



# AEROSPACE MATERIAL SPECIFICATION

AMS2406™

REV. P

Issued 1946-11  
Revised 2020-12

Superseding AMS2406N

Plating, Chromium  
Hard Deposit

## RATIONALE

AMS2406P results from a Five-Year Review and update of this specification with additions to ordering information, update requirements to stress relief treatment (3.1.1, 3.1.1.1, 3.1.1.3), added standard wording for electrical contact points (3.1.3), updated type of parts to procedure (3.2.1), added fastener wording for hydrogen embrittlement relief (3.3), added dimensional inspection to thickness (3.4.1), clarified requirements for adhesion (3.4.3), added fastener wording for hydrogen embrittlement (3.4.4), added fastener wording to periodic tests (4.2.2), added standard lot wording to sampling and testing (4.3), updated test specimens to periodic and preproduction tests (4.3.2), added standard sizes to sample configuration (4.3.3.2, 4.3.3.3), updated wording in approval (4.4.1, 4.4.3), and added a standard environmental notice to notes.

## 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:

- AMS2406P
- Plating thickness desired (see 3.4.1)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal
- If pre-plate stress relief to be performed by plating processor (time and temperature) and if different from 3.1.1
- If steel parts were machined, ground, cold formed or cold straightened after heat treat (3.1.1)
- If steel parts have been shot peened, specify if required stress relief has been completed (3.1.1.3)
- Special features, geometry or processing present on parts that requires special attention by the plating processor
- Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.3
- Optional: Fixture/electrical contact locations, when not specified (see 3.1.3)
- Minimum thickness on internal surfaces, if required (see 3.4.1.2)

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- Optional: Sample quantity and frequency of periodic testing (see 4.2.2 and 4.3.2)
  - Whether approval is based on approval of process/control factors or sample part or both (see 4.4.1)
  - Quantity of pieces to be plated
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 cognizant engineering organization and is not controlled by this specification.

## 1. SCOPE

### 1.1 Purpose

This specification covers the requirements for electrodeposited hard chromium plate.

### 1.2 Application

This plating has been used typically on parts for increasing abrasion resistance, increasing tool and die life, maintaining accuracy of gauges, and reconditioning worn or undersized parts, 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 sole 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](http://www.sae.org).

AMS2759/9      Hydrogen Embrittlement Relief (Baking) of Steel Parts

ARP1917        Clarification of Terms Used in Aerospace Metals Specifications

ARP4992        Periodic Test for Processing Solutions

### 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](http://www.astm.org).

ASTM B253      Preparation of Aluminum Alloys for Electroplating

ASTM B374      Terminology Relating to Electroplating

ASTM B487      Measurement of Metal and Oxide Coating Thicknesses 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 E384	Microindentation Hardness of Materials
ASTM F519	Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

### 3. TECHNICAL REQUIREMENTS

#### 3.1 Preparation

##### 3.1.1 Stress Relief Treatment

All steel parts having a hardness of 36 HRC and higher and steel threaded fasteners having a hardness of 34 and higher 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. Temperatures to which parts are heated shall be such that maximum stress relief is obtained while still maintaining hardness of parts within drawing limits. (Residual tensile stresses have been found to be damaging during electrofinishing.) Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5 and Type D instrumentation. Unless otherwise specified, the following treatment temperatures and times shall be used:

- 3.1.1.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and higher, including carburized and induction hardened parts, stress relieve at 275 °F ± 25 °F (135 °C ± 14 °C) for 5 hours minimum.
- 3.1.1.2 For parts having a hardness lower than 55 HRC, stress relieve at 375 °F ± 25 °F (191 °C ± 14 °C) for a minimum of 4 hours. Nitrided parts fall into this category. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.
- 3.1.1.3 For peened parts, if stress relief temperatures above 375 °F (191 °C) are specified, the stress relieve shall be performed prior to peening.

- 3.1.2 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.

##### 3.1.3 Electrical Contact Points

Except for barrel plating, electrical contact points shall be as follows:

- 3.1.3.1 For parts which are to be plated all over and fixture contact points are not specified, contact locations shall be at the discretion of the processor.
- 3.1.3.2 For parts which are not to be plated all over and fixture contact locations are not specified, locations shall be in areas on which plate is not required.
- 3.1.4 Prior to plating, aluminum alloys shall be zincate treated in accordance with ASTM B253 or other method specified or approved by the cognizant engineering organization.

### 3.2 Procedure

3.2.1 The chromium shall be deposited directly on the basis metal without a flash coating of other metal underneath, except in the case of parts made of maraging steels, corrosion-resistant steels, nickel/cobalt alloys, or aluminum alloys, on which a preliminary deposit of nickel or other suitable metal 0.0002 inch (5 µm) thickness maximum is permissible.

### 3.3 Hydrogen Embrittlement Relief

Hydrogen embrittlement relief of steel parts 36 HRC and higher and threaded steel fasteners 34 HRC and higher shall be performed in accordance with AMS2759/9.

