

# TECHNICAL BULLETIN



## TECHNICAL BULLETIN #2-13

### *"Specifying Anodized Aluminum"*

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# Specifying Anodized Finishes On Aluminum

## Introduction

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Anodized aluminum is used in diverse applications in many different industries. Its wide range of use has resulted in a correspondingly wide variety of anodic oxide designations. The Aluminum Association (AA), in its Publication #45, "Designation System for Aluminum Finishes," has provided assistance to industry designers and specifiers to designate the correct finish of their choice for the many applications of anodized aluminum. This designation system is particularly helpful to those who are somewhat familiar with anodized finishes and who have some idea of the finish they require.

Many people desiring anodized finishes on aluminum may not be knowledgeable about the types of anodic finishes available and how to specifically call out their requirements to anodizers. This Technical Bulletin of the Aluminum Anodizers Council is intended to help those who are not familiar with the many aspects of anodized finishes. For those who already are familiar with anodic finishes and their various applications, this Bulletin may serve as a quick reference guide to specifying anodized aluminum.

In addition to the AA designation system, three other designation or specification systems are in common use. These are the Alumilite Finishes nomenclature originated by Alcoa, military specification MIL-A-8625 (most current "F" version as of April 2000) and AAC1119 Automotive Standard. Reference will be made in this Bulletin to all of these "systems" to give the reader some familiarity with them. The American Architectural Manufacturers Association (AAMA) has adopted the AA designation system in its "Voluntary Standards for Anodized Architectural Aluminum."

The Aluminum Association categorizes its designation system by "M" for mechanical finishes, "C" for chemical processes, and "A" for anodic finishes.

The system originated by Alcoa divides its nomenclature into three parts:

- Surface preparation (mechanical and chemical)
- Anodic coatings for wrought products
- Anodic coatings for cast products.

The "Mil Spec" (MIL-A-8625) classifies finishes by *Types* and *Classes*.

The AAC1119 Automotive Standard designates the finish types by a letter.

Details of these designation systems used for the specification of anodizing aluminum are listed in the Appendices of this Bulletin. In addition to these commonly used designation systems, many proprietary specifications are written for industry-specific or individual company applications.

## General Discussion

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Aluminum alloys are available as wrought products and as castings. There are a number of factors to consider when specifying anodic finishes. Different finishing processes may be specified depending on the use or application of the final product. Some of the factors to be considered are:

- Appearance: Bright, matte, colored, brushed, other
- Environment of use:
  - Interior (architectural, commercial, decorative, other use)
  - Exterior (architectural, marine)
  - Industrial/Automotive (corrosive or noncorrosive application; resistance to wear or abrasion, other)
  - Aerospace (corrosion resistance, dielectric, emissivity, fatigue strength, other)

The factors outlined above determine the type of finish to be specified. When specifying anodized aluminum products, the following specific criteria should be addressed:

- Alloy and temper of aluminum to be used
- Mechanical finish, if any, required
- Chemical finish in preparation for anodizing
- Anodic oxide type required.

## Alloy and Temper

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**Wrought Alloys.** The alloy and temper of the product to be anodized will affect both the strength and the appearance of the part after it is anodized. Various combinations of constituent elements cause each aluminum alloy to react differently to the process of anodizing; this is particularly evident between alloy series. As a result, each alloy or alloy series yields a different appearance, even if treated to identical anodizing processes. Also, each alloy exhibits its unique characteristics such as good formability, ease of machining, strength, response to anodizing, etc. Examples of some of these general characteristics follow:

- The 2xxx Series alloys are high in copper, have relatively high strength, are hard, and have good machinability. As copper content increases, anodizing generally becomes more difficult. Anodizing conditions should be closely controlled. The anodic oxide on 2xxx alloys is usually softer and has lower corrosion resistance than on alloys with lower copper content. Special anodizing techniques may be used to obtain acceptable coatings.
- The 3xxx Series have relatively high levels of manganese. These alloys are work-hardened (non-heat-treatable) and exhibit excellent formability characteristics. They anodize clear silver, grayish, or brownish depending on the production conditions.

