



# AEROSPACE MATERIAL SPECIFICATION

AMS2403

REV. M

Issued 1948-11  
Reaffirmed 2009-06  
Revised 2015-01

Superseding AMS2403L

(R) Plating, Nickel  
General Purpose

## RATIONALE

AMS2403M 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:

- AMS2403M
  - Plating thickness desired. See 3.4.1.
  - Basis metal to be plated
  - Tensile strength or hardness of the basis metal
  - Preplate 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 3.3.1
  - Minimum thickness on internal surfaces, if required. See 3.4.1.2.
  - 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 or purchaser and is not controlled by this specification.

## 1. SCOPE

### 1.1 Purpose

This specification covers the engineering requirements for electrodeposition of nickel and the properties of the deposit.

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## 1.2 Application

This process has been used typically to provide moderate corrosion and oxidation resistance to metal parts but without control of other characteristics, and for the buildup of surfaces, but usage is not limited to such applications. If a hard plate is required, AMS2423 should be used; if a low-stressed plate is required, AMS2424 should be used.

## 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 issues 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](http://www.sae.org).

AMS2423	Plating, Nickel, Hard Deposit
AMS2424	Plating, Nickel, Low Stressed Deposit
AMS2750	Pyrometry
AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts

### 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 B117	Operating Salt Spray (Fog) Testing Apparatus
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 of Magnetic Basis Metals
ASTM B504	Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B568	Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B571	Qualitative Adhesion of Metallic Coatings
ASTM E376	Measuring of Coating Thickness by Magnetic Field or Eddy Current (Electromagnetic) Test Methods
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

3.1.1.1 All steel parts having a hardness of 40 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:

3.1.1.1.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at  $275\text{ }^{\circ}\text{F} \pm 25$  ( $135\text{ }^{\circ}\text{C} \pm 14$ ) for 5 to 10 hours.

3.1.1.1.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at  $375\text{ }^{\circ}\text{F} \pm 25$  ( $191\text{ }^{\circ}\text{C} \pm 14$ ) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.1.1.1.3 For peened parts: If stress relief temperatures above  $375\text{ }^{\circ}\text{F}$  ( $191\text{ }^{\circ}\text{C}$ ) 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 Parts shall have clean surfaces, free of water break, prior to immersion in the plating solution.

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 acceptable to purchaser, for parts which are not to be plated all over, locations shall be in areas on which plating is not required.

#### 3.2 Procedure

3.2.1 Nickel shall be electrodeposited from a suitable plating solution. Additives are permitted only if they do not have a detrimental effect on the properties of the plate or the basis metal; stress-reducing agents shall not be used unless specifically authorized by purchaser. Except as specified in 3.2.1.1, nickel shall be deposited directly on the basis metal without a prior flash coating of metal other than nickel.

3.2.1.1 A preliminary chemical coating, immersion plate, and/or flash is permissible on aluminum, magnesium, beryllium, and their alloys.

#### 3.3 Hydrogen Embrittlement Relief

After plating, rinsing, and drying, -steel parts shall be treated in accordance with AMS2759/9. Parts, if plated as an aid to brazing, and if brazed within four hours after completion of plating, do not require hydrogen embrittlement relief.

#### 3.4 Properties

##### 3.4.1 Thickness

Thickness shall be determined in accordance with ASTM B487, ASTM B499, ASTM B504, ASTM B568, ASTM E376 or other method acceptable to purchaser.

3.4.1.1 Where "nickel flash" is specified, plate thickness shall be approximately 0.0001 inch (2.5  $\mu\text{m}$ ).

3.4.1.2 For surfaces that will not be machined after plating, the plate shall be substantially uniform in thickness on significant surfaces except that slight buildup on exterior corners or edges will be permitted provided finished drawing dimensions are met.

3.4.1.3 Unless otherwise specified on the drawing for specific areas, thickness shall apply to surfaces of parts that can be touched by a 0.75 inch (19.0 mm) sphere. Surfaces that cannot be touched by a 0.75 inch (19.0 mm) sphere, such as holes, recesses, internal threads, and other areas where a controlled deposit cannot be obtained under normal plating conditions shall not be masked during plating. This requirement will be satisfied for carbon and low-alloy steels if such surfaces show no film of copper after being immersed in a solution containing 4 grams copper sulphate  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , 10 grams sulfuric acid  $\text{H}_2\text{SO}_4$  (sp. gr. 1.84), and 90 mL distilled water for not less than six minutes at room temperature. If internal surfaces are required to be plated to meet a thickness requirement, the drawing shall so specify.

#### 3.4.2 Adhesion

##### 3.4.2.1 Specimens

Specimens as in 4.3.3 shall not show separation of the plating from the basis metal, when examined at approximately 4X magnification, after being bent rapidly, in accordance with ASTM B571, through an angle of 180 degrees around a diameter equal to the thickness of the specimen. Formation of cracks which do not result in flaking or blistering of the plating is acceptable.

##### 3.4.2.2 Machined Plating

Adhesion of plating after finish machining of the plating will be considered acceptable evidence of plating adhesion.