### 3.4 Properties

#### 3.4.1 Thickness

Thickness of the plate shall be as specified on the drawing, determined in accordance with any of the following methods as applicable: ASTM B487, ASTM B499, ASTM B567, ASTM B568, ASTM B748, direct dimensional inspection provided the resolution of the measuring instrument is ten times more precise than the attribute being measured, or by other method permitted by the cognizant engineering organization.

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

3.4.1.2 All surfaces of the part, except those which cannot be touched by a sphere 0.75 inch (19 mm) in diameter, shall be plated to the thickness specified. Unless otherwise specified, these surfaces, such as holes, recesses, threads, and other areas where a controlled deposit cannot be obtained under normal plating conditions, may be under specified limits provided they show coverage.

#### 3.4.2 Hardness

The plate hardness shall be not lower than 700 HV, or equivalent, determined in accordance with ASTM E384 using a Vickers indenter and 100 gram load.

#### 3.4.3 Adhesion

3.4.3.1 For parts where the chrome plating is to be subsequently ground, the plating shall withstand the grinding operations with no evidence of delamination or separation from the basis metal.

3.4.3.2 For parts where the chrome plating is not subsequently ground, adhesion testing shall be performed in accordance with the ASTM B571 bend test without using a mandrel. With approval from the cognizant engineering organization, the following tests may be used in lieu of the ASTM B571 bend test:

3.4.3.2.1 For thin plating deposits up to 0.001 inch (2.5 µm) thickness, the heat quench test in ASTM B571 may be used in place of the bend test.

3.4.3.2.2 For deposits thicker than 0.005 inch (12.5 µm), the chisel-knife test, file test, or grind-saw test in ASTM B571 may be used in place of the bend test.

3.4.3.2.3 For parts or specimens tested in accordance with ASTM B571, when examined at a magnification of approximately 4X, neither the chromium plating nor any electrodeposited underplate(s) shall show separation from the basis metal or from each other. The formation of cracks in the plating or the basis metal which do not result in flaking, peeling, or blistering of plated layers shall not be cause for rejection.

#### 3.4.4 Hydrogen Embrittlement

The chromium plating process, after baking, shall not cause hydrogen embrittlement in steel parts 36 HRC and higher and threaded steel fasteners 34 HRC and higher, determined in accordance with the requirements of ASTM F519 (see 4.3.3.2).

### 3.5 Quality

Plating, as received by purchaser, shall be firmly bonded to the basis metal, and shall be smooth and uniform in appearance and, except as noted in 3.5.1, shall be bright, free from frosty areas, pinholes, nodules, blisters, and other imperfections detrimental to performance of the deposit. Visual inspection may be aided by not greater than 5X magnification.

3.5.1 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 processor shall supply all specimens for processor's tests and shall be responsible for the performance of all required tests. Where parts are to be tested, such parts shall be supplied by purchaser. Purchaser 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 each lot.

#### 4.2.2 Periodic Tests

Hardness (3.4.2) is a periodic test and shall be performed at least quarterly unless frequency of testing is specified by the cognizant engineering organization. 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. Tests of cleaning and plating 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 4.4.3 and 8.4). Hydrogen embrittlement (3.4.4) is a periodic test and shall be determined at least once in each month that steel parts 36 HRC and higher or threaded steel fasteners 34 HRC and higher are plated.

#### 4.2.3 Preproduction Tests

All property verification tests are preproduction tests and shall be performed when prior to initial shipment and when the cognizant engineering organization deems confirmatory testing to be required.

### 4.3 Sampling and Testing

Shall be as follows: 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 Tests

Test samples shall be selected randomly from all parts in the lot. Unless the cognizant engineering organization supplies a sampling plan, the minimum number of samples shall be as shown in Table 1.

**Table 1 - Sampling for acceptance testing**

Number of Parts in Lot		Quality	Thickness
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 and Preproduction Tests

Sample quantity shall be one for hardness and as specified in ASTM F519 for hydrogen embrittlement unless otherwise specified by the cognizant engineering organization. When test specimens are used 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 Separate test specimens may be used under any one of the following circumstances: the 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. When used, separate test specimens shall be of the same generic class of alloy as the parts, distributed within the lot, cleaned, plated, and post-treated with the parts.

4.3.3.2 Hydrogen embrittlement test specimens shall conform to ASTM F519 Type 1a.1 using notched round bars, stressed in tension under sustained load unless a different specimen is specified by the cognizant engineering organization. For test purposes, plating thickness shall be a minimum of 0.002 inch (51 µm), measured on the smooth section of the specimen, but with visual evidence of plating in the root of the notch. Testing beyond the 200 hour test period is not required.

4.3.3.3 Test specimens for adhesion testing shall be 0.025 inch (0.6 mm) minimum thickness and not less than 1 x 4 inch (25 x 102 mm).

