



Standard Specification for Chromates on Aluminum¹

This standard is issued under the fixed designation B 449; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers the requirements relating to rinsed and nonrinsed chromate conversion coatings on aluminum and aluminum alloys intended to give protection against corrosion and as a base for other coatings. This edition of the specification has been coordinated with ISO 10546 and is technically equivalent.

1.2 Aluminum and aluminum alloys are chromate coated in order to retard corrosion; as a base for organic films including paints, plastics, and adhesives; and as a protective coating having a low electrical contact impedance.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- B 117 Practice for Operating Salt Spray (Fog) Apparatus
 - B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
 - B 767 Guide for Determining Mass Per Unit Area of Electrodeposited and Related Coatings by Gravimetric and Other Chemical Analysis Procedures
 - D 1730 Practices for Preparation of Aluminum and Aluminum-Alloy Surfaces for Painting
 - D 3359 Test Methods for Measuring Adhesion by Tape Test
- #### 2.2 ISO Standards:
- ISO 2409 Paint and Varnishes—Cross-Cut Test³
 - ISO 3768 Metallic Coatings—Neutral Salt Spray Test (NSS Test)³

ISO 3892 Conversion Coatings on Metallic Materials—Determination of Mass Per Unit Area—Gravimetric Method³

ISO 4519 Electrodeposited Metallic Coatings and Related Finishes—Sampling Procedures for Inspection by Attributes³

ISO/ DIS 10546 Chemical Conversion Coatings—Rinsed and Nonrinsed Chromate Conversion Coatings—On Aluminum and Aluminum Alloys³

2.3 Federal Standard:

Fed. Std. No. 141 Paints, Varnish, Lacquer, and Related Materials; Methods of Inspection⁴

2.4 Military Specification:

MIL-C-5541 Chemical Films for Aluminum and Aluminum Alloys⁴

3. Terminology

3.1 Definitions:

3.1.1 *nonrinsed*—chromate coatings that are dried immediately after the chromating step without receiving a water rinse.

3.1.1.1 *Discussion*—This special type of coating is typically used on long coils of aluminum sheet stock that receive an immediate subsequent paint or adhesive coating.

NOTE 1—Nonrinsed chromate coatings are finding increased usage on fabricated parts and castings.

3.1.2 *rinsed*—chromate coatings that are rinsed in water prior to drying.

3.1.2.1 *Discussion*—This type of coating is typically applied to extruded aluminum fabricated parts and castings.

4. Classification

4.1 Chromate finishes can be applied ranging in color from brown, thick coatings (Class 1) providing maximum corrosion protection to yellow, intermediate thickness coatings (Class 2) suitable as an organic film base or to colorless, thin coatings (Class 3) suitable for low electrical contact resistance. The yellow coatings vary from golden yellow to iridescent light yellow. Chromate-phosphate finishes (Class 4) can be applied

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

⁴ Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

ranging in color from green to iridescent light green. The Class 4 coatings comply with the requirements of MIL-C-5541.

4.2 Finishers can seldom guarantee to supply exact shades of color with chromate conversion coatings. If it is necessary to have exact shades of color, it is possible to dye chromate coatings having a coating mass greater than 0.4 g/m^2 to obtain a wide range of colors, but they can only be expected to give an order of added corrosion resistance similar to that provided by the undyed coatings. It should be noted that color and color uniformity will vary somewhat between one alloy and another and from a polished surface to an etched surface. Iridescence and variations in color density from one area of the surface to another are normal and shall not be considered a sign of poor quality.

4.3 The finishes are divided into four classes; their most important characteristics are listed in Table 1.

5. Surfaces Preparation

5.1 The surfaces of the parts to be chromated must be clean and free of any oxidation, scale, or soils such as metal turnings, grinding dust, oil, grease, lubricants, hand-sweat, or any other contamination detrimental to the chromating process. The parts must therefore, as far as necessary, be cleaned before chromating and if necessary be pickled. Fig. X2.1 shows the various processing step options.

