



# AEROSPACE MATERIAL SPECIFICATION

Society of Automotive Engineers, Inc.  
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

## AMS 2424B

Superseding AMS 2424A

Issued 6-30-62

Revised 1-15-77

### NICKEL PLATING 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: Primarily to provide moderate corrosion and oxidation resistance to parts which may operate at temperatures up to 700° F (370° C), where low tensile stress in the deposit is required to avoid marked reduction of fatigue strength.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

- 2.1 SAE Publications: Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specification:

AMS 2350 - Standards and Test Methods

- 2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM B117 - Salt Spray (Fog) Testing

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 on Magnetic Basis Metals

ASTM B504 - Measurement of the Thickness of Metallic Coatings by the Coulometric Method

ASTM B529 - Measurement of Coating Thicknesses by the Eddy-Current Test Method: Non-conductive Coatings on Nonmagnetic Basis Metals

ASTM B530 - Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates

ASTM E92 - Vickers Hardness of Metallic Materials

- 2.3 Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

#### 3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

- 3.1.1 All machining, welding, forming, and heat treating shall be completed before parts are plated.

SAE Technical Board rules provide that: "All technical reports, including standards, approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

- 3.1.2 Surfaces of parts to be plated shall be smooth and substantially free from blemishes, pits, tool marks, and other irregularities.
- 3.1.3 Parts having hardness of 40 HRC or higher and which have been ground after heat treatment, except those to be plated in preparation for brazing, shall be suitably stress-relieved before cleaning 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.
- 3.1.4 Parts shall have chemically clean surfaces prepared with minimum abrasion, erosion, or pitting, prior to immersion in the plating solution. Treatments which may produce hydrogen embrittlement shall be avoided.
- 3.1.5 Electrical contacts between the parts and power source shall be made in such manner as will ensure that neither chemical or immersion deposition nor electrical arcing or overheating will occur. 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 Parts shall be plated by electrodeposition of nickel from a sulfamate 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. 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, and their alloys, a preliminary chemical coating, immersion plate, and/or metal flash is permissible.
- 3.2.2 The plated parts shall be removed from the plating solution, thoroughly rinsed, and dried.
- 3.3 Post Treatment: After plating, rinsing, and drying, parts, except those plated in preparation for brazing, shall be heat treated as in 3.3.1, 3.3.2, or 3.3.3, as applicable, to remove hydrogen embrittlement; heating shall be in air, preferably in a circulating air furnace. Post heat treatment should be started as soon as practicable, preferably within 60 min., after plating.
- 3.3.1 Ferrous parts, including roll-threaded parts, cold worked after being heat treated by hardening and tempering, regardless of hardness, springs, and other parts having hardness of 33 HRC or higher shall be heated to  $375^{\circ}\text{F} \pm 15$  ( $190^{\circ}\text{C} \pm 8$ ) and held at heat for not less than 3 hours.
- 3.3.1.1 Parts having hardness of 40 HRC or higher may require heating for up to 23 hours.
- 3.3.2 Parts and assemblies, including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating as in 3.3.1 shall be heated to  $275^{\circ}\text{F} \pm 15$  ( $135^{\circ}\text{C} \pm 8$ ) and held at heat for not less than 5 hours.
- 3.3.3 Parts requiring special handling shall be post treated as agreed upon by purchaser and vendor.
- 3.4 Properties: Plated parts shall conform to the following requirements except that the requirements of 3.4.1.1, 3.4.3, and 3.4.6 shall not apply to parts plated in preparation for brazing:
- 3.4.1 Thickness: Shall be as specified on the drawing, determined on representative parts or test panels in accordance with ASTM B487, ASTM B499, ASTM B504, ASTM B529, ASTM B530, or other suitable method agreed upon by purchaser and vendor.
- 3.4.1.1 The plated deposit shall be substantially uniform in thickness on significant surfaces except that slight build-up at exterior corners or edges will be permitted provided finished drawing dimensions are met.

3.4.1.2 No requirements are established for minimum plate thickness for surfaces of holes, recesses, internal threads, contact areas of parts plated all over, and other areas where a controlled deposit cannot be obtained under normal plating conditions, but such areas shall not be masked to prevent plating. Unless otherwise specified, resultant thickness shall be considered only when such surfaces of parts can be touched by a sphere 0.75 in. (19 mm) in diameter but such surfaces shall not show a film of copper after being immersed for 6 min.  $\pm$  0.5 at room temperature in a solution containing 4 g cupric sulfate, 10 g sulfuric acid (sp gr 1.84), and 90 cm<sup>3</sup> distilled water.