#### 4.4 Approval

4.4.1 The process procedures and control factors, a preproduction sample, plated 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, would affect properties or performance of the parts. Production parts plated by the revised procedure shall not be shipped prior to receipt of reapproval.

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

Surface preparation and cleaning procedures  
Surface activation procedure(s)  
Plating bath composition and composition control limits  
Plating bath temperature limits and controls  
Current or voltage limits and controls  
Method for testing plating thickness  
Method for testing adhesion  
Stripping procedure, if used  
Fixture/electrical contact locations, when approval is required by the cognizant engineering organization  
Current density (amps per part or amps per total surface area of the parts plated at one time in each tank)  
Periodic test plan for cleaning and processing solutions (see 8.4)

#### 4.5 Reports

The processor shall furnish with each shipment a report stating that the parts have been processed and tested in conformance with specified requirements and that they conform to the acceptance test requirements. This report shall include the results of the acceptance tests, purchase order number, lot identification, AMS2406P, part number, and quantity.

#### 4.6 Resampling and Retesting

4.6.1 If any acceptance test fails to meet specified 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. After stripping and replating, parts shall meet the dimensions on the drawing.

4.6.1.1 When stripping is performed, the method shall be permitted by 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 cognizant engineering organization shall be informed.

4.6.2 If any periodic test fails to meet specified requirements, the process is nonconforming. No additional parts shall be plated until the process is corrected and specimens are plated and retested. Results of all tests shall be recorded and, when requested, reported. Purchaser shall be notified of all parts plated since the last acceptable test. Alternatively, adhesion test failures on plated parts may be dispositioned as specified in 4.6.1.

### 5. PREPARATION FOR DELIVERY

#### 5.1 Packaging

5.1.1 Plated parts shall be handled and packaged to ensure that the required physical characteristics and properties of the plating and parts are preserved.

5.1.2 Packages of plated parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery.

### 6. ACKNOWLEDGMENT

The processor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.

### 7. REJECTIONS

Parts on which the plating does not conform to this specification, or to modifications authorized by purchaser, will be subject to rejection.



## 8. NOTES

### NOTICE

This specification may reference the use of substances, products, or procedures that are restricted or banned by local (regional) chemical substance regulations. Users of this specification should consider the implications of local legislation on the products, substances, and processes referred to within the document.

#### 8.1 Revision Indicator

A change bar (|) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 The parts manufacturer should ensure that the surfaces of metal parts supplied to the processor are free from blemishes, pits, tool marks, and other irregularities that will affect the quality of the finished parts. Defects and variations in appearance that arise from surface conditions of the substrate, such as porosity, scratches, or inclusions, that persist in the finished plate despite observance of industry accepted plating practices would not be considered as cause for rejection.

8.3 Ferrous parts with tensile strength higher than 180 ksi may be alkaline cleaned using anodic current, but cathodic or periodic current reverse current should not be used.

8.4 ARP4992 is recommended to satisfy the requirements for control of processing solutions.

8.5 An acid dip may be used for surface activation or neutralization of residual alkaline cleaner; however, the immersion time should be minimized (as measured in seconds) to preclude pitting or hydrogen embrittlement effects.

8.6 Recommended maximum thickness of chromium is 0.015 inch (0.38 mm) except on tools and dies. Recommended minimum thickness of chromium, when used for protection against corrosion, is 0.002 inch (0.05 mm); however, this does not imply any minimum corrosion resistance.

8.7 The following procedures have been used to produce plating meeting specified requirements. No assurance is given that use of these procedures will, in fact, produce conforming hardware. They are presented for reference only.

8.7.1 Except as specified in 8.7.1.1, the final step in cleaning should consist of anodically etching the parts in a chromic acid solution of concentration approximately equal to that of the chromic acid solution used in plating or in the plating bath.

8.7.1.1 For plating nickel alloys, and for plating other alloys on which a deposit of nickel is used as an undercoating for chromium, the final step in cleaning should consist of anodically etching the parts in a sulfuric-hydrofluoric acid solution (25% by volume H<sub>2</sub>SO<sub>4</sub> and 4.5% by volume HF) or in a 40% by volume solution of sulfuric acid.

8.7.2 Parts should be plated by electrodeposition of chromium from a chromic acid solution containing added sulfate or fluoride ions.

8.7.3 When grinding after plating is required, it should be done with soft wheel, proper coolant, never dry, and never with a very heavy cut. Recommend 0.0001 inch (2.5 μm) maximum per pass.

8.8 Terms used in AMS are clarified in ARP1917. ASTM B374 should be utilized as a reference and referee document when areas of design definition or technical interpretation arise.

8.9 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.



- 8.10 This plating process alters the product dimensions. Compliance with dimensional tolerances affected by the plating/coating process requires communication of manufacturing planning information between the part fabricator and the plating processor. The cognizant engineering organization should specify the stage at which the plating (coating) thickness and the product dimensions (e.g., threads, features) apply, such as before plating, as-plated, or after metal removal operations that are to follow plating.

PREPARED BY AMS COMMITTEE "B"