- The 4xxx Series alloys are high in silicon and generally are not anodized.
- The 5xxx Series alloys are high purity aluminum with magnesium added. Alloys of this series are work-hardened (non-heat-treatable) and have good formability. Alloys 5252, 5457, and 5657 are low in iron and have good luster for chemically brightened finishes. These alloys are used largely in automotive and appliance trim applications. Alloy 5052, while higher in iron, chrome, and magnesium, is a high-strength alloy and is used in structural applications such as truck panels. Alloy 5005 is higher in iron and silicon than 5052. It is a good general-purpose architectural sheet and plate alloy. Alloy 5052 anodizes yellowish in thicker coatings, while 5005 anodizes clear silver, gray, or brownish.
- The 6xxx Series offer good, general-purpose, heat-treatable alloys. Alloys of this series have excellent response to anodizing. For example, 6063 and 6463 are popular extrusion alloys having good strength and excellent anodizing characteristics. Principal alloying elements are magnesium and silicon; 6463 is low in iron and is used for bright finishes. Both have good luster and anodize clear silver. Alloy 6061 is higher in silicon, iron, copper, magnesium, and chrome than 6063. It is a high-strength structural alloy having excellent machinability, a favorite of machine shops, especially if the parts are to be hard anodized.
- The 7xxx Series alloys are high in zinc. They are considered ultra-high-strength alloys and find wide use in the aircraft and aerospace industries. They anodize gray, blue-gray, and brown-black (mottled), depending on the alloy and the anodizing process.

**Casting Alloys.** Several aluminum casting alloys also can be anodized. Unfortunately, the characteristics that make good castings are not necessarily the best for anodizing. Alloys with the best casting characteristics are those containing up to 12-percent silicon. High-silicon alloys do not anodize well because silicon is not readily soluble in aluminum. Only the aluminum on the surface of the part anodizes, leaving areas with higher silicon unanodized and the entire part with a black or gray silicon powder.

Aluminum casting alloys containing relatively low amounts of silicon and iron and higher amounts of magnesium, chrome, and zinc tend to anodize well. Aluminum-magnesium alloys such as 514 and 535 anodize well. Aluminum-zinc alloys like 712, 713, and 771 also respond well to anodizing. Some higher silicon casting alloys, such as 356, can be anodized using special techniques and processes. It is best to check with an anodizing expert before specifying casting alloys for projects that call for anodized finishes.

## Mechanical Finish

Mechanical finishing, if specified, is done before chemical finishing or anodizing. Mechanical finishes give surface texture or remove surface defects and irregularities. Appearance can be varied but usually gives a uniform, matte finish, directional or nondirectional sanded finish, or a specular (mirror-like) finish. The mechanical finish shows through the anodic oxides because uncolored anodic oxides are transparent or translucent and anodic oxides conform to the surface texture. This means that surface defects, as well as applied surface textures, are not covered up by anodizing. Examples of mechanical finishes are buffing, polishing, sanding, sand blasting, and shot peening. Refer to the appendix for specific designations of mechanical finishes.

## Chemical Finish

Chemical treatment of the part significantly affects its matteness or brightness (specularity). Chemical treatment is done prior to anodizing and is a very important factor in the final appearance of the anodized part. The pre-anodize chemical treatment of aluminum is often called the cleaning, clean-up or pretreatment phase of the process.

Cleanliness of the part is critical to quality in anodizing. A typical chemical treatment process might be as follows:

- Treatment in an inhibited acid or alkaline cleaner to remove dirt and oils
- Deoxidize in strong acidic solution to remove natural oxides or heat-treat scale
- Chemical etch or brightening.

**Etching** is frequently accomplished in a weak solution of caustic soda (sodium hydroxide). Etching removes metal uniformly and roughens the surface of the metal to give a uniform, matte finish. Acid etching also may be done. Treatment in solutions such as ammonium bifluoride or trisodium phosphate produces a white, matte (satin) finish without as much metal removal as alkaline etching. Different anodizers customize the cleaning and etching process to meet the needs of the products they process. Some examples of chemical finishes:

Fine matte etch: (AA) C21; Alcoa R2

Medium matte etch: (AA) C22; Alcoa R1

Note: MIL-A-8625 does not specify pretreatment processes by number or type designation.

There are other etching processes that may be used; each has a designation that may be called out by using the AA or Systems originated by Alcoa.

**Brightening** is the micro-leveling (micro-smoothing) of the aluminum surface by either chemical or electrochemical means. High luster is created because the process removes the micro-peaks but does not affect the micro-valleys. The

surface is smoothed or leveled, which renders high luster to the surface. Both of these methods of achieving a specular finish may be specified by the AA designation C31. The Alcoa designation for this finish is R5. There are a number of other chemical bright dip solutions and electrobrightening baths, which may be specified by designation or by trade name.