6. Methods of Application of Chromate Coatings

6.1 Metallic material other than aluminum should not be treated with the parts to be chromated.

6.2 Chromate conversion coatings are normally applied by dipping; the coating may also be applied by inundation, spraying, roller coating, or by wipe-on techniques. The application method used should be taken from the operating instructions for the chromating process employed. Chromating solutions are usually acidic and may contain hexavalent chromium salts together with other salts that may be varied to affect the appearance and hardness of the film. The color of the film, and, therefore, the type of conversion coating, depends on the composition of the chromating solution, but it is also affected by the pH and temperature, the duration of the treatment, and the nature and surface condition of the alloy being treated.

6.3 These coatings receive a final water rinse. If the coating is meant to be a basis for additional coatings, the detail shall be

subject to a rinse in deionized water with a conductivity less than $100 \mu\text{S/cm}$. If hot water is used as the final rinse after the chromating process, it is essential that the time of rinsing should be kept as short as possible in order to prevent the dissolution of the hexavalent chromium. The drying of the coating shall be carried out at a temperature not exceeding 60°C to prevent cracking due to dehydration, which causes loss of adhesion and performance of the chromate coating.

6.4 Any additional subsequent treatments depend upon the purpose for which the chromated parts are intended.

7. Coating Requirements

7.1 *General*—Chromate conversion coatings harden with age by gradual dehydration. They should, therefore, be handled carefully for the first 24 h after treatment, and any tests (including corrosion tests) shall be deferred until the expiration of that period. The green chromate-phosphate coatings usually continue to improve in corrosion resistance after initial formation. They achieve their maximum corrosion resistance after 1 to 2 months at room temperature. It is not required to store parts for this purpose.

7.2 *Electrical Resistance*—Colorless, light yellow, or light green iridescent chromate layers of low mass per unit area increase the electrical resistance between an electrical contact and the aluminum to a very small extent. When measured at 9-V and a 2-A current the resistance should be less than 0.1Ω . Highly colored brown, yellow, or green coatings show a marked increase in electrical contact resistance with increasing mass per unit area of the chromate layer and may reach resistances of $10\,000 \Omega$ or more.

7.3 *Adhesion*—The coatings shall be adherent and non-powdery. There are no practical tests for measuring the adhesion of a chromate conversion coating on aluminum. However, a practical evaluation of the adhesion can be made by measuring the adhesion of a secondary organic film applied to the chromated aluminum. When specified, the chromate conversion coating shall pass the organic coating adhesion test in Test Methods D 3359 or the equivalent ISO 2409.

7.3.1 Class 4 coatings intended for use under MIL-C-5541 shall have their adhesion evaluated by Method 6301 of Fed. Std. No. 141.

7.3.2 Additional treatments applied under MIL-C-5541 can be found in Practices D 1730, Methods 5, 6, and 7.

7.4 *Corrosion Resistance*—When subjected to the neutral salt spray test specified in Practice B 117 or in the equivalent ISO 3768, three separate test specimens of the coating shall withstand exposure for the hours shown in Table 2 without giving evidence, to the unaided eye, of more than a total of 8 isolated spots or pits. None shall be larger than 1 mm in diameter. Each individual test specimen shall not have more than 5 isolated spots or pits, none larger than 1 mm in diameter on their respective surfaces. Spots within 10 mm of the edges of the panels are not counted.

7.5 *Coating Mass Per Unit Area*—The mass of the coating per unit area of coated surface shall conform to the values given in Table 1. Use the procedure in ISO 3892 as referenced in Guide B 767.

7.5.1 *Coating Mass Significance*—It should be recognized that heavier coating masses do not always provide better

TABLE 1 Classification of Chromate Coatings

Class ^A	Appearance	Coating Mass per Unit Area, g/m^2	Corrosion Protection
1	yellow to brown	0.4 to 2	maximum corrosion resistance generally used as final finish
2	colorless to yellow	0.1 to 0.4	moderate corrosion resistance, used as a paint base and for bonding to rubber
3	colorless	<0.1	decorative, slight corrosion resistance, low electrical contact resistance
4	light green to green	0.2 to 5	moderate corrosion resistance, used as a paint base and for bonding to rubber

^ANo relationship exists between class numbers and degree of corrosion resistance. Class numbers have been assigned on the basis of traditional usage and for compatibility with national standards.

