

# AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard



**AMS 2404D**

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Superseding AMS 2404C

(R)

## Plating, Electroless Nickel

### 1. SCOPE:

#### 1.1 Purpose:

This specification covers the engineering requirements for electroless nickel deposited on various materials.

#### 1.2 Application:

This deposit has been used typically to provide a uniform build-up on intricate shapes, to improve wear and/or corrosion resistance, or to improve solderability on or for selected materials, but usage is not limited to such applications. The deposit has been used in service up to 1000 °F (540 °C) although wear and/or corrosion resistance may degrade as service temperature increases.

#### 1.3 Classification:

Plating covered by this specification is classified as follows:

Class 1: Except for hydrogen embrittlement relief, no post plating thermal treatment.

Class 2: Thermal treatment at 450 °F (232 °C) or above to harden the deposit.

Class 3: Thermal treatment at 375 °F (191 °C) to verify adhesion for nonheat-treatable aluminum and beryllium alloys.

Class 4: Thermal treatment at 250 °F (121 °C) to verify adhesion for heat-treatable aluminum alloys.

#### 1.3.1 Unless a specific class is specified, Class 1 shall be supplied.

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#### 1.4 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 following publications form a part of this specification to the extent specified herein. The latest issue of referenced publications shall be the issue in effect on the date of the purchase order.

##### 2.1 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

- ASTM B 117 Operating Salt Spray (Fog) Testing Apparatus
- 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 568 Measurement of Coating Thickness by X-Ray Spectrometry
- ASTM B 571 Adhesion of Metallic Coatings
- ASTM B 636 Measurement of Internal Stress of Plated Metallic Coatings with the Spiral Contractometer
- ASTM B 748 Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope
- ASTM B 764 Simultaneous Thickness and Electrochemical Potential Determination of Individual Layers on Multilayer Nickel Deposit (STEP Test)
- ASTM E 384 Microhardness of Materials
- ASTM F 519 Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals

#### 3. TECHNICAL REQUIREMENTS:

##### 3.1 Preparation:

- 3.1.1 Unless otherwise specified, fabrication operations, such as forming, perforating, heat treating, welding, and brazing, shall be completed before parts are plated, unless surfaces are plated to aid in joining by brazing.
- 3.1.2 Surfaces of metal parts to be plated shall be free from blemishes, pits, tool marks, and other irregularities that will affect the quality of the finished parts.

- 3.1.3 Steel parts having a hardness of 40 HRC or higher and which have been ground after heat treatment shall be cleaned to remove surface contamination and stress relieved before preparation for plating. Unless otherwise specified, the stress relief temperature shall be not less than  $275\text{ °F} \pm 25$  ( $135\text{ °C} \pm 14$ ) for not less than four hours for parts with hardness of 55 HRC or greater and not less than  $375\text{ °F} \pm 25$  ( $191\text{ °C} \pm 14$ ) for not less than four hours for other parts.
- 3.1.4 Parts shall have clean surfaces, free of water break, prior to immersion in the plating solution.
- 3.1.4.1 Care must be used if parts are to be cleaned with acids which may pit the surface or induce hydrogen embrittlement in ferrous alloys. This includes, but is not limited to, hydrochloric and sulfuric acids. In general, a momentary dip in such acids for surface activation or neutralization after alkaline cleaning is permissible, but immersion for an extended time is prohibited.
- 3.2 Procedure:
- 3.2.1 Plating shall be performed by chemical deposition of a nickel-phosphorus coating onto a properly prepared surface.
- 3.2.2 Plated parts shall be removed from the plating solution, thoroughly rinsed, and dried.
- 3.2.3 Double plating is prohibited.
- 3.3 Post Treatment:
- 3.3.1 Hydrogen Embrittlement Relief Bake: Post-treatment to prevent hydrogen embrittlement in Class 1 and Class 2 plated steel parts having a hardness of 33 HRC and over shall follow the plating process with a maximum delay of four hours after the parts have been removed from the plating bath. Thermal post treatment shall be in air, preferably in a circulating-air oven. Class 2 thermal treatment (See 3.3.2.1) that starts within four hours after the parts have been removed from the plating bath is an acceptable alternative.
- 3.3.1.1 Parts shall be heated to  $375\text{ °F} \pm 15$  ( $191\text{ °C} \pm 8$ ) and held at heat for not less than three hours.
- 3.3.1.2 Parts, including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating to  $375\text{ °F}$  ( $191\text{ °C}$ ) shall be heated to  $275\text{ °F} \pm 25$  ( $135\text{ °C} \pm 14$ ) and held at heat for not less than five hours.
- 3.3.1.3 Parts requiring special handling shall be post-treated as specified by purchaser.
- 3.3.2 Heat Treatment for Hardness: When Class 2, 3, or 4 is specified, parts, after plating, rinsing, and drying, shall be thermally treated.
- 3.3.2.1 When Class 2 is specified, parts shall be heated to a selected temperature within the range of 450 to 800 °F (232 to 427 °C) and held for sufficient time to increase hardness of the deposit (See 3.4.4 and 8.2).