Different mechanical finishes may be combined with satin or bright chemical finishes to produce a variety of appearances. For example, the AA designation M21C21 indicates a "smooth specular buffed" (M21) mechanical finish followed by a fine matte (C21) chemical finish. The specifier, working in conjunction with the finisher, may select the exact type of "fine matte chemical finish" to achieve the desired look. This is best accomplished by producing sample coupons of different versions of the finish and choosing the one that comes closest to the desired appearance. The nomenclature originated by Alcoa for the above finish would be A1R1 or A1R2, "polished and buffed with light etch" or "polished and buffed with satin etch." See the Appendix for a detailed list of finishes, designations, and nomenclature.

## Anodic Finish

The anodic finish is the result of the carefully controlled electrochemical oxidation of the aluminum surface. There are numerous types of anodic finishes. Each finish is specified to obtain certain appearance and/or performance characteristics desired according to the end use of the product. Some of the characteristics of anodized finishes are:

- decorative
- reflective
- corrosion resistant
- absorption/emissivity of heat
- abrasion resistant
- dielectric
- color.

Coating thickness is an important attribute of every type of anodized finish. It may be specified as either coating thickness or coating weight, or both. Common units of measurement are:

- inches,
- mils,
- microns,

where 1.0 mil equals 0.001" (one mil = one one-thousandth of an inch); 25 microns equals 1.0 mil; or 1 micron equals 0.00004 inches.

Coating weight, or mass per unit area, may be stated as mg/cm<sup>2</sup> (milligrams per square centimeter), mg/dm<sup>2</sup> (milligrams per square decimeter) or mg/ft<sup>2</sup> (milligrams per square foot). There are both processing and testing specifications that call out coating weight in these terms.

The most commonly used anodizing process is sulfuric acid anodizing. It produces a colorless, transparent anodic coating on most aluminum alloys. It may be specified in different coating thicknesses to satisfy different functions.

**Protective and Decorative (< 0.4 mil thick).** These coatings are used where somewhat limited protection from corrosion and abrasion is suitable. They are also used in bright finish applications, giving protection, but allowing the brightness to show through. These coatings are not recommended for architectural use, but are very satisfactory where appearance is more important than durability.

Examples of products using this type of anodized finish are:

Lighting reflectors	0.03 to 0.3 mil
Clear anodized automotive trim	0.3 mil
Lithographic plates	0.03 mil
Appliance trim	0.1 to 0.2 mil

The following designation / nomenclature / specification systems apply to this group of coatings.

- Aluminum Association (AA): A2 Series of designations, which include:

A21	Clear anodize
A22	Integral color
A23	Impregnated color (dyed)
A24	Electrolytically deposited color

- Nomenclature originated by Alcoa:

Alumilite 200	0.10 mil coating thickness
Alumilite 201	0.15 to 0.20 mil
Alumilite 202	0.20 to 0.25 mil
Alumilite 203	0.30 mil (not commonly used)

- MIL-A-8625:

Type II Coating thickness called out in purchase document or drawings.

- AAC1119:

See Table 3 in appendix 4.

Note: The "mil spec" is generally used only for military or aerospace finishing, but can be used to designate other finish applications if desired.

**Architectural Class II (0.4 to 0.7 mil coating).** Anodic coatings of this thickness range have greater resistance to corrosion and abrasion than Protective and Decorative coatings. These coatings are recommended for interior architectural use and they may be used outside with regular maintenance of the finish. This thicker class of coatings will give the aluminum a more matte appearance than the thinner coatings. Greater coating thickness makes it possible to produce darker colors when coloring the product.

Examples of anodized products that have a coating thickness in this range are:

Interior architectural panels	0.4 to 0.7 mil
Black automotive trim	0.6 mil
Bleacher seating	0.4 to 0.5 mil

Architectural Class II finishes are designated as follows:

- Aluminum Association (AA): A3 Series of designations, which include:
  - A31 Clear Coating
  - A32 Integral color
  - A33 Impregnated color
  - A34 Electrolytically deposited color
- Nomenclature originated by Alcoa:
  - Alumilite 204 0.4 mil coating thickness
  - Alumilite 214 0.6 mil (not commonly used)
- MIL-A-8625:
  - Type II Coating thickness called out in purchase document or drawings.
- AAC 1119:
  - See Table 3 in appendix 4.

#### **Architectural Class I (0.7 mil and thicker anodic coatings).**

Anodized coatings produced in this class are thicker than Class II coatings and Protective and Decorative coatings.