TABLE 2 Relative Corrosion Resistance

Coating Class ^A	Exposure Time, h ^B		
	Non-Heat-Treatable Wrought Alloys	Heat-Treatable Alloys and Cast Alloys with a Nominal Silicon Content <1 %	Cast Alloys with a Nominal Silicon Content >1 %
1	500	336	48
2	250	168	24
3	168	120	12
4	500	336	48

^A Class numbers are assigned on the basis of traditional usage and do not reflect a ranking of corrosion resistance.

^B The exposure times are indicative of the relative corrosion resistance of the various coating classes on the different alloys, but no direct relationship exists between performance in the neutral salt spray test and performance in service.

performance, particularly when using the coating for an organic film or adhesive base.

7.6 Confirming Class 2 Coatings—The presence of a Class 2 coating shall be confirmed by the spot test in Appendix X1.

7.7 Coating Identification:

7.7.1 Colorless, Yellow, or Brown Coatings—The determination of chromium in the coating will identify the layer as a chromate conversion coating. Use the test in Appendix X1.

7.7.2 Green Coatings—It is necessary to determine the presence of phosphate and the absence of zinc in order to distinguish chromate-phosphate coatings from anodized coatings or zinc phosphate coatings. Use the test in Appendix X1.

7.8 Test Specimens and Samplings—Unless otherwise specified the sampling plans of Test Method B 602 or the equivalent ISO 4519 shall be used to test the coatings.

7.8.1 Test specimens should be of the same alloy and surface condition as the articles represented. Test specimens should be 150 by 100 mm.

8. Keywords

8.1 chromate; clear chromate; conversion coating; non-rinsed; passivation coating; rinsed; yellow chromate

APPENDIXES

(Nonmandatory Information)

X1. QUALITATIVE TESTING OF THE LAYER COMPOSITION

X1.1 Reagents

X1.1.1 Only analytical grade reagents should be used. The water used shall be distilled or deionized water. Solutions without indication of the solvent are solutions in distilled or completely demineralized water.

X1.1.1.1 *Sodium Hydroxide*, approximately 5 % solution of NaOH.

X1.1.1.2 *Sodium Hydroxide*, approximately 20 % solution of NaOH.

X1.1.1.3 *Hydrogen Peroxide*, approximately 30 % solution of H₂O₂.

X1.1.1.4 *Acetic Acid*, approximately 10 % solution of CH₃·COOH.

X1.1.1.5 *Lead Nitrate Solution*, approximately 10 % solution of Pb(NO₃)₂.

X1.1.1.6 *Nitric Acid*, approximately 65 % solution of HNO₃ (density, 1.40 g/cm³ at 20°C).

X1.1.1.7 *Nitric Acid*, approximately 38 % solution of HNO₃, made up for instance by mixing 1 part by volume of nitric acid of density 1.40 g/cm³ at 20°C with 1 part by volume of water.

X1.1.1.8 *Ammonium Molybdate-Reagent*—88.5 g ammonium molybdate (NH₄)₆Mo₇O₂₄·4 H₂O, 34-mL aqueous ammonium hydroxide solution with 25 % NH₃, and 240 g ammonium nitrate NH₄NO₃ are dissolved in water up to 1 L total.

X1.1.1.9 *Ammonium Nitrate*, NH₄NO₃.

X1.1.1.10 *Hydrochloride Acid*, approximately 25 % solution of HCl.

X1.1.1.11 *Potassium Ferrocyanide Solution*, approximately 5 % solution of K₄Fe(CN)₆.

X1.1.1.12 *Sulfuric Acid*, approximately 25 % solution of H₂SO₄.

