



AEROSPACE MATERIAL SPECIFICATION	AMS2438™	REV. F
	Issued 1987-01 Revised 2021-12	
Superseding AMS2438E		
Plating, Chromium Thin, Hard, Dense Deposit		

RATIONALE

AMS2438F results from a Five-Year Review and update of this specification with changes to the Ordering Information applicable to the changes in the document, clarify surface texture (3.1.1) to ensure that it is applicable to the surface prior to plating, revise stress relief for Peened Parts (3.1.2.3) to use standard wording, added Fixture/Electrical Contact Locations (3.1.3, 4.4.3) per GAB19AB, added direct dimensional inspection of Thickness (3.4.1) as standard wording, full revision of Taber Test requirements (3.4.4.1, 4.3.3.2.4, 4.6.2.1, 8.14) to ensure accurate test methods and results, deleted solvent acceptability to purchaser (3.4.5.b) as it was unnecessary, added standard wording for suspension of Periodic Testing (4.2.2.1), and revised definition of lot in Sampling (4.3) per GAB16AA.

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:

- AMS2438F
- Plating thickness desired (see 3.4.1)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal
- If preplate stress relief is to be performed by plating processor and if different from 3.1.2, time and temperature are to be specified
- If steel parts were machined, ground, cold formed or cold straightened after heat treat (3.1.2)
- If steel parts have been shot peened, specify if required stress relief has been completed (3.1.2.3)
- Optional: Fixture/Electrical contact locations, when not specified (3.1.3)
- 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

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- 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.

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. This process does not provide sacrificial corrosion protection as with cadmium, zinc, or zinc nickel plating (see 8.6).

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 +1 724-776-4970 (outside USA), www.sae.org.

AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS6330	Steel Bars, Forgings, and Tubing, 0.65Cr - 1.25Ni (0.33 - 0.38C)
ARP4992	Periodic Test Plan for Process Solutions
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
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 B117	Operating Salt Spray (Fog) Apparatus
ASTM B253	Preparation of Aluminum Alloys for Electroplating
ASTM B374	Standard Terminology Relating to Electroplating
ASTM B487	Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of 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 B567	Measurement of Coating Thickness by the Beta Backscatter Method
ASTM B568	Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B571	Qualitative Adhesion Testing of Metallic Coatings
ASTM B748	Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope
ASTM D2625	Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method)
ASTM D4060	Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM E376	Measuring of Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods
ASTM E384	Microindentation Hardness of Materials
ASTM F519	Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.3 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org/>

ANSI B46.1 Surface Texture (Surface Roughness, Waviness, And Lay)

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Surface texture of functional surfaces to be plated shall be sufficiently smooth to ensure that after plating (see 4.3.3.3) the functional surface texture is 16 microinches (0.40 μm) Ra or smoother determined in accordance with ANSI B46.1.

3.1.2 Stress Relief Treatment

All steel parts having a hardness of 36 HRC and above and that are machined, ground, cold formed or cold straightened after heat treatment shall be cleaned to remove surface contamination and thermally stress relieved before plating. (Residual tensile stresses have been found to be damaging during electroplating.) Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5, with Type D Instrumentation. Temperatures to which parts are heated shall be such that stress relief is obtained while still maintaining hardness of parts within drawing limits. Unless otherwise specified, the following treatment temperatures and times shall be used:

- 3.1.2.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at 275 °F ± 25 °F (135 °C ± 14 °C) for 5 to 10 hours.
- 3.1.2.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at 375 °F ± 25 °F (191 °C ± 14 °C) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.
- 3.1.2.3 For peened parts, if stress relief temperatures above 375 °F (191 °C) are specified, the stress relieve shall be performed prior to peening.
- 3.1.3 Fixture/Electrical Contact Location
- 3.1.3.1 Except for barrel plating, for parts that are to be plated all over, and contact locations are not specified, contact locations shall be at the discretion of the processor.
- 3.1.3.2 For parts that are not to be electroplated/coated all over, and contact locations are not specified, locations shall be in areas on which coating is not required.
- 3.1.4 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).
- 3.1.5 Aluminum alloys shall be zincate treated in accordance with ASTM B253 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) of steel parts shall be performed in accordance with AMS2759/9.