Class I coatings are used primarily for exterior building products and other products that must withstand continuous outdoor exposure. This coating thickness range is not suitable for highly specular (bright) finishes. Most applications are matte finished.

Class I anodic coatings are thick enough to receive lightfast (fade-resistant) coloring processes. Common coloring methods include adsorptive organic and inorganic dyeing and electrolytically deposited coloring.

Examples of products specified with Class I finishes are:

- Exterior architectural products such as curtain wall, window, and door frames 0.7 to 1.2 mil
- Marine products 0.7 to 1.2 mil

Architectural Class I finishes are designated as follows:

- Aluminum Association (AA): A4 Series of designations, which include:
  - A41 Clear anodize
  - A42 Integral color
  - A43 Impregnated color (dyed)
  - A44 Electrolytically deposited color
- Nomenclature originated by Alcoa:

Alumilite 215 0.7 mil and greater in thickness

- MIL-A-8625:
  - Type II Coating thickness called out on purchase documents or drawings.
- AAC 1119:
  - See Table 3 in appendix 4.

Class I and II finishes have wide use in both clear and colored finishes.

**Clear Anodize.** These transparent coatings show off the silver-gray metallic properties of the aluminum. They are most often anodized in sulfuric acid and the anodic coating is sealed to enhance the protective qualities of the coating.

**Integral Coloring.** These finishes are produced in a mixed electrolyte of various organic or inorganic acids and sulfuric acid. The resulting colors range from a champagne color to dark bronze, gray, and black. Integral coloring, although an excellent finish, has seen decreasing usage as an architectural and commercial finish over the past several years, primarily due to the relatively higher cost of producing integral color finishes. Thanks to their extremely hard coating, integral color electrolytes may be used in hardcoat anodizing processes. Electrolytic coloring methods, generally less expensive to produce, have largely replaced integral color processes in the marketplace today.

**Impregnated Coloring.** Products with these finishes are first clear anodized and then immersed in organic or inorganic dyes. The dye is absorbed by the porous anodic oxide. Anodic oxide thickness and the amount of dye absorbed into the coating are largely responsible for the degree of lightfastness of the colors. Some dyes are not lightfast in any case. Common colors made with organic dyes are red, blue, green, brown, and black. Although virtually any color is available, most organic dyes are not fade-resistant. Inorganic colors are somewhat limited in range, golds and bronzes being the most commonly used.

**Electrolytically Deposited Coloring.** Products using this type of finish are first clear anodized and then color is added by a second step in a bath of metallic salts. The most common metals used for coloring are tin, cobalt, and nickel. The metal is electrolytically deposited into the bottom of the pores of the aluminum oxide (anodic) coating. The color obtained depends on the metal being deposited and the amount of deposit in the anodic pore. These colors range from light bronze to dark bronze and black. Other metals, such as copper, give a reddish color but are not as colorfast as colors produced from tin, cobalt, and nickel.

**Other Coloring Processes.** There are other processes used to color anodized aluminum. The most notable of these processes is called Interference Coloring. As this process gains in popularity it is becoming more readily available. In this process the base of the anodic pore is modified by



electrochemical processing after clear anodizing. Then electrolytic coloring in a standard metallic salt bath deposits a very thin layer of metal at the base of the modified pores. This thin layer of deposited metal is capable of giving visible color interference. Colors produced are shades of blue-gray, green, yellow, and red.

**Special Anodic Coatings.** This group of widely used industrial anodize finishes is classed "General" in the AA designation system. Some of the most commonly used categories of finishes in this diverse group are specifically called out in the following manner:

- Aluminum Association (AA): A1 Series of designations, which include:
  - A11 Preparation for other applied coatings
  - A12 Chromic acid anodic coatings
  - A13 Hard, wear- and abrasion-resistant coatings
- Nomenclature originated by Alcoa:

Alumilite 1000 Series	Chromic Acid anodized
Alumilite 225, 226	Hard anodized, 0.001 / 0.002 mil, respectively (sulfuric-oxalic mixed acid electrolyte)
- MIL-A-8625:
  - Type I Chromic acid anodized
  - Type IB Chromic acid anodized (low voltage method)
  - Type IC Non-chromic acid anodized (e.g., boric-sulfuric)
  - Type III Hard anodized.

**Preparation for Other Applied Coatings.** These anodic finishes are produced so that other coatings may be applied over the anodized coating. Very thin coatings (0.01 mil to 0.1 mil) that are produced by the standard sulfuric acid method are sometimes used as a base for organic (painted) finishes.

