SAE Aerospace
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS2405 | REV. D

Issued 1965-02
Noncurrent 2000-12
Reaf. Nonc. 2010-05
Revised 2013-06

Superseding AMS2405C

Electroless Nickel Plating
Low Phosphorus

RATIONALE

AMS2405D has been reactivated and revised to include the latest requirements on hydrogen embrittlement relief consistent with similar plating specifications.

ORDERING INFORMATION: The following information shall be provided to the plating processor by the purchaser.

1) Purchase order shall specify not less than the following:

- AMS2405D
- Plating thickness desired
- Basis metal to be plated
- Tensile strength or hardness of the basis metal (steel alloys only)
- Pre-plate stress relief to be performed by plating processor (time and temperature) if different from 3.1.4.
- Special features, geometry or processing present on parts that require special attention by the processor
- Hydrogen embrittlement relief to be performed by plating processor if different from 3.3
- Post plating bake to be performed by plating processor (to harden plating on substrates capable of high temperature, or to improve adhesion) (See 3.3.3)
- Quantity of pieces to be plated

2) Parts manufacturing operations such as heat treating, forming, joining and media finishing can affect the condition of the substrate for plating, or if performed after plating, could adversely affect the plated part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

SAE values your input. To provide feedback on this Technical Report, please visit
http://www.sae.org/technical/standards/AMS2405D

1. SCOPE

1.1 Purpose

This specification covers the engineering requirements for electroless deposition of low-phosphorus nickel on various materials and the properties of the deposit.

1.2 Application

Primarily to provide hard, ,wear-resistant, and corrosion-resistant surfaces for operation up to 1000 °F (540 °C) and to provide uniform build-up on complex shapes. Maximum hardness and wear resistance are obtained by heating parts as in 3.3.2.

1.2.1 Application of electroless nickel plating to steel parts having a hardness of 46HRC (ultimate tensile strength of 220 ksi (1517 MPa) or higher shall not be performed unless authorized by the design documentation or specific approval has been received from the cognizant engineering organization.

1.3 Safety – Hazardous Materials

1.4 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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS2350 Standards and Test Methods

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

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 E 290 Semi-Guided Bend Test for Ductility of Metallic Materials

2.3 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: (215) 697-6396, http://quicksearch.dla.mil/.

MIL-STD-2073-1 Standard Practice for Military Packaging

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 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 smooth and substantially free from blemishes, pits, tool marks, and other irregularities.

3.1.3 Surfaces of nonmetallic parts shall show no marks other than those necessary to provide a freshly-abraded surface.

3.1.4 Stress Relief Treatment

All steel parts having a hardness of 40 HRC and above and that are machined, ground, cold formed or cold straightened after heat treatment shall be cleaned to remove surface contamination and thermally stress relieved before plating. (Residual tensile stresses have been found to be damaging during electrofinishing.) Temperatures to which parts are heated shall be such that maximum stress relief is obtained while still maintaining hardness of parts within drawing limits. Unless otherwise specified, the following treatment temperatures and times shall be used:

3.1.4.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, including carburized and induction hardened parts, stress relieve at 275 °F ± 25 (135 °C ± 14) for 5 to 10 hours.

3.1.4.2 For parts having a hardness less than 55 HRC, stress relieve at 375 °F ± 25 (191 °C ± 14) for a minimum of 4 hours. Nitrided parts fall into this category. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.1.4.3 For peened parts

If stress relief temperatures above 375 °F (191 °C) are elected, the stress relieve shall be performed prior to peening or the cognizant engineering organization shall be consulted and shall approve the stress relief temperature.

3.1.5 Prior to immersion in the plating solution, parts surfaces shall be chemically clean and free from water breaks, prepared with minimum abrasion, erosion, or pitting.

3.2 Procedure

3.2.1 Plating shall be performed by chemical deposition of a homogenous, high-nickel, low-phosphorus metallic compound on a catalytic or catalyzed surface from an aqueous bath containing nickel and hypophosphite ions and which bath may include a soluble compound to inhibit decomposition of the bath. The nickel-phosphorus plate shall, unless otherwise specified, be deposited directly on the basis metal without a deposit of other metal underneath except in the case of parts fabricated from corrosion-resistant steels or alloys on which a preliminary deposit of nickel or other suitable metal is permissible.

3.2.2 The plated parts shall be removed from the plating solution, thoroughly rinsed, and dried.

3.3 Post Treatment

3.3.1 Steel parts shall receive a hydrogen embrittlement relief treatment in accordance with AMS2759/9 or an alternate procedure approved by the cognizant engineering organization. Other metals and alloys do not require hydrogen embrittlement relief baking.

3.3.2 Parts requiring special handling shall be treated as agreed upon by purchaser and vendor.

3.3.3 When post plating bake is specified by the cognizant engineering organization for improved adhesion or hardening of the deposit, parts shall be heated for 30 to 60 minutes, preferably in an inert atmosphere, at 750 °F ± 15 (400 °C ± 8) except that parts made of nonheat treatable aluminum alloy shall be heated at 375 °F ± 15 (190 °C ± 8) for not less than 4 hours, and heat treatable aluminum alloys shall be heated at 250 °F ± 15 (120 °C ± 8) for not less than 4 hours.

3.4 Properties

Plating shall conform to the following requirements:

3.4.1 Composition

The phosphorus content of the deposited nickel-phosphorus alloy shall be held as low as possible and shall not exceed 8%.

3.4.2 Thickness

Shall be as specified on the drawing, determined on representative parts or test panels by micrometer method, by microscopic method in accordance with ASTM B 487, or by other method agreed upon by purchaser and vendor.

3.4.3 Adhesion

Specimens shall show no separation of plating from the basis metal, when examined at up to 6X magnification, after being bent rapidly at room temperature, in accordance with ASTM E 290, through an angle of 180 degrees around a diameter equal to the nominal thickness of the specimen. Formation of cracks which do not result in flaking or blistering of the plating is acceptable.

3.4.3.1 As a referee test, plating shall show no blisters or cracks on representative steel parts or test panels after being heated in air, preferably in a circulating-air furnace, at 700 °F ± 15 (370 °C ± 8) for 23 hours ± 1 followed by heating at 1000 °F ± 15 (540 °C ