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400 Commonwealth Dr., Warrendale, PA 15096

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard

AMS 2438

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CHROMIUM COATING
Thin, Hard, Dense Deposit

1. SCOPE:

1.1 Purpose: This specification covers the engineering requirements for the deposition of a thin, hard, dense chromium coating on surfaces of ferrous and nonferrous alloys and the properties of the coating.

1.2 Application: Primarily for use on metallic parts for increasing abrasion resistance, preventing galling and seizing, resisting erosion, and increasing corrosion resistance. This coating is not recommended for use on magnesium or lead alloys, or on beryllium.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 6294 - Steel Bars and Forgings, Carburizing, 1.8Ni - 0.25Mo (0.17 - 0.22C) (SAE 4620)
AMS 6330 - Steel Bars, Forgings, and Tubing, 1.25Cr - 0.65Ni (0.33 - 0.38C)
AMS 6350 - Steel Sheet, Strip, and Plate, 0.95Cr - 0.20Mo (0.28 - 0.33C) (SAE 4130)

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B117 - Salt Spray (Fog) Testing
ASTM B487 - Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
ASTM B499 - Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B504 - Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM D2714 - Calibration and Operation of the Alpha Model LFW-1 Friction and Wear Testing Machine
ASTM E92 - Vickers Hardness of Metallic Materials
ASTM F519 - Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Federal Standards:

Federal Test Method Standard No. 141 - Paint, Varnish, Lacquer, and Related Materials; Methods for Testing of
Federal Test Method Standard No. 791 - Lubricants, Liquid Fuels, and Related Materials; Methods of Testing

2.3.2 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

2.4 ANSI Publications: Available from American National Standards Institute, Inc., 1430 Broadway, New York, NY 10018.

ANSI B46.1 - Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 The basis metal shall be free from all imperfections detrimental to the appearance, utility, or corrosion resistance of the coating.

3.1.2 Coating shall be deposited after all basis metal heat treatment and fabrication operations have been completed. Surface texture shall be not rougher than 16 μin. (0.40 μm) RHR, determined in accordance with ANSI B46.1.

3.1.3 Nitrided parts and the welded or brazed areas of parts shall be machined or vapor blasted prior to coating.

3.1.4 Parts having hardness higher than 40 HRC and which have been ground after heat treatment shall be suitably stress-relieved before cleaning for coating. Temperatures to which parts are heated and time at heat shall be such that maximum stress-relief is obtained without reducing mechanical properties of parts below specified limits.

3.1.5 When magnetic particle inspection is required, parts shall be so inspected before coating and shall be so inspected after coating and complete finishing.

3.1.6 Parts, prior to coating shall have chemically clean surfaces, free from water-breaks, prepared with minimum abrasion, erosion, or pitting.

3.2 Procedure:

3.2.1 Chromium shall be deposited directly on the basis metal without a coating of other metal underneath, except that a preliminary deposit of nickel or copper is permissible on aluminum and titanium alloys when a surface texture of 16 μin. (0.5 μm) RHR or smoother is required on the coated surface.

3.2.2 After coating, parts shall be thoroughly rinsed and dried.

3.2.3 Steel parts having specified minimum tensile strength of 180,000 psi (1240 MPa) or over, or equivalent hardness (40 HRC), shall, after being dried, be baked as follows to minimize the embrittling effects of cleaning and coating. Baking shall be done in air within 4 hr after coating, preferably in an circulating-air furnace.

3.2.3.1 Parts having specified minimum tensile strength of 180,000 to 220,000 psi (1240 to 1515 MPa), excl, or equivalent hardness (40 HRC to 46 HRC), shall be baked at 375°F ± 25 (190°C ± 15) for not less than 3 hours.

3.2.3.2 Parts having specified minimum tensile strength of 220,000 psi (1515 MPa), or higher or equivalent hardness (46 HRC), shall be baked at 375°F ± 25 (190°C ± 15) for not less than 5 hours.

3.2.3.3 Parts and assemblies, including carburized and hardened parts, which will decrease in hardness or be otherwise deleteriously affected by heating to 375°F (190°C) shall be heated to 275°F ± 15 (135°C ± 8) and held at heat for not less than 8 hours.

3.3 Properties: The coating shall conform to the following requirements:

3.3.1 Thickness: The finished thickness shall be as specified on the drawing, determined on representative parts or test panels in accordance with ASTM B487, ASTM B499, ASTM B504, or other method agreed upon by purchaser and vendor. Recommended coating thickness range is 0.00025 - 0.0006 in. (6.25 - 15 m). Thickness tolerances are as follows:

TABLE I

Thickness Range Inch	Tolerance, Inch plus and minus
Up to 0.0001, incl	0.00001
Over 0.00001 to 0.00025, incl	0.000025
Over 0.00025 to 0.0006, incl	0.00005

TABLE I (SI)

Thickness Range Micromillimetres	Tolerance, Micromillimetres plus and minus
Up to 2.5, incl	0.25
Over 2.5 to 6.25, incl	0.62
Over 6.25 to 15.0, incl	1.25

3.3.1.1 The coating shall be substantially uniform in thickness on significant surfaces except that slight build-up at exterior corners or edges will be permitted provided drawing dimensions are met.