**Phosphoric Acid Anodizing** and processes employing a mixture of phosphoric and other acids have gained widespread use as a base for other types of coatings. Typical uses of these very thin coatings include lithographic plates prepared for photo-sensitive emulsions, preparation for adhesive bonding applications in the aircraft and aerospace industries, and as a pretreatment for certain types of electroplating on aluminum.

**Chromic Acid Anodizing** produces very thin films that are more opaque than sulfuric acid anodized coatings. Coating thickness may range from 0.03 mils to 0.10 mils, depending on the alloy and the processing conditions. Chromic acid anodic coatings are usually gray in color and have an attractive enamel-like appearance. These coatings are very resistant to corrosion, resulting in wide use on military hardware and other products requiring excellent corrosion protection.

**Hardcoat Anodizing** can be carried out under a multitude of different processing conditions including electrolytes, temperatures, current densities, and times. The single objective, however, is to create a coating that is thicker than other coatings (1.0 mil to 5.0 mil or greater), has good corrosion resistance, and excellent abrasion resistance. Hardcoat anodized coatings generally have a Rockwell C hardness ranging from 50 to 70. These coatings have outstanding abrasion resistance in rubbing or sliding applications. They are said to be "file hard" but are not resistant to point pressure, as the softer aluminum substrate will give way, causing the hard anodic coating to collapse. Hard anodized finishes are often left unsealed, as sealing can be detrimental to coating hardness. Hardcoat anodizing is used on applications that include aircraft, machined parts, cookware, and many others.

Appendices begin on the following page.

- Appendix 1: Aluminum Association Designation System for Aluminum Finishes (From Publication 45)
- Appendix 2: Alcoa Nomenclature System
- Appendix 3: Military Specification MIL-A-8625
- Appendix 4: Automotive Standard AAC1119

## **APPENDIX 1**

### **ALUMINUM ASSOCIATION DESIGNATION SYSTEM**

#### **For ALUMINUM FINISHES**

The Aluminum Association Designation System divides finishes for aluminum into three major categories:

1. Mechanical Finishes (M)
2. Chemical Finishes (C)
3. Coatings;

The Coatings category is subdivided into:

- Anodic Coatings (A)
- Resinous and Other Organic Coatings (R)
- Vitreous Coatings (V)
- Electroplated and Other Metallic Coatings (E)
- Laminated Coatings (L).

Each category and subcategory is designated by a letter. Only designations pertaining to pretreatment and anodizing are detailed in this reference. The various types of anodized finishes are designated by the letter "A" followed by a two-digit number to call out the specific anodic finish. Finishes designations may be used singly or in conjunction with other designations to specify a complete finishing system. When designations for the anodic coating are used alone, the pretreatment is usually left up to the processor to determine best fit for the product and its end use.

Example of a typical finishing designation for an interior architectural panel might be:

- AA-M42C21A34
- AA Aluminum Association Designation
- M42 Fine matte, nondirectional textured mechanical finish
- C21 Fine matte chemical etch
- A34 Architectural Class II anodize, electrolytically colored.

Note: The finisher and customer will determine, by sampling or discussion, exactly what process constitutes the M42 and C21 finishes.

Example of a typical finishing designation for automotive trim could be:

- AA-M11C11C31A21
- AA - Aluminum Association
- M11 - As fabricated specular
- C11 - Degreased, nonetched cleaned.
- C31 - Highly specular chemical brightening
- A21 - Protective and decorative clear anodic coating less than 0.4 mil thick

#### **MECHANICAL FINISHES (M)**

The mechanical finishes are broken down into four groups:

##### **As Fabricated**

- M10 - Unspecified
- M11 - Specular as fabricated
- M12 - Nonspecular as fabricated
- M1X - Other (to be specified)

##### **Buffed**

- M20 - Unspecified
- M21 - Smooth specular
- M22 - Specular
- M2X - Other (to be specified)

##### **Directional Textured**

- M30 - Unspecified
- M31 - Fine satin
- M32 - Medium satin
- M33 - Coarse satin
- M34 - Hand rubbed
- M35 - Brushed
- M3X - Other (to be specified)

##### **Nondirectional Textured**

- M40 - Unspecified
- M41 - Extra fine matte
- M42 - Fine matte
- M43 - Medium matte
- M44 - Coarse matte
- M45 - Fine shot blast
- M46 - Medium shot blast
- M47 - Coarse shot blast
- M4X - Other (to be specified)

#### **CHEMICAL FINISHES (C)**

##### **Nonetched Cleaned**

- C10 - Unspecified
- C11 - Degreased
- C12 - Inhibited chemical cleaned
- C1X - Other (to be specified)

##### **Etched**

- C20 - Unspecified
- C21 - Fine matte
- C22 - Medium matte
- C23 - Coarse matte
- C2X - Other (to be specified)

##### **Brightened**

- C30 - Unspecified
- C31 - Highly specular
- C32 - Diffuse bright
- C3X - Other (to be specified)

##### **Chemical Conversion Coatings**

(Note: These processes are not followed by anodizing.)