3.3.2.2 When Class 3 is specified, parts shall be heated to 375 °F ± 15 (191 °C ± 8) for 1 to 1.5 hours.

3.3.2.3 When Class 4 is specified, parts shall be heated to 250 °F ± 10 (121 °C ± 6) for 1 to 1.5 hours.

#### 3.4 Properties:

Plating shall conform to the following requirements:

- 3.4.1 Thickness: Shall be as specified on the drawing, determined in accordance with ASTM B 487, ASTM B 499, ASTM B 568, ASTM B 748, ASTM B 764, or by other method acceptable to purchaser.
- 3.4.2 Adhesion: Shall meet the requirements of ASTM B 571 or, when acceptable to purchaser, 3.4.2.1.
- 3.4.2.1 When specified by purchaser, plating shall comply with all criteria of 3.5 after being heated in air, preferably in a circulating-air furnace, at 700 °F ± 15 (371 °C ± 8) for 23 hours ± 1 followed by heating at 1000 °F ± 15 (538 °C ± 8) for 60 minutes ± 5.
- 3.4.3 Corrosion Resistance of Plated Carbon and Alloy Steels: Carbon and low-alloy steel parts or test panels (See 4.3.1.3) having minimum plating thickness of 0.001 inch (25 µm), shall, after plating and embrittlement-relieving, show no visual evidence of corrosion of the basis metal after being subjected for not less than 48 hours to continuous salt spray corrosion test conducted in accordance with ASTM B 117.
- 3.4.4 Hardness: Class 2 plating shall be not lower than 800 HK100, or equivalent, determined in accordance with ASTM E 384.
- 3.4.5 Hydrogen Embrittlement: The plating process shall not cause hydrogen embrittlement in steel parts, after baking, determined in accordance with 4.3.1.4.
- 3.4.6 Internal Stress: The cognizant engineering organization may specify a compressive stress value for Class 1 plating up to 10 ksi (69 MPa), determined in accordance with ASTM B 636.
- 3.4.7 Composition: The cognizant engineering organization may specify a phosphorus content range of the deposit. When specified, the composition of the deposit shall be determined by a method acceptable to purchaser.

#### 3.5 Quality:

Plating, as received by purchaser, shall be smooth, continuous, and uniform in appearance and shall be free from frosty areas, pinholes, blisters, and other imperfections detrimental to usage of the plate. Slight staining or discoloration is permissible. Class 2 plating may discolor from thermal treatment. There shall be no evidence of double plating.

#### 4. QUALITY ASSURANCE PROVISIONS:

##### 4.1 Responsibility for Inspection:

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

##### 4.2 Classification of Tests:

4.2.1 Acceptance Tests: Thickness (3.4.1), adhesion (3.4.2), and quality (3.5) are acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Corrosion resistance (3.4.3), hardness (3.4.4), hydrogen embrittlement (3.4.5), internal stress (3.4.6), if specified, composition (3.4.7) if specified, and tests of cleaning and plating solutions to ensure that the deposited metal will conform to specified requirements are periodic tests and shall be performed at a frequency selected by the processor unless frequency of testing is specified by purchaser.

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 approval by the cognizant engineering organization (See 4.4.2), and when purchaser deems confirmatory testing to be required.

##### 4.3 Sampling for Tests:

##### 4.3.1 Sample Configuration:

4.3.1.1 Nondestructive testing shall be performed wherever practical. Except as noted below, actual parts shall be selected as samples for tests.

4.3.1.2 Separate test specimens, made of the same generic class of alloy as the parts, distributed within the lot, cleaned, plated, and post treated with the parts shall be used when plated parts are of such configuration or size as to be not readily adaptable to specified tests, when nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive tests on actual parts.

4.3.1.3 Corrosion Test: Test panels shall be low carbon steel approximately 0.032 x 4 x 6 inches (0.81 x 102 x 152 mm) or bars approximately 0.5 inch (13 mm) in diameter and four inches (102 mm) long having a surface roughness not to exceed 40 microinches (1  $\mu$ m) RHR.

4.3.1.4 Hydrogen Embrittlement Relief Test: Test specimens shall conform to ASTM F 519, Type 1. Plating shall be 0.001 to 0.0012 inch (25 to 30  $\mu$ m) thick.

4.3.1.5 Internal Stress Test: When an internal stress requirement is imposed by the cognizant engineering organization, test specimens shall be plated to a thickness not less than 0.0006 inch (15  $\mu$ m) and shall conform to ASTM B 636.

4.3.2 Sample Quantity:

4.3.2.1 Acceptance Tests: Shall be in accordance with Table 1; 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.

TABLE 1 - Sampling for Acceptance Tests

Number of Parts in Lot		Quality	Thickness and Adhesion
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
501 to	700	50	8
701 to	1200	75	10
Over	1200	125	15

4.3.2.2 Sample Quantities for Periodic Tests and Preproduction Tests: Shall be selected at the discretion of the processor unless otherwise specified.

4.4 Approval:

4.4.1 The process and control factors, a preproduction 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 controls from those on which the 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 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, including strike if used
- Plating bath composition and composition control limits
- Plating bath temperature limits and controls
- Thermal post treatment times and temperatures
- Method for testing plate thickness
- Method for testing plate adhesion
- 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, AMS 2404D, part number, and quantity.

4.6 Resampling and Retesting:

- 4.6.1 If the result of any acceptance test fails to meet specified test requirements, the parts in that lot may be stripped by a method acceptable to purchaser that does not roughen, pit, or embrittle the basis metal, pretreated, plated, post treated as defined herein, and tested. Alternatively, all parts in the lot may be inspected for the nonconforming attribute, and the nonconforming parts may be stripped by a method acceptable to purchaser that does not roughen, pit, or embrittle the basis metal, pretreated, plated, post treated as defined herein, and tested.
- 4.6.2 If the result of any periodic test fails to meet specified test requirements, the process is nonconforming. No additional parts shall be plated until the process is corrected and new specimens are plated and tested. Results of all tests shall be recorded and, when requested, reported. Purchaser shall be notified of all parts plated since the last acceptable test.

5. PREPARATION FOR DELIVERY:

- 5.1 Plated parts shall be handled and packaged to ensure that required physical characteristics and properties of the plating are preserved.
- 5.2 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 plated parts to ensure carrier acceptance and safe delivery.

6. ACKNOWLEDGMENT:

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