SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2438C

Issued 1987-01
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Superseding AMS 2438B

Plating, Chromium
Thin, Hard, Dense Deposit

RATIONALE

AMS 2438C results from a Five Year Review and update of this specification.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the plating processor by the purchaser.

1) Purchase order shall specify not less than the following:
   - AMS 2438C
   - Plating thickness desired (see 3.4.1)
   - Basis metal to be plated
   - Tensile strength or hardness of the basis metal
   - Pre-plate stress relief to be performed by plating processor (time and temperature) if different from 3.1.2
   - Special features, geometry or processing present on parts that requires special attention by the plating processor. Shot peening requirements and parameters if specified.
   - Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.3.1
   - Minimum thickness on internal surfaces, if required (see 3.4.1.2)
   - Optional: Periodic testing frequency (4.2.2) and sample quantity (4.3.2)
   - Quantity of pieces to be plated
   - Part number

2) Parts manufacturing operations such as heat treating, forming, joining and media finishing can affect the condition of the substrate for plating, or if performed after plating, could adversely affect the plated part. The sequencing of these types of operations should be specified by the purchaser or cognizant engineering organization and is not controlled by this specification.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

1. SCOPE

1.1 Purpose

This specification covers the requirements for thin, hard, dense electrodeposited chromium plating on surfaces of ferrous and nonferrous alloys.

1.2 Application

This plating has been used typically to provide improved lubricity, wear and/or corrosion resistance to selected materials but usage is not limited to such applications.

1.3 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

2. APPLICABLE DOCUMENTS

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS 2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS 6330	Steel Bars, Forgings, and Tubing, 0.65Cr - 1.25Ni (0.33 - 0.38C)
AS2390	Chemical Process Test Specimen Material

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B 117	Operating Salt Spray (Fog) Apparatus
ASTM B 253	Preparation of Aluminum Alloys for Electroplating
ASTM B 487	Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
ASTM B 499	Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B 504	Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B 567	Method for Measurement of Coating Thickness by the Beta Backscatter Method
ASTM B 568	Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B 571	Qualitative Adhesion Testing of Metallic Coatings
ASTM B 748	Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope
ASTM D 2625	Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vice Method)
ASTM E 376	Measuring of Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods
ASTM E 384	Microhardness of Materials
ASTM F 519	Mechanical Hydrogen Embrittlement Evaluation of Plating Processes and Service Environments

2.3 ANSI Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036, Tel: 212-642-4900, www.ansi.org.

ANSI B46.1 Surface Texture

2.4 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch.

FED-STD-141 Paint, Varnish, Lacquer, and Related Materials; Methods for Testing of

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Surface texture of functional surfaces shall be 16 microinches (0.40 µm) Ra or smoother determined in accordance with ANSI B46.1.

3.1.2 Steel parts having hardness higher than 36 HRC and which have been machined or ground after heat treatment shall be cleaned to remove surface contamination and stress-relieved before preparation for plating. Unless otherwise specified, the stress relief shall be not less than 275 °F (135 °C) for five hours for parts 55 HRC or higher and not less than 375 °F (191 °C) for four hours for other parts.

3.1.3 The plating shall be applied over a surface free from water breaks. The cleaning procedure shall not produce pitting or intergranular attack of the basis metal and shall preserve dimensional requirements. See 8.5.

3.1.4 Aluminum alloys shall be zincate treated in accordance with ASTM B 253 or other method acceptable to the cognizant engineering organization prior to plating.

3.2 Procedure

3.2.1 Parts shall be plated by electrodeposition of chromium onto a properly prepared surface directly on the basis metal without a coating of other metal underneath, except that a preliminary plating of nickel or copper 0.00005 inch (1 µm), maximum, is permissible on aluminum and titanium alloys.

3.2.2 Spotting-in is not permitted.

3.3 Post Treatment

3.3.1 Hydrogen embrittlement relief (baking) shall be performed in accordance with AMS 2759/9.

3.4 Properties

The plating shall conform to the following requirements:

3.4.1 Thickness

The finished thickness shall be as specified on the drawing, determined on representative parts or test panels in accordance with ASTM B 487, ASTM B 499, ASTM B 504, ASTM B 567, ASTM B 568, ASTM B 748, or other method acceptable to the cognizant engineering organization. Recommended plating thickness range is 0.00025 to 0.0006 inch (6.3 to 15 µm). When a single thickness value is specified, the applicable tolerance shall be in accordance with Table 1.

TABLE 1A - THICKNESS TOLERANCES, INCH/POUND UNITS

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

TABLE 1B - THICKNESS TOLERANCES, SI UNITS

Thickness Range Micrometers	Tolerance, Micrometers plus and minus
Up to 2.5	0.25
2.5 to 6.3	0.63
6.3 to 15.0	1.3

3.4.1.1 The plating 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.

3.4.1.2 Surfaces as specified on the engineering drawing, except those which cannot be touched by a sphere 0.75 inch (19 mm) in diameter, shall be plated to the specified thickness.

