SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2424E

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Superseding AMS 2424D

Plating, Nickel
Low-Stressed Deposit

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for electrodeposition of a low-stressed nickel and the properties of the deposit.

1.2 Application:

This process has been used typically to provide moderate corrosion and oxidation resistance to parts which may operate in service at moderately elevated temperatures, where low tensile stress in the deposit is required to avoid marked reduction of fatigue strength, 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 cancelled and no superseding document has been specified, the last published issue of that document shall apply.

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

2.1 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 504	Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B 530	Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates
ASTM B 568	Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B 571	Qualitative Adhesion Testing of Metallic Coatings
ASTM B 636	Measurement of Internal Stress of Plated Metallic Coatings with the Spiral Contractometer
ASTM E 92	Vickers Hardness of Metallic Materials
ASTM E 376	Measurement Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods
ASTM F 519	Mechanical Hydrogen Embrittlement Evaluation of Plating Processes and Service Environments

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 Steel parts having hardness higher than 40 HRC 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 from waterbreak, 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 Parts shall be plated by electrodeposition of nickel from a sulfamate solution or other suitable plating solution containing no addition agents, including stress-reducing agents, which might have a detrimental effect on properties of the plate or of the basis metal. The addition of organic wetting agents for the purpose of lower surface tension and to avoid gas-pitting is permitted. Except as permitted by 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 On aluminum, magnesium, beryllium, and their alloys, and corrosion-resistant steels or similarly passive materials, a preliminary chemical coating, immersion plate, or metal flash is permissible.

3.2.2 Spotting in is not permitted.

3.3 Hydrogen Embrittlement:

After plating, rinsing, and drying, ferrous parts shall be treated in accordance with AMS 2759/9.

3.4 Properties:

The deposited nickel shall conform to the following requirements except that the requirements of 3.4.3, 3.4.6, and 3.4.7 shall not apply to parts plated in preparation for brazing:

3.4.1 Thickness: Shall be as specified on the drawing. Thickness shall be determined in accordance with ASTM B 487, ASTM B 499, ASTM B 504, ASTM B 530, 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 .0001 inch (2.5 μm).

3.4.1.2 Thickness requirements apply to surfaces that can be touched by a sphere 0.75 inch (19 mm) in diameter. Other areas, such as surfaces of holes, recesses, internal threads or contact areas of parts plated all over, where a controlled deposit cannot be obtained under normal plating conditions, shall show evidence of plating.

3.4.1.2.1 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 $CuSO_4 \cdot 5H_2O$, 10 grams H_2SO_4 (sp. gr. 1.84), and 90 mL distilled or deionized water for not less than six minutes at room temperature.

3.4.1.2.2 If internal surfaces are required to be plated to meet a thickness requirement, the drawing shall so specify.

3.4.2 Hardness: Shall be not higher than 300 HV, or equivalent, determined in accordance with ASTM E 92 on deposits 0.005 inch (0.13 mm) and over in thickness.

3.4.3 Residual Stress: Shall be within the range 5 ksi (34.5 MPa) in compression to 15 ksi (103 Mpa) in tension, determined on specimens having plate thickness of 0.0003 inch (7.6 µm) or greater, determined in accordance with ASTM B 636 or other instrument acceptable to purchaser.

3.4.4 Adhesion: Shall conform to one of the following:

3.4.4.1 Specimens, as in 4.3.3, shall not show separation of the plate from the basis metal, when examined at approximately 4X magnification, after being bent approximately 180 degrees around a diameter equal to twice the thickness of the specimen. Formation of cracks which do not result in flaking or blistering of the plate is acceptable.

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

3.4.4.3 There shall be no blisters or other evidence of poor adhesion when parts are subjected to the heat-quench test of ASTM B 571.

3.4.5 Heat Resistance: Plated parts, when specified by purchaser, or representative test panels, except aluminum or magnesium, shall withstand, without blistering or cracking, being heated in a circulating-air furnace to 1000 °F ± 15 (538 °C ± 8) and holding at heat for not less than two hours.

3.4.6 Corrosion Resistance: Carbon or low-alloy steel plated parts, except parts plated to aid in brazing or plated for dimensional restoration, or representative test specimens plated to a thickness as follows and post treated as in 3.4.6.1 or 3.4.6.2, shall show no visual evidence of corrosion of significant surfaces after being subjected for 48 hours ± 1 to continuous salt spray corrosion test conducted in accordance with ASTM B 117.

3.4.6.1 When specified minimum plate thickness is 0.002 inch (0.05 mm) or greater, parts or panels shall withstand the test either after embrittlement relief as in 3.3 or after the heat resistance test of 3.4.5 following embrittlement relief as in 3.3.

3.4.6.2 When the specified minimum plate thickness is 0.0005 inch (12.7 µm) or greater but less than 0.002 inch (0.05 mm), parts or panels shall withstand the test only after the heat resistance test of 3.4.5 following embrittlement relief as in 3.3.

3.4.7 Hydrogen Embrittlement: The process shall not cause embrittlement in ferrous metals. Testing in accordance with ASTM F 519, Type 1a, using notched round specimens, unless a different specimen type is specified by the purchaser, stressed in tension under constant load, is required when parts 40 HRC or higher are plated. Plating shall meet the requirements of this specification on the specimen surfaces and shall be visible at the root of the notch on notched specimens.

3.5 Quality:

Plating shall be smooth, continuous, free of delamination within the plating, uniform in appearance, and free of imperfections detrimental to usage of plating. Plating shall be visually free from frosty areas, pinholes, porosity, blisters, nodules, and pits. Slight discoloration or staining is permissible.

3.5.1 For surfaces that will not be machined after plating, the plate shall be substantially uniform in thickness on significant surfaces except that slight build-up at exterior corners or edges is permissible provided finished drawing dimensions are met.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The processor shall supply all samples for processor tests and shall be responsible for 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), adhesion (3.4.4.3), and quality (3.5) are acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Hardness (3.4.2), stress (3.4.3), adhesion (3.4.4.1), heat resistance (3.4.5), corrosion resistance (3.4.6), embrittlement (3.4.7), and tests of cleaning and plating solutions (See 8.5) to ensure that deposited metal will conform to the specified requirements are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Test: Tests for 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 of the cognizant engineering organization as in 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 solutions in each consecutive 24 hours of operation, and presented for processor's inspection at one time.

4.3.1 For Acceptance Tests: Shall be as shown in Table 1.

TABLE 1 – Sampling

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
Over 500	50	8

4.3.2 For Periodic Tests: Frequency of testing shall be at the discretion of the processor unless a test frequency is specified by the purchaser.

4.3.3 When plated parts are of such configuration and size as to be not adaptable to the specified test or for periodic tests, as applicable, or when there is no nondestructive test adaptable to the part, separate specimens, cleaned, plated, and post-treated with the parts represented may be used; specimens shall be plated for a longer or shorter time than the parts as necessary to produce the plate thickness required for hardness, stress, and corrosion resistance tests. For adhesion tests, specimens shall be panels approximately 0.032 x 1 x 4 inches (0.81 x 25 x 102 mm). For thickness tests, specimens shall be panels of the same size and type or bars approximately 0.5 inch (13 mm) in diameter and 4 inches (102 mm) long. For hardness, heat resistance, and corrosion 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 and hardness 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 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 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.