. The test shall be done according to ASTM B136. It is only applicable for transparent (clear, uncolored) oxide films. Sealed anodized test pieces shall not be dyed by the test solution.

3.4.6 Acid Dissolution Test (ADT). The test shall be performed according to ASTM B680 and ASTM B137. It is applicable for colored coatings or as an alternate to 3.4.5 for transparent coatings. The maximum ADT rating shall be 6.0 when calculated per the following equation:

$$\text{Rating} = ((W1 - W2)/(W1 - W3)) \times 7.8T$$

Where:

T = Coating thickness in micrometers (μm)

W1 - W2 = Weight of coating in milligrams (mg), dissolved in chromic-phosphoric acid solution per ASTM B680

W1 - W3 = Total coating mass in mg per ASTM B137

3.4.7 Alkaline Resistance Tests (Decorative Exterior Parts Only).

Note: Only virgin/non-cut edges of samples shall be used for the following tests.

3.4.7.1 Extreme Alkaline Resistance test (pH 13.5) – Required for Exterior Class A. Test samples shall be dipped at 20 °C to 23 °C in the test solution for 10 minutes (+30 s) then rinsed with water and air dried. The surface may not change its appearance (polishing is not allowed, but samples may be lightly wiped with a soft cloth while rinsing). Any temporary or reversible changes in appearance after dipping in the test solution must be reviewed with GM Materials Engineering for judgement and acceptance.

Test solution: For a 1 L test solution, add the following to 1 L of DI water:

- 12.7 g Sodium Hydroxide (NaOH).
- 4.64 g Sodium Phosphate Dodecahydrate ($\text{Na}_3\text{PO}_4 + 12 \text{H}_2\text{O}$).
- 0.33 g Sodium Chloride (NaCl).

This solution has a calculated pH of 13.5.

Note: For solution preparation and storage see 3.7.

3.4.7.2 High Alkaline Resistance Test (pH 13.0) – Required for Exterior Class B. Test samples shall be dipped at 20 °C to 23 °C in the test solution for 10 minutes (+30 s) then rinsed with water and air dried. The surface may not change its appearance (dull areas, lost color, etc.) by more than a factor of 1 per the American Association of Textile Chemists and Colorists ((AATCC) see 2.3) gray scale for staining. Samples may be polished with commercial, non-abrasive car wax/polish (Turtle Wax Super Hard-Shell Paste Wax or equivalent) prior to evaluation.

Test solution: For a 1 L test solution, add the following to 500 mL of DI water:

- 4.0 g Sodium Hydroxide (NaOH).
- 4.64 g Sodium Phosphate Dodecahydrate ($\text{Na}_3\text{PO}_4 + 12 \text{H}_2\text{O}$).