- C40 - Unspecified
- C41 - Acid chromate-fluoride
- C42 - Acid chromate-fluoride-phosphate
- C43 - Alkaline chromate
- C4X - Other (to be specified)

## ANODIC COATINGS (A)

### General

- A10 - Unspecified
- A11 - Preparation for other applied coatings
- A12 - Chromic acid anodic coatings
- A13 - Hard, wear- and abrasion-resistant coatings
- A1X - Other (to be specified)

### Protective and Decorative (Coatings less than 0.4 mil thick)

- A21 - Clear - Coating thickness to be specified.
- A22 - Integral color - Coating thickness to be specified.  
Color dependent on alloy and processing conditions.
- A23 - Impregnated color - Coating thickness to be specified.
- A24 - Electrolytically deposited - Coating thickness to be specified.
- A2X - Other (to be specified)

### Architectural Class II (0.4 to 0.7 mil coating)

- A31 - Clear Coating
- A32 - Integral color
- A33 - Electrolytically deposited color
- A3X - Other (to be specified)

### Architectural Class I (0.7 mil and thicker anodic coatings)

- A41 - Clear
- A42 - Integral color
- A43 - Impregnated color
- A44 - Electrolytically deposited color
- A4X - Other (to be specified)

## APPENDIX 2

### ALCOA NOMENCLATURE SYSTEM

Note: This list of nomenclature originated by Alcoa does not include all anodic finishes in the system. Only the designations for the most commonly used Alumilite (clear anodized) finishes are included. The nomenclature for Mechanical Finishes and Chemical Finishes are complete as listed. Only the designators for hardcoat finishes are included for cast products. The Alcoa integral color (Duranodic) system is not shown because this system is no longer in widespread use.

An example of nomenclature originated by Alcoa for an architectural clear anodized building mullion is:

Alumilite 215R1

R1 Caustic etch (sodium hydroxide), followed by 215 60-minute anodize to produce 0.7 mil minimum coating.

Note that the other steps in the process, such as cleaning, deoxidizing and amount of etch are not specifically called out. This is generally left up to the finisher.

### Mechanical and Chemical Pretreatments

#### Mechanical Finishes

- A1 Preliminary grinding and polishing prior to buffing
- A2 Buff directly on as-fabricated (mill finish) surface
- B Polish finish (round tube only)
- C1 Polish finish, No. 180-220 emery
- C2 Satin finish, hand rubbed with steel wool
- C3 Satin finish, compound or brushed backed sander
- D Polish finish, No. 140-180 emery
- E Polish finish, No. 120-140 emery
- G1 Very fine sand blast
- G2 Fine blast
- G3 Medium blast
- G4 Coarse blast
- H1 Fine shot blast
- H2 Medium shot blast
- H3 Coarse shot blast
- K Wire brush finish
- M Burnished finish
- N Sand burnished finish

Note: Although viable, the above nomenclature is rarely used today. It is presented here for completeness and "historical" value.

#### Chemical Finishes

- R1 Caustic etch
- R2 Caustic etch for diffuse reflectors
- R3 Sulfuric-chromic acid etch
- R4 Bright dip (nitric-hydrofluoric)
- R5 Bright dip (nitric-phosphoric)



**Anodic Finishes** (Note: The Alcoa system designates processing conditions but does not designate coating thickness. The processing conditions are 15-percent sulfuric acid electrolyte, 12 amps per square foot, 68°F to 74°F, sealed in hot water @ 208°F to 212°F for 15 minutes unless otherwise stated. Recommended anodizing times under these processing conditions, as well as nominal coating thicknesses, are given below for each finish. Anodized finishes nomenclature for castings is given only for hardcoat. The casting alloys designation for all sulfuric acid finishes is the 700 Series instead of the 200 Series used for wrought alloys. Only the most commonly used finishes are shown.)