3.4 Properties

The plating shall conform to the following requirements:

3.4.1 Thickness

The finished thickness shall be as specified, determined on representative parts or test specimens in accordance with ASTM B487, ASTM B499, ASTM B504, ASTM B567, ASTM B568, ASTM B748, ASTM E376, direct dimensional inspection provided the resolution of the measuring instrument is ten times more precise than the attribute being measured or other method acceptable to the cognizant engineering organization. When a single thickness value is specified, the applicable tolerance shall be in accordance with Table 1 (see 8.13).

Table 1A - Thickness tolerances, inch/pound units

Thickness Range Inches	Tolerance, Inches 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 All surfaces of the part, except those that cannot be touched by a sphere 0.75 inch (19 mm) in diameter, shall be plated to the specified thickness. Unless otherwise specified, surfaces such as holes, recesses, threads, and other areas where a controlled deposit cannot be obtained under normal plating conditions, may be under the specified limit provided they show visual plating coverage.
- 3.4.2 Hardness shall be 900HV100 or higher (or equivalent), determined on a metallographic cross section in accordance with ASTM E384. 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 B571 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

Abrasion and wear resistance shall be such that the plating passes either the taber test or the falex test as follows:

3.4.4.1 Taber Test

3.4.4.1.1 Specimens

Three Taber specimens (see 4.3.3.2.4) shall be cleaned, plated except thickness as stated in 4.3.3.2.4, and post-treated in the same manner as the parts represented.

3.4.4.1.2 Preparation

Conditioning of the specimens under temperature-humidity controls per ASTM D4060 prior to Taber abrasion is not required. Taber specimens may be prepared to remove microscopic surface glaze (see 3.5.2 and 8.12) by subjecting the test specimen to an initial abbreviated Taber abrasion test of up to 2500 cycles. If performed, the specimens shall subsequently be re-weighed and tested as in 3.4.4.1.3.

3.4.4.1.3 Testing

Testing shall be performed in accordance with ASTM D4060 using CS-10 wheels with a 1000 gram load or equivalent method approved by the cognizant engineering organization. Before Taber testing begins, the initial weight of each specimen shall be determined by weighing to the nearest 0.1 mg. After 5000 cycles of the Taber test each specimen shall be re-weighed to the nearest 0.1 mg. The average weight loss per 1000 cycles for each specimen shall be calculated by taking the weight loss of each specimen (initial weight minus final weight after 5000 cycles) and dividing by 5. The average of the weight loss of the three specimens per 1000 cycles shall be equal to or less than 1.2 mg and is calculated by adding together the average weight loss per 1000 cycles for each of the three specimens and dividing by 3.

3.4.4.1.4 Recommended Testing Practice

For reliable and consistent Taber wear test results, recommended test practices are stated in 8.14.

3.4.4.2 Falex Text

An AMS6330 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 D2625, 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). Although not capable of providing sacrificial corrosion protection as with some other metallic plating systems, the thin dense chrome shall provide a capability to protect the basis metal from corrosion when tested by either one of the following methods:

- a. Plated carbon and alloy steel parts or test specimens (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 B117.

or

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

Plated low alloy steel parts or low steel specimens shall be evaluated. Note: Specimens 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 testing surfaces shall be cleaned as needed to remove any oil or grease. 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 ($\text{K}_3\text{Fe}(\text{CN})_6$) 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 and 3.5.2, 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.
- 3.5.2 Thin dense chrome deposits can exhibit a surface glaze which is acceptable provided the abrasion-wear resistance requirements of 3.4.4 are met (see 8.12).

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), 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), abrasion resistance (3.4.4), and corrosion resistance, porosity (3.4.5) are 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). Adhesion (3.4.3) is a periodic test that shall be performed no less than daily for each generic class of alloy as defined by AS2390 processed during that day. Hydrogen embrittlement (3.4.6) is a periodic test and shall be performed in accordance with ASTM F519 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.

