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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2403J

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Superseding AMS 2403H

Submitted for recognition as an American National Standard

(R) PLATING, NICKEL
General Purpose

1. **SCOPE:**

1.1 **Purpose:**

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

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, AMS 2423 should be used; if a low-stressed plate is required, AMS 2424 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 following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2423 Plating, Nickel, Hard Deposit
AMS 2424 Plating, Nickel, Low Stressed Deposit

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM B 117 Salt Spray (Fog) Testing
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 of Magnetic Basis Metals
ASTM B 504 Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B 568 Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B 571 Adhesion of Metallic Coatings
ASTM E 290 Semi-Guided Bend Test for Ductility of Metallic Materials
ASTM E 376 Measuring of Coating Thickness by Magnetic Field or Eddy Current (Electromagnetic) Test Methods
ASTM F 519 Mechanical Hydrogen Embrittlement Testing of Plating Processes and Aircraft Maintenance Chemicals

2.3 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 All fabrication operations, such as forming, heat treating, shot peening, roll threading, welding, and all brazing except on parts to be plated as an aid to brazing, shall be completed before parts or assemblies are plated.

3.1.2 Surfaces of parts to be plated shall be smooth and free of blemishes, pits, tool marks, and other irregularities that will affect the appearance or quality of the finished parts.

3.1.3 Steel parts, except those to be plated as an aid to brazing, having hardness higher than 40 HRC and which have been ground after heat treatment shall be suitably stress-relieved before cleaning for plating.

3.1.4 Parts shall have clean surfaces, free of waterbreak, prior to immersion in the plating solution.

3.1.5 Steel parts having hardness of 40 HRC or higher and parts roll-threaded after heat treatment shall not be cleaned with inorganic acids such as hydrochloric or sulfuric acids, unless specifically approved by purchaser.

3.1.6 Electrical contacts between the parts and power source shall be made to prevent chemical or immersion deposition, electrical arcing, or overheating. If parts are to be plated all over, contact points shall be located where specified or where agreed upon by purchaser and vendor. If parts are not required to be plated all over, contact points shall be located in areas on which plating is not required or is optional.

3.2 Procedure:

3.2.1 Nickel shall be electrodeposited from a chloride, sulfate-chloride, fluoborate, or sulfamate solution containing no addition agents which may 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 Post Treatment:

After plating, rinsing, and drying, steel parts, except those plated as an aid to brazing, shall be treated as in 3.3.1 to minimize the effects of hydrogen embrittlement; heating shall be in air, preferably in a circulating-air furnace. Post treatment shall follow the plating operation with a maximum delay of four hours from removal of parts from the plating

3.3.1 Except as follows, steel parts, including roll-threaded parts, cold worked after being heat treated by hardening and tempering, steel springs, and other steel parts having hardness of 33 HRC or higher, shall be heated to 375 °F ± 25 (191 °C ± 14) and held at heat for not less than three hours.

3.3.1.1 Some parts having hardness of 40 HRC and higher may require heating for up to 23 hours or as specified by the cognizant engineering organization.

3.3.1.2 Steel parts, including carburized parts, which will decrease in hardness if heated to 375 °F (191 °C) shall be heated to 275 °F ± 25 (135 °C ± 14) and held at heat for not less than five hours.

3.4 Properties:

3.4.1 Thickness: Shall be as specified on the drawing, determined on actual parts where feasible. Representative parts may be substituted for actual parts if necessary. Test panels may be used if that is the only means for obtaining data without damaging parts. For buildup or repair purposes, plate thickness shall be as required to provide the desired thickness or dimension when post-plate machined. Plating thickness determination shall apply after machining where applicable. Thickness shall be determined in accordance with ASTM B 487, ASTM B 499, ASTM B 504, ASTM B 568, ASTM E 376 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 µm).

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, 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 $CuSO_4 \cdot 5H_2O$, 10 grams sulfuric acid H_2SO_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 E 290, 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 B 571.

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 °F ± 25 (538 °C ± 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 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 of significant surfaces after being subjected for not less than 48 hours to a continuous salt spray corrosion test conducted in accordance with ASTM B 117 when plate is in the following conditions:

3.4.4.1 When specified minimum plate thickness is 0.002 inch (51 µm) 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 µm) or greater but less than 0.002 inch (51 µm), 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 Embrittlement: The nickel plating process shall not cause hydrogen embrittlement in steel parts, after baking, determined in accordance with 4.3.4 using round notched steel specimens.

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. Visual deficiencies in plating that will be subsequently removed by machining are acceptable. Standards for acceptance may be agreed upon b-y purchaser and vendor. There shall be no evidence of double plating or spotting-in after plating.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The processing vendor shall be responsible for obtaining all samples for vendor's tests and shall be responsible for performing all required tests. 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: Tests for thickness (3.4.1), adhesion (3.4.2.3) when specified, and quality (3.5) are acceptance tests and shall be performed to represent each lot.

4.2.2 Periodic Tests: Tests to ensure that plating parameters used will result in plated parts or panels which will conform to requirements for adhesion (3.4.2.1), heat resistance (3.4.3), corrosion resistance (3.4.4), and embrittlement (3.4.5) are periodic tests and shall be performed at a frequency selected by the processing vendor unless frequency of testing is specified by purchaser and tests of cleaning and plating solutions to ensure that the deposited metal will conform to this specification.

4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed prior to or on the first-article 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.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and, when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

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 vendor'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

Number of Parts in Lot	Number of Samples Quality	Number of Samples 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
Over 500	50	8

4.3.2 Periodic and Preproduction Tests: Test frequency shall be acceptable to purchaser.

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, plated, and post-treated with the parts represented may be used. For adhesion tests, such specimens shall be panels of approximately 0.032 x 1 x 4 inches (0.81 x 25 x 102 mm); for thickness and quality tests, such specimens shall be panels of the same size and type or shall be bars approximately 0.5 inch (12.7 mm) in diameter and 4 inches (102 mm) long. 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.

4.3.4 Specimens for embrittlement relief test shall be round notched steel constant-load specimens conforming to ASTM F 519 with the axis of the specimen (load direction) parallel to the grain flow direction. Specimens shall be prepared, plated, and post-plate baked in accordance with 3.3. Plating thickness shall be not less than 0.002 inch (51 µm) on the shaft with visual evidence of plate on the notch. Tests shall conform to ASTM F 519.

4.4 Approval:

4.4.1 The process and control factors, 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 The supplier 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 for the process 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
Stress relief and embrittlement relief bake oven temperatures and times
Method used to determine plating thickness
Periodic test plan