#### Alcoa Alumilite System

Alumilite 200	10	0.10
Alumilite 201	15	0.15 to 0.20
Alumilite 202	20	0.20 to 0.25
Alumilite 204	30	0.35 to 0.40
Alumilite 215	60	0.7 minimum
Alumilite 225*	20	1.0
Alumilite 226*	40	2.0

\*Alumilite 225 and 226 finishes are produced at 36 amps per square foot in an electrolyte of 12-percent sulfuric acid and one-percent oxalic acid at a temperature of 50°F. These finishes are not sealed unless they are dyed.

If the above finishes are produced on castings the designation numbers start with 7 instead of 2. A hardcoat finish of 1.0 mil thickness would be designated as Alumilite 725.

## APPENDIX 3

### MILITARY SPECIFICATION MIL-A-8625

#### ANODIC COATINGS FOR ALUMINUM AND ALUMINUM ALLOYS

This specification is the model for much of the anodizing specified for military and aerospace products. It covers the requirements for six types and two classes of anodizing for nonarchitectural applications. MIL-A-8625 also forms the basis for many anodizing specifications that are proprietary to individual companies. Nearly all of these proprietary specifications refer to one or more requirements of this mil spec.

The specification includes broad processing conditions for anodizing. It also gives important performance and acceptance criteria for such attributes as coating weight, corrosion resistance, lightfastness, paint adhesion, abrasion resistance, and dying. Additionally, standards are set for general appearance, workmanship, contact marks, inspection, process control, and testing.

The anodic coating types and classes are:

<b>Type I</b>	Chromic acid anodizing (conventional)
<b>Type IB</b>	Chromic acid anodizing (low voltage method)
<b>Type IC</b>	Non-chromic acid anodizing (for use as a non-chromate alternative for Type I and IB coatings)
<b>Type II</b>	Sulfuric acid anodizing (conventional)
<b>Type IIB</b>	Sulfuric acid anodizing (for use as a non-chromate alternative for Type I and IB coatings)
<b>Type III</b>	Hard anodize
<b>Class 1</b>	Non-dyed
<b>Class 2</b>	Dyed

Types I and IB are used when outstanding corrosion resistance, paint adhesion, and fatigue resistance are required.

Types IC and IIB are used for these same attributes. An example of Type IC would be the Boeing Boric-Sulfuric Anodizing process. Type IIB is a thin film sulfuric acid anodize.

The specification states that anodic coating thickness should be specifically called out by the purchase documents and/or the part drawing.

An example of a hard anodized and black dyed finish designated by this specification would be:

MIL-A-8625(latest version), Type III, Class 2 black, 2.0 mil coating thickness.

## APPENDIX 4

### AAC1119

#### AAC AUTOMOTIVE STANDARD FOR ANODIC OXIDE FINISHES PRODUCED BY SULFURIC ACID ANODIZING OF ALUMINUM

##### 1. SCOPE

This standard covers the typical requirements for clear and colored anodic oxide finishes on automotive aluminum and aluminum alloy parts. Based upon application, six types of anodic oxide finishes are specified with each having a letter designation as shown in Table 1.

**TABLE 1 FINISH APPLICATION TYPES**

Application	Type
Clear Exterior	A
Colored Exterior	B
Clear Interior	C
Colored Interior	D
Non-decorative (functional)	E
Unsealed for paint base (functional)	F

##### 2. REFERENCED STANDARDS

ASTM B137	ASTM B244	ASTMB368
ASTM B487	ASTM B680	SAE J1885 S
AE J1960	SAE J1976	

##### 3. TESTING REQUIREMENTS

Table 2 indicates which tests must be conducted for each of the six application types in Table 1. The required tests are denoted by an X. Test methods follow the Table 2.

**TABLE 2 TESTING REQUIREMENTS FOR  
ANODIZED ALUMINUM**

Test	Type A	Type B	Type C	Type D	Type E	Type F
Finish Thickness	X	X	X	X	X	X
Finish Mass	X	X	X	X	X	X
Finish Density	X	X	X	X	X	X
Seal Quality (ADT)	X	X	X	X	X	
Corrosion Resistance (CASS)	X	X			X	
Weatherometer		X		X		
Florida Exposure		X		X		

##### 3.1 Finish Thickness

Finish thickness shall be determined by microscopical examination of a cross-section per ASTM B487. Measurement by eddy current per ASTM B244 may be used if results obtained can be correlated with the microscopical examination method. Thickness shall be as specified in Table 3.