4.2.2.1 Periodic Testing may be suspended in any test period when parts are not processed but shall be performed before or at time such processing is resumed. Preproduction testing may be required by the cognizant engineering organization, upon resumption of processing.

4.2.3 Preproduction Tests

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

4.3 Sampling

Shall not be less than the following: A lot is a group of parts, all of the same part number, processed through the same chemical solutions in the same tanks under the same conditions, which have completed the chemical processing within a period of 24 hours of each other and are presented to inspection at the same 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
up to	7	All	All or 3 ⁽¹⁾
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

NOTE:

⁽¹⁾ Whichever is less.

4.3.2 Periodic Tests

Sample size shall be four specimens for corrosion resistance and porosity, one for hardness, four for hydrogen embrittlement as specified in ASTM F519 unless otherwise specified by the cognizant engineering organization, and three for abrasion and wear resistance. For adhesion tests, four test specimens of each generic class of alloy, as defined by AS2390, that have been processed through the same cleaning and plating operations as the parts that they represent. These adhesion test specimens shall be processed prior to the first production lot of parts or with the first production lot of parts.

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 specimens to parts for characteristics that differ from parts, such as thickness, must be established.

4.3.3.2 Thickness, Hardness, Adhesion Tests, and Taber Tests

4.3.3.2.1 Separate test specimens for thickness made of the alloy established in accordance with AS2390, 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 specimens is required to obtain a valid test result. Hydrogen embrittlement relief (baking) is not required of hardness test specimens.

4.3.3.2.3 Separate test specimens for adhesion tests, shall be made of the same generic class of alloy as defined by AS2390 processed. The test specimens shall be 0.025 inch (0.6 mm) minimum thickness and not less than 1 x 4 inches (25 x 102 mm).

4.3.3.2.4 Separate test specimens for Taber wear tests, shall be made of normalized or higher strength steel alloy. A minimum hardness of 40 HRC is recommended for consistent and repeatable test results. The specimen dimension shall be 4 inch (10 cm) diameter or 4 x 4 inch (10 x 10 cm) square. Thickness of the specimen shall be 0.064 inch (1.6 mm) maximum. For more accurate weighing of the specimen, it is recommended that the Taber specimen weigh less than 100 grams prior to plating (i.e., 4 x 4 x .032 inch steel specimen weighs approximately 65 grams). It is recommended that for optimum and consistent wear test results that the surface finish be 20 Ra maximum. Thickness of plating on the Taber specimen shall be 0.00015 to 0.00025 inch (3.8 to 6.5 µm).

4.3.3.3 Corrosion Tests

Corrosion testing shall be performed on separate low carbon or low alloy steel specimens approximately 4 x 1 inch (102 x 25 mm) and 0.025 inch (0.64 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 F519 Type 1a.1 using round notched specimens, unless a different specimen is specified by the cognizant engineering organization, stressed in tension under sustained load. For test purposes, the plating thickness, as measured on the smooth section of the specimen, shall be the same thickness as the parts normally processed or 0.00004 to 0.00025 inches as a default, but with visual plating at the root of the notch. Testing beyond the 200 hour test period is not required. When parts to be plated are fabricated from an alloy for which AMS2759/9 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

Fixture/Electrical contact locations when approval is required by the cognizant engineering organization

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, AMS2438F, part number, and quantity.

4.6 Resampling and Retesting

4.6.1 If any acceptance test fails to meet specified test requirements, the parts in that lot may be stripped, pretreated, plated, and post treated as defined herein and retested. Alternatively, all parts in the lot may be inspected for the nonconforming attribute, and the nonconforming parts may be stripped, pretreated, plated, post treated as defined herein, and retested.

4.6.1.1 When stripping is performed, the method shall be acceptable to the cognizant engineering organization and shall not roughen, pit, or embrittle the basis metal or adversely affect part dimensions. When parts have been stripped and replated, the purchaser shall be informed.