3.4.2 Hardness shall be 900HV100 or higher (or equivalent), determined on a metallographic cross section in accordance with ASTM E 384. Plating thickness for determination of microhardness shall be 0.001 inch (0.025 mm) thick minimum in order to produce valid test impressions.

3.4.3 Adhesion

Adhesion shall meet the requirements of ASTM B 571 by the Bend Test method with no mandrel. When examined at 3 to 5X magnification, there shall be no evidence of internal delamination or loss of adhesion from basis metal. The formation of cracks in the plating or the basis metal which do not result in flaking, peeling or blistering of the plating shall not be cause for rejection.

3.4.4 Abrasion and wear resistance shall be such that the plating passes either one of the following tests:

3.4.4.1 A standard Taber specimen, cleaned, plated, and post-treated in the same manner as 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 milligrams, for three tests, determined in accordance with FED-STD-141, Method 6192, using a Taber abrasion tester with CS-10 wheels or equivalent approved by the cognizant engineering organization, each subjected to a 1000 gram load.

3.4.4.2 An AMS 6330 steel pin, cleaned, plated, and post-treated with the parts represented shall show an average endurance life of 60 minutes minimum and an average weight loss of 2 milligrams/hour maximum for three tests, determined in accordance with ASTM D 2625, using a Falex lubricant tester, or equivalent approved by cognizant engineering organization and a 750 pound (340 kg) gage load in additive-free, white mineral oil, U.S.P. 18. The 96 degree V-blocks shall be 50 HRC minimum and shall not be coated or treated.

3.4.5 Corrosion Resistance and Porosity on Steel

Thin dense chrome plating shall be as free from surface imperfections as possible, such that a uniform, tightly adherent barrier coating is produced. See 3.5.1 and 8.6.

a) Plated carbon and alloy steel parts or test panels (4.3.3) having a plating thickness of 0.0005 inch (13 µm) maximum, shall show no visible evidence of corrosion of the basis metal after being subjected for not less than 50 hours to a continuous salt fog corrosion test conducted in accordance with ASTM B 117.

b) Plated carbon and alloy steel parts or test panels, having a plating thickness of 0.0005 inch (13 um) maximum shall show no visible indications (blue) when subjected to the potassium ferricyanide (ferroxyl) porosity test below.

Plated low alloy steel parts or low alloy steel specimens shall be evaluated. Note: Panels subjected to distortion or flexing during processing can exhibit cracking or crazing type indications, so care should be exercised to prevent such false indications. All specimen surfaces shall be cleaned to remove any oil or grease. Contamination removal shall be accomplished with a solvent acceptable to the purchaser. A sheet of filter paper or other suitable adsorbent paper, saturated in the ferroxyl solution shall be applied for 10 minutes to the flat surface of the specimen or the article. Complete contact of the filter paper with the chrome plated test specimen shall be ensured using strokes with a soft bristle brush. Filter paper shall be kept saturated during the duration of the 10 minute test. Pits, pores, or cracking of the chrome are revealed by dark blue spots or lines. For a permanent record, the filter paper may be dried. The approximate solution composition shall be as follows:

Potassium ferricyanide $(K_3Fe(CN)_6)$ 1 gm
Sodium Chloride (NaCl) 10 gm
Water (distilled or deionized) to make 1 liter

c) Imperfections as noted in 3.5.1 that result in positive test indications from a) or b) above shall not be cause for rejection.

3.4.6 Hydrogen Embrittlement

The plating process after baking shall not cause hydrogen embrittlement in steel parts 36 HRC and over determined in accordance with 4.3.3.4.

3.5 Quality

Plating, as received by purchaser, shall be smooth, continuous, free from delamination within the plating, uniform in appearance and, except as noted in 3.5.1, shall be free from imperfections detrimental to usage of the plating. Plating shall be visually free from frosty areas, pin holes, porosity, blisters, nodules, and pits. Slight staining or discoloration shall be acceptable.

3.5.1 Pinholes and other imperfections which can be shown to be the result of failure of the plating to bridge or fill imperfections in the surface of the base metal, such as acceptable levels of porosity in a casting are acceptable.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all samples for processor's tests and shall be responsible for the performance of all required tests. Parts, if required for tests, shall be supplied by purchaser. The cognizant engineering organization reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (3.4.1), adhesion (3.4.3), and quality (3.5) are acceptance tests and shall be performed on parts, or samples representing parts when permitted herein (See 4.3.3.2.1), from each lot.

