AEROSPACE MATERIAL SPECIFICATION

AMS2406	REV. N
Issued 1946-11 Revised 2015-01 Superseding AMS2406M	

Plating, Chromium Hard Deposit

RATIONALE

AMS2406N changes the hydrogen embrittlement relief requirement to the standard wording of 40 HRC for use with AMS2759/9, added hydrogen embrittlement relief requirement for hardnesses of 36-39 HRC and changes adhesion testing from an acceptance test to a periodic test.

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:

- AMS2406N
- 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 3.1.1
- 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.
- Minimum thickness on internal surfaces, if required (See 3.4.1.2)
- 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.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2406N

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 canceled 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.

AMS2759/9 Hydrogen Embrittlement Relief (Baking) of Steel

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 B253 Preparation of Aluminum Alloys for Electroplating

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 B567 Method for 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 Knoop and Vickers Hardness of Materials

ASTM F519 Mechanical Hydrogen Embrittlement Evaluation of Plating Processes/Coating and Service Environments

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Stress Relief Treatment

All steel parts having a hardness of 40 HRC and above and that are machined, ground, cold formed or cold straightened 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.) 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 above, including carburized and induction hardened parts, stress relieve at 275 °F ± 25 (135 °C ± 14) for a minimum of 5 hours.

3.1.1.2 For parts having a hardness less than 55 HRC, stress relieve at 375 °F ± 25 (191 °C ± 14) 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 elected, the stress relieve shall be performed prior to peening or the cognizant engineering organization shall be consulted and shall approve the stress relief temperature.

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 Except for barrel plating, electrical contact points shall be as follows: For parts which are to be plated all over, locations shall be specified or approved by the cognizant engineering organization. For parts which are not to be plated all over, locations shall be in areas on which plating is not required, or locations shall be specified or approved by the cognizant engineering organization.

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, 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

Treatment of steel parts 40 HRC and above shall be in accordance with AMS2759/9. For steel parts 36-39 HRC, regardless of alloy type, treatment shall be in accordance with AMS2759/9 using the minimum bake soak times specified in Table 1 for "Lower Strength Carbon, Low-Alloy, Tool Steel".

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, 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 Vicker's indenter and 100 gram load

3.4.3 Adhesion

Adhesion shall meet the requirements of ASTM B571 Bend Test method with no mandrel. 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 over, 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 over 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 shall be all parts of the same part number processed in a continuous operation, to the same thickness range, in the same set of solutions, in not longer than 24 consecutive hours, and presented for processor's inspection at one 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. For adhesion tests, four test specimens of each generic class of alloy, as defined by AS2390, that have been be 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 0.002 inch ± 0.0002 (51 µm ± 5), 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.

4.4 Approval

4.4.1 The process and control procedures, a preproduction sample 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
Rack locations
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, AMS2406N, 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

8.1 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, Periodic Test Plan for Process Solutions, 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_2SO_4 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 “Terminology Relating to Electroplating” 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.