X1.2 Determination of Chromium in the Layer

X1.2.1 A sample of about 300-cm² surface is treated with 50 mL of 5 % sodium hydroxide solution, to which 5 mL of 30 % hydrogen peroxide is added; the solution, at 50 to 60°C, is poured over, repeatedly if necessary, until the layer is completely removed. The resulting solution is poured off, boiled until all hydrogen peroxide is destroyed (about 5 to 6 min), cooled down and precipitated with an approximately 10 % lead nitrate solution. A yellow precipitate shows the presence of hexavalent chromium. The least quantity of total chromium detectable by this method corresponds to about 5 mg chromium per square metre of surface.

X1.3 Testing for Phosphate

X1.3.1 To test for the presence of phosphate in the chromated layer, a sample is taken whose surface to be tested is about 100 cm²; this is treated with 100 mL of 5 % sodium hydroxide solution at 80 to 90°C until the layer is completely dissolved or at least until the surface has been clearly attacked. The resulting solution is filtered, and 25 mL of the filtrate are acidified with approximately 38 % nitric acid then 10 mL ammonium molybdate reagent and 5 g ammonium nitrate are added. The sample is allowed to stand for at least 15 min. A yellow precipitate shows the presence of phosphate. The least

quantity of phosphate detectable by this process corresponds to about 40 mg P₂O₅ per square metre of surface.

X1.4 Testing for Zinc

X1.4.1 To test for the presence of zinc in the layer, a sample is taken whose surface to be tested is about 100 cm²; this is treated with 50 mL of approximately 65 % nitric acid at room temperature until the layer is either completely dissolved or at least until the surface has clearly been attacked. The resulting

solution is filtered through glass wool, and 25 mL of the filtrate are neutralized with 20 % caustic soda until phenolphthalein indicator gives a red coloration. The solution is then weakly acidified by addition of about 10 drops of 25 % sulfuric acid. After addition of 5 mL of 5 % potassium ferrocyanide solution, a greenish-white precipitate shows the presence of zinc. The least quantity of zinc detectable by this process corresponds to about 20 mg zinc per square metre of surface.

X2. TREATMENT SEQUENCE OPTIONS

X2.1 The chromate process necessitates a specified sequence of treatments that depends upon the surface condition of the parts to be treated, the aluminum alloy used, and the desired appearance of the parts. See Fig. X2.1.

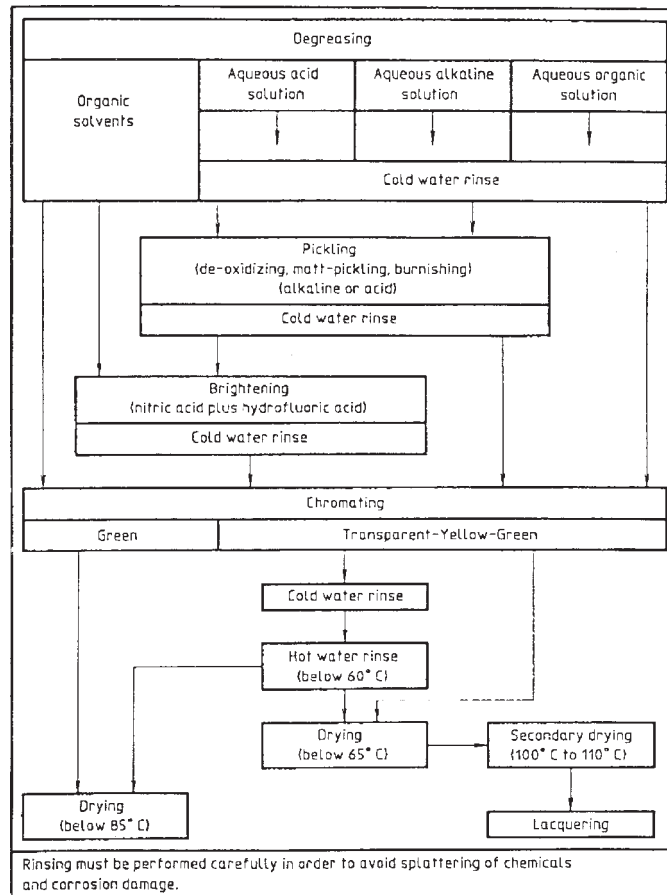


FIG. X2.1 Treatment Stages of the Chromating of Aluminum and Aluminum Alloys

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