4.2.2 Periodic Tests

Hardness (3.4.2) and corrosion resistance and porosity (3.4.5) are a periodic tests and shall be performed at least monthly unless frequency of testing is specified by the cognizant engineering organization. Tests of cleaning and processing solutions are periodic tests and shall be performed at a frequency established by the processor unless frequency of testing is specified by the cognizant engineering organization. See 8.7 and 4.4.3. Hydrogen embrittlement (3.4.6) is a periodic test and shall be performed in accordance with ASTM F 519 at least once in each month that steel parts 36 HRC and over are plated unless frequency of testing is specified by the cognizant engineering organization.

4.2.3 Preproduction Tests

All property verification tests (section 3.4) are preproduction tests and shall be performed prior to production and when the cognizant engineering organization requires confirmatory testing.

4.3 Sampling for testing shall not be less than the following; a lot shall be all parts of the same part number, plated to the same range of plate thickness in the same solutions in each eight hours of continuous production, and presented for processor's inspection at one time.

4.3.1 Acceptance Testing

Test samples shall be selected randomly from all parts in the lot. The minimum number of samples shall be as shown in Table 2 unless the cognizant engineering organization provides a differing quantity or sampling plan.

TABLE 2 - SAMPLING FOR ACCEPTANCE TESTS

Number of Parts in Lot	Quality	Thickness/ Adhesion
up to 7	All	All or 3*
8 to 15	7	4
16 to 40	10	4
41 to 110	15	5
111 to 300	25	6
301 to 500	35	7
501 to 700	50	8
701 to 1200	75	10
over 1200	125	15

*Whichever is less

4.3.2 Periodic Tests

Sample size shall be four for corrosion resistance and porosity, one for hardness, as specified in ASTM F 519 for hydrogen embrittlement unless otherwise specified by the cognizant engineering organization.

4.3.3 Sample Configuration

4.3.3.1 Nondestructive testing shall be performed wherever practical and where authorized herein. Except as noted below, actual parts shall be selected as samples for tests. Correlation of results on panels to parts for characteristics that differ from parts, such as thickness, must be established.

4.3.3.2 Thickness, Adhesion, and Hardness Tests

4.3.3.2.1 Separate test specimens for thickness and adhesion made of the alloy established in accordance with AS 2390, cleaned, plated, and post treated with the parts represented may be used when plated parts are of such configuration or size as to be not readily adaptable to the specified tests, or when nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive tests on actual parts.

4.3.3.2.2 Separate test specimens may be used for hardness, and should be from an alloy established in accordance with AS2390. A greater plating thickness on microhardness test panels is required to obtain a valid test result. Hydrogen embrittlement relief (baking) is not required of hardness test specimens.

4.3.3.3 Corrosion Tests

Corrosion testing shall be performed on separate low carbon or low alloy steel panels approximately 4 x 1 inch (102 x 25 mm) and 0.025 inch (6.2 mm) thick minimum or bars approximately 0.5 inch (13 mm) in diameter and 4 inches (102 mm) long. Surface texture shall be not rougher than 16 microinches (0.40 µm) RHR, determined in accordance with ANSI B46.1.

4.3.3.4 Hydrogen Embrittlement Test

Test shall be in accordance with the requirements of ASTM F 519 Type 1a.1 using round notched specimens, unless a different specimen is specified by the cognizant engineering organization, stressed in tension under constant load. For test purposes, the plating thickness shall be 0.0003 to 0.0005 inch (8 to 13 µm) measured on the smooth section of the specimen, but with visual plating at the root of the notch. When parts to be plated are fabricated from an alloy for which AMS 2759/9 requires a baking temperature lower than 375 °F (191 °C), test specimens shall be baked at the same temperature for 96 hours.

4.4 Approval

4.4.1 The process and control factors or a preproduction part, or both, whichever is specified, shall be approved by the cognizant engineering organization before production parts are supplied.

4.4.2 If the processor makes a significant change to any material, process, or control factor from that which was used for process approval, all preproduction tests shall be performed and the results submitted to the cognizant engineering organization for process reapproval unless the change is approved by the cognizant engineering organization. A significant change is one which in the judgment of the cognizant engineering organization could affect the properties or performance of the parts.

4.4.3 Control factors shall include, but not be limited to the following:

Surface preparation
Plating bath composition and composition control limits
Plating bath temperature limits and controls
Thermal post treatment times and temperatures
Method for determining plating thickness
Method of adhesion test
Pretreatment, plating voltage/current
Method of stripping (if required)
Periodic test plan for cleaning and processing solutions. See 8.7.

4.5 Reports

The processor shall furnish with each shipment a report stating that the parts have been processed and tested in accordance with the specified requirements and that they conform to the acceptance tests requirements. This report shall include the purchase order number, lot number, AMS 2438C, part number, and quantity.