3.3.1.2 No requirements are established for minimum thickness of coating for surfaces of holes, recesses, contact areas of parts coated all over, and other areas on which a controlled deposit cannot be obtained under normal coating conditions but such areas shall not be masked to prevent coating. Unless otherwise noted on drawings, the resulting thickness shall be considered only when such surfaces of parts can be touched by a sphere 0.375 in. (9.5 mm) in diameter.

3.3.1.2.1 If interal surfaces as defined in 3.3.1.2 are required to be coated to a specific thickness, notes on the part drawing will so specify.

3.3.2 Hardness: Shall be not lower than 900 HV or equivalent, determined in accordance with ASTM E92.

3.3.3 Adhesion: When examined at 4X magnification, coatings on test specimens as in 4.3.4 shall not show separation from the basis metal after being fractured by bending repeatedly through an angle of 180 deg on a diameter equal to the thickness of the test specimen or by clamping the test specimen in a vise and bending repeatedly.

3.3.4 Abrasion and Wear Resistance:

3.3.4.1 A standard Taber specimen, cleaned, coated, and post-treated with the parts represented shall, after 5000 cycles, show a wear index based on the weight-loss method of less than 1.2 average, or 6 mg, for three tests, determined in accordance with FED-STD-141, Method 6192, using the Taber abrasion tester with CS-10 wheels, each subjected to a 1000 g load.

3.3.4.2 An AMS 6330 steel pin, cleaned, coated, and post-treated with the parts represented shall show an average endurance life of not less than 60 min. and an average weight loss of not more than 2 mg/hr for three tests, determined in accordance with FED-STD-791, Method 3807.1, using the Falex lubricant tester and a 750 lb (340 kg) gage load in additive-free, white mineral oil, U.S.P. 18. The 96 deg V-blocks shall not be coated or treated.

3.3.4.3 A carburized and hardened AMS 6294 test ring, cleaned, coated, and post-treated with the parts represented, and sliding against the LFW-1 tool steel rectangular test block shall have adhesive wear coefficients in the 10^{-6} range submersed in average synthetic wet lubricant and in the 10^{-7} range submersed in hydrocarbon or good synthetic wet lubricant, tested in accordance with ASTM D2714. The adhesive wear coefficients shall be determined using the J. T. Archard equation as follows:

$$\text{Adhesive Wear Coefficient, } K = \frac{V.3.P}{L.X.}$$

Where V = Volume of Worn Material cu in. (cm^3)
L = Normal Load lbs (N)
X = Sliding Distance in. (mm)
P = Plastic Flow Pressure, psi (MPa), derived from Vickers Hardness Number

3.3.5 Corrosion Resistance: Test panels, as in 4.3.5, shall withstand a 50-hr salt spray test in accordance with ASTM B117 without exhibiting evidence of corrosion except for isolated pits or surface flaws in the basis metal.

3.3.6 Hydrogen Embrittlement: The coating shall be non-embrittling, determined in accordance with ASTM F519 except that, when approved by purchaser, a suitable electronic meter or gauge may be used.

3.4 Quality: Coating, as received by purchaser, shall be firmly bonded to the basis metal, shall be smooth and uniform in appearance and, except as noted in 3.4.1, shall be free from frosty areas, pinholes, nodules, blisters, edge buildup, and other imperfections detrimental to performance of the coating. Visual inspection may be aided by not greater than 5X magnification. Slight discoloration resulting from baking after coating shall be acceptable.

3.4.1 Pinholes and other imperfections which can be shown to be the result of failure of the deposit to bridge or fill imperfections, such as porosity, in the surface of the basis metal are acceptable.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The processing vendor shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for thickness (3.3.1), adhesion (3.3.3), and quality (3.4) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests to determine conformance to requirements for hardness (3.3.2), abrasion and wear resistance (3.3.4), corrosion resistance (3.3.5), and hydrogen embrittlement (3.3.6) are classified as periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests to determine conformance to all technial requirements of this specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of a coated part to a purchaser, when a change in material, processing, or both requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, the contracting officer, or the request for procurement.

4.3 Sampling: Shall not be less than the following; a lot shall be all parts of the same part number processed in a continuous operation to the same thickness range and presented for vendor's inspection at one time:

4.3.1 For Acceptance Tests:

4.3.1.1 Thickness and Adhesion: Three parts from each lot.

4.3.1.2 Quality: All parts in each lot.

4.3.2 For Periodic Tests and Preproduction Tests: As agreed upon by purchaser and vendor.

4.3.3 When coated parts are of such configuration or size as to be not readily adaptable to the specified tests, separate test specimens cleaned, coated and post-treated with the parts they represent may be used.