

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 improve adhesion for nonheat-treatable aluminum alloys and beryllium alloys.

Class 4: Thermal treatment at 250 °F (121 °C) to improve 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 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, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS-C-26074	Coatings, Electroless Nickel Requirements for

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959 or www.astm.org.

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 567	Method for Measurement of Coating Thickness by the Beta Backscatter Method
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 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 suitably stress relieved before preparation for plating. Temperatures to which parts are heated shall be such that maximum stress relief is obtained without reducing hardness of parts below drawing limits, but, unless otherwise specified, not less than 275 °F (135 °C) for not less than five hours for parts having hardness of 55 HRC or higher or not less than 375 °F (191 °C) for not less than four hours for other parts.

3.1.2 Parts shall have clean surfaces, free of water break, prior to immersion in the plating solution.

3.1.2.1 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. Spotting in is not permitted.

3.3 Post Treatment:

3.3.1 Hydrogen Embrittlement Relief: Treatment of steel parts shall be in accordance with AMS 2759/9.

3.3.2 Heat Treatment for Hardness or Adhesion Enhancement: 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 8.6). Hydrogen embrittlement relief (3.3.1) may be omitted if Class 2 hardening is accomplished within four hours after plating.

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 567, 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 bend test or, when acceptable to purchaser, 3.4.2.1.
 - 3.4.2.1 Plating shall comply with all criteria of 3.5 after being heated in air, preferably in a circulating-air furnace, at $700^{\circ}\text{F} \pm 15$ ($371^{\circ}\text{C} \pm 8$) for 23 hours ± 1 followed by heating at $1000^{\circ}\text{F} \pm 15$ ($538^{\circ}\text{C} \pm 8$) 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 (See 4.3.1.2).
 - 3.4.3.1 When AMS-C-26074 Grade A is specified, aluminum alloy parts or test panels having minimum plating thickness of 0.0010 inch (25 μm), shall, after plating and thermal treatment, show no visual evidence of corrosion of the basis metal after being subjected for not less than 100 hours to continuous salt spray corrosion test conducted in accordance with ASTM B 117.
 - 3.4.3.2 When AMS-C-26074 Grade C is specified, carbon and low alloy steel parts or test panels having minimum plating thickness of 0.0015 inch (37 μm), shall, after plating and embrittlement-relieving, show no visual evidence of corrosion of the basis metal after being subjected for not less than 100 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.

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), internal stress, if specified (3.4.6), composition, if specified (3.4.7), and cleaning and plating solution analyses (See 8.4) to ensure that the deposited metal will conform to this specification are periodic tests and shall be performed at a frequency selected by the processor unless frequency of testing is specified by purchaser. Testing for hydrogen embrittlement (3.4.5) shall be performed in accordance with ASTM F 519 at least once in each month that parts 36 HRC and over are plated. Testing for hardness (3.4.4) shall be performed at least once in each month.

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 μ m) RHR. Aluminum alloy test panels, made of the same generic class of alloy as the parts being plated, shall be used in any month when aluminum alloy parts are plated.
- 4.3.1.4 Hydrogen Embrittlement Test: Test shall be in accordance with the requirements of ASTM F 519 Type 1A using round notched specimens, unless a different specimen is specified by the purchaser, stressed in tension under constant load. For test purposes, the plating thickness shall be 0.001 to 0.0012 inch (25 to 30 μ m) measured on the smooth section of the specimen, but with visual plating at the root of the notch.
- 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 μ 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 For Periodic Tests: Sample quantity and frequency of testing shall be at the discretion of the processor unless otherwise specified by the purchaser or herein. Sample quantity for hydrogen embrittlement and hardness tests shall be four minimum.

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 2404E, 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, adversely affect part dimensions, 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.

7. REJECTIONS:

Parts on which 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 (I) 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 a specification. An (R) symbol to the left of the document title indicates a complete revision of the specification, including technical revision. Change bars and (R) are not used in original publications, nor in specifications that contain editorial changes only.
- 8.2 Part manufacturing operations, such as heat treatment, forming, joining, and media finishing, can affect the condition of the substrate for plating, or, if performed after plating, could adversely affect the plate. The sequencing of these operations should be specified by the cognizant engineering organization and is not controlled by this specification.
- 8.3 The parts manufacturer should ensure that the surfaces of the metal parts supplied to the plater 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 finish plate despite observance of accepted industry practices are not cause for rejection.
- 8.4 ARP 4992, Periodic Test Plan for Process Solutions, is recommended to satisfy the requirements for the 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 to preclude pitting.
- 8.6 The following thermal treatments have been used to achieve Class 2 hardness requirements. The supplier is cautioned to avoid a thermal treatment that could soften or otherwise degrade the substrate.

TABLE 2 - Class 2 Thermal Treatments

Temperature	Time, hours
450 °F (232 °C)	4, minimum
500 °F (260 °C)	4, minimum
550 °F (288 °C)	2, minimum
650 °F (343 °C)	1 to 1.5
750 °F (399 °C)	0.5 to 1

- 8.7 Special surface preparation techniques, such as electropolishing, may be employed to minimize plating porosity and maximize corrosion protection.
- 8.8 Phosphorus content of the plate may range from 1 to 13% by weight. Ductility is generally less for low phosphorus (2 to 8%) deposits compared with high phosphorus (8 to 13%) deposits. Class 1 deposits that are low in phosphorous generally have less corrosion resistance than Class 1 high-phosphorus deposits whereas Class 2 deposits that are high in phosphorus may provide less salt fog corrosion protection to steel than Class 2 low-phosphorus coatings.
- 8.9 Terms used in AMS are clarified in ARP1917.
- 8.10 Dimensions in inch/pound units and the Fahrenheit temperatures are primary; dimensions in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.
- 8.11 Procurement documents should specify the following information:
- AMS 2404E
 - Class of plate (See 1.3)
 - Plate composition, if specified
 - Plate thickness desired
 - Part number and quantity of pieces to be plated
 - Material
 - Minimum hardness or tensile strength of parts to be plated
 - Preplate stress relief temperature, if required
 - Special packaging, if required
 - Hydrogen embrittlement testing for each lot, if required, and specific test method required
 - Compressive stress, if required.