##### 3.2 Finish Mass

Finish mass shall be determined per ASTM B137. Mass shall be as specified in Table 3. Finish mass on colored parts should be determined on an equivalent clear sealed finish prior to coloring.

**TABLE 3 FINISH THICKNESS AND FINISH MASS**

Color	Thickness Minimum (μm)		Mass Minimum (g/m <sup>2</sup> )	
	Exterior	Interior	Exterior	Interior
Clear/Nondecorative/Functional	8.0	3.0	20	6
Electrolytic Black* (Sn)**	15.0	8.0	40	20
Electrolytic Black* (Co/Ni)**	8.0	8.0	20	20
Gold (FAO/FSO)**	8.0	3.0	20	6

\* Colors other than black may be available. For black finishes, thicker finishes may be needed to meet requirements of color and gloss.

\*\* Materials in parentheses indicate elements or compounds in the pigmentation.

##### 3.3 Finish Density

Finish density shall be determined from the results of the finish thickness and mass testing. Density shall be a minimum of 36 g/in<sup>3</sup> (equivalent to 2197 g/dm<sup>3</sup>).

Finish Density = Finish Mass / Finish Thickness = (FM in mg/in<sup>2</sup>) / (FT in mils) = g/in<sup>3</sup> or if using metric measurements for length:

Finish Density = Finish Mass / Finish Thickness = (FM in mg/dm<sup>2</sup>) x 100 / (FT in microns) = g/dm<sup>3</sup>

##### 3.4 Seal Quality (ADT)

The maximum Acid Dissolution Test (ADT) rating shall be 6.0 when tested as in ASTM B680 and calculated (using the result from ASTM B137) per the following equation:

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

Where:

W1-W2 = Mass (in mg) of Finish removed resulting from ASTM B680.

W1-W3 = Total mass (in mg) of Finish resulting from ASTM B137.

T = Finish thickness in mils or microns.

If T is measured in mils: F = 200

If T is measured in microns: F = 7.874

3.5 Corrosion Resistance (CASS)

Corrosion resistance shall be determined per ASTM B368. The minimum exposure shall be 16 h unless otherwise specified. There shall be no pitting, corrosion, or other appearance change after exposure.

3.6 Weatherometer

**Type B** finished products shall be exposed per SAE J1960 for 2500 kJ/m<sup>2</sup>. After exposure there shall be no base metal corrosion or objectionable change in color or gloss level, and no development of a weathering bloom which cannot be easily removed by polishing with Original DuPont Formula #7 Auto Polish and Cleaner (made by Borden, Inc.) or equivalent.

**Type D** finished products shall be exposed per SAE J1885 for 1241 kJ/m<sup>2</sup>. After exposure there shall be no indication of loss of gloss, objectionable color change, or other visible detrimental surface deterioration.

3.7 Florida Exposure

**Type B** finished products shall be exposed per SAE J1976 for 31380 MJ/m<sup>2</sup> total solar radiation. After exposure there shall be no base metal corrosion or objectionable change in color or gloss level, and no development of a weathering bloom which cannot be easily removed by polishing with Original DuPont Formula #7 Auto Polish and Cleaner (made by Borden, Inc.) or equivalent.

**Type D** finished products shall be exposed per SAE J1976 for 12550 MJ/m<sup>2</sup> total solar radiation. After exposure there shall be no indication of loss of gloss, objectionable color change, or other visible detrimental surface deterioration.

Note

The Weatherometer and Florida Exposure requirements are considered to be developmental tests intended for Type B and D finished products. They are required for new coloring technologies that are not included in Table 3. Individual suppliers may independently choose to periodically conduct these tests to verify their process.

4. INITIAL SOURCE APPROVAL

No shipment shall be made by any anodize supplier to a customer until representative initial production samples have been approved by the customer as meeting the requirements of this specification.

5. INSPECTION AND REJECTION

All shipments of material or parts under contract or purchase order manufactured to this specification shall be equivalent in every respect to the initial samples approved by the customer. Without prior notification and approval by the customer there shall be no changes permitted in either formulation or manufacturing processes which would produce products different from the initial production samples. Lack of notification by the supplier constitutes grounds for rejection of any shipment. While samples may be taken from incoming shipments and checked for conformance to this specification, the anodize supplier shall accept the responsibility for incoming shipments meeting this specification without dependence upon the customer's inspection.

6. REVISION HISTORY

This standard was initiated in February 2004.

Revision	Date	Changes
Initial	2/04	None