3.4.1.2.1 If internal surfaces as specified in 3.4.1.2 are required to be plated, the drawing will so specify.

3.4.2 Hardness: Shall be not higher than 300 HV, determined in accordance with ASTM E92 on  $\emptyset$  deposits 0.005 in. (0.13 mm) and over in thickness.

3.4.3 Stress: Shall be within the range 5,000 psi (34.5 MPa) in compression to 15,000 psi (103 MPa) in tension, determined at plate thickness of 0.0003 in. (8  $\mu$ m) by calculation from spiral contractometer reading or other instrument agreed upon by purchaser and vendor.

3.4.4 Adhesion: Shall be such that, when examined at approximately 4X magnification, plate does not separate from the basis metal after being bent approximately 180 deg (3.14 rad) around a  $\emptyset$  diameter equal to twice the thickness of the test panel. Formation of cracks which do not result in flaking or blistering of the plate is acceptable.

3.4.5 Heat Resistance: Plated ferrous parts or representative test panels shall withstand, without blistering or cracking, being heated in air, preferably in a circulating air furnace, to 700° F  $\pm$  15 (371°C  $\pm$  8) and held at heat for not less than 23 hr followed by heating to 1000° F  $\pm$  15 (538° C  $\pm$  8) and holding at heat for not less than 60 minutes.

3.4.6 Corrosion Resistance: Plated parts or representative test panels, 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 hr  $\pm$  1 to continuous salt spray corrosion test conducted in accordance with ASTM B117.

3.4.6.1 When specified minimum plate thickness is 0.002 in. (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 in. (13  $\mu$ m) or greater but less than 0.002 in. (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.

3.5 Quality: Plated nickel shall be smooth, continuous, adherent to the basis metal, and uniform in appearance and shall be essentially free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to performance of parts. Slight straining or discoloration is permissible. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.5.1 Double plating and spotting-in after plating are not permitted, unless otherwise specified.

#### 4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The processing vendor shall supply all samples and shall be responsible for performing all required tests. Purchaser reserves the right to perform such confirmatory testing as he deems necessary to ensure that processing conforms to the requirements of this specification.

#### 4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to thickness (3.4.1), hardness (3.4.3), and quality (3.5) requirements are classified as acceptance tests.

4.2.2. Periodic Tests: Tests to determine conformance to adhesion (3.4.2), stress (3.4.4), heat resistance (3.4.5), and corrosion resistance (3.4.6) requirements and of cleaning and plating solutions to ensure that the deposited metal will conform to the requirements of this specification are classified as periodic tests.

4.2.3 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests.

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, the contracting officer, or the request for procurement.

#### 4.3 Sampling: Shall be not less than the following:

##### 4.3.1 Acceptance Tests:

4.3.1.1 Thickness: Three parts for each consecutive 8 hr of operation of the same set of solutions, except as specified in 4.3.3.

4.3.1.2 Hardness: Three parts for each consecutive 8 hr of operation of the same set of solutions when minimum thickness of plate is 0.005 in. (0.13 mm) or more; otherwise, three panels as in 4.3.3.

4.3.1.3 Quality: As agreed upon by purchaser and vendor.

4.3.2 Periodic and Preproduction Tests: As agreed upon by purchaser and vendor.

4.3.3 When plated parts are of such configuration and size as to be not readily adaptable to the specified test, 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 hardness and adhesion tests, specimens shall be panels of low-carbon steel, approximately 0.032 x 4 x 1 in. or 1 x 100 x 25 mm. For thickness and quality tests, specimens shall be panels of the same size and type or bars approximately 0.5 in. or 10 mm in diameter and 4 in. or 100 mm long. For heat resistance and corrosion resistance tests, specimens shall be panels 0.062 - 0.125 in. or 1.5 - 3 mm in nominal thickness and not less than 4 in. or 100 mm long by 3 in. or 75 mm wide.

#### 4.4 Approval:

4.4.1 Plated parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived. Results of tests on production parts shall be essentially equivalent to those on the approved sample parts.

4.4.2 Vendor shall use manufacturing procedures, processes, and methods of inspection on production parts which are essentially the same as those used on the approved sample parts. If any change is necessary in type of equipment or in established composition limits and operating conditions of process solutions, vendor shall submit for reapproval of the process a statement of the proposed changes in processing and, when requested, sample plated parts, test panels, or both. Production parts plated by the revised procedure shall not be shipped prior to receipt of reapproval.