##### 3.4.2.3 Parts

When specified by purchaser, there shall be no blisters or other evidence of poor adhesion when parts are subjected to the heat-quench test of ASTM B571.

#### 3.4.3 Heat Resistance

Specimens as in 4.3.3, except aluminum and magnesium, shall show no cracks or blisters in the plate after being heated to  $1000\text{ }^\circ\text{F} \pm 25$  ( $538\text{ }^\circ\text{C} \pm 14$ ), held at heat for not less than two hours, and cooled; heating shall be in a circulating-air furnace.

#### 3.4.4 Corrosion Resistance

Carbon and low-alloy steel parts (except as provided in 3.4.1.3) when required by purchaser, or test specimens, excluding those parts plated to aid in brazing or where plating is used for dimensional restoration, shall show no visual evidence of corrosion after being subjected for not less than 48 hours to a continuous salt spray corrosion test conducted in accordance with ASTM B117 when plate is in the following conditions:

3.4.4.1 When specified minimum plate thickness is 0.002 inch (51  $\mu\text{m}$ ) or greater, parts or panels shall withstand the test either after embrittlement relief as in 3.3 or after the heat resistance test of 3.4.3 following embrittlement relief as in 3.3.

3.4.4.2 When specified minimum plate thickness is 0.0005 inch (12.7  $\mu\text{m}$ ) or greater but less than 0.002 inch (51  $\mu\text{m}$ ), parts or panels shall withstand the test only after the heat resistance test of 3.4.3 following embrittlement relief as in 3.3.

#### 3.4.5 Hydrogen Embrittlement

The plating process shall not cause hydrogen embrittlement in ferrous metals. Testing in accordance with the requirements of ASTM F519 Type 1A using notched round specimens, unless a different specimen type is specified by the purchaser, stressed in tension under a sustained load, is required only when parts 40 HRC or higher are plated. For test purposes, plating thickness shall be not less than 0.002 inch (51  $\mu\text{m}$ ), measured on the smooth section of the specimen, but with visual plating at the root of the notch. Testing beyond the 200 hour test period is not required.

### 3.5 Quality

Plating, as received by purchaser, shall be smooth, continuous, adherent to the basis metal, and uniform in appearance and shall be visually free from frosty areas, pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to usage of the plating. Slight staining or discoloration is permissible. There shall be no evidence of double plating or spotting-in after plating.

## 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. Where actual 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 the requirements of this specification.

### 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 to represent each lot.

4.2.1.1 If the nickel plate is used for braze preparation, acceptance test requirements for thickness and adhesion may be modified with the approval of the purchaser.

#### 4.2.2 Periodic Tests

Heat resistance (3.4.3), corrosion resistance (3.4.4), and embrittlement (3.4.5) are periodic tests and shall be performed at least monthly unless frequency of testing is specified by the cognizant engineering organization. Adhesion (3.4.2) 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 (See 8.5) to ensure that the deposited metal will conform to this specification.

#### 4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of plated parts to a purchaser, when a change in material and/or processing requires reapproval by the cognizant engineering organization (See 4.4.2), and when purchaser deems confirmatory testing to be required.

### 4.3 Sampling and Testing

Shall be not 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 set of solutions, in each consecutive 24 hour period of operation, and presented for processor's inspection at one time:

#### 4.3.1 For Acceptance Tests

Test samples shall be selected randomly from all parts in the lot. The minimum number of samples shall be as shown in Table 1.

**TABLE 1 - Sampling for Acceptance Tests**

Number of Parts in Lot	Quality	Thickness
Up to 7	All	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
Over 500	50	8

#### 4.3.2 Periodic Tests

Sample quantity and frequency of testing shall be at the discretion of the processor unless a test frequency is specified by the purchaser. 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 When plated parts are of such configuration or size as to be not adaptable to the specified tests, or for periodic tests as applicable, or when there is no nondestructive test adaptable to the parts, separate test specimens cleaned, pretreated, plated, and post-treated with the parts represented may be used. For adhesion tests, such specimens 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). For corrosion resistance and heat resistance tests, specimens shall be panels 0.062 to 0.125 inch (1.57 to 3.18 mm) in nominal thickness and not less than 4 inches (102 mm) long by 3 inches (76 mm) wide. Except for corrosion testing, specimens shall be made from material generically similar to the parts, such as low-alloy steel, age-hardenable nickel alloy, aluminum alloy, or corrosion-resistant steel. Corrosion test specimens shall be low-alloy steel.

#### 4.4 Approval

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

4.4.2 The processor shall make no significant change to materials, processes, or control factors from those on which approval was based, 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 the properties or performance of the parts.

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

- Activation procedure(s)
- Composition limits or the plating bath
- Plating bath temperature
- Plating current (or voltage) limits
- Frequency of plating bath composition determination
- Tooling and fixturing
- Time in cleaning, activation (pickling), and plating solutions
- Stripping procedure, when applicable
- Stress relief and embrittlement relief bake oven temperatures and times
- Method used to determine plating thickness
- Periodic test plan

#### 4.5 Reports

The processor of plated parts shall furnish with each shipment a report stating that the parts have been processed and tested in accordance with specified requirements and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS2403M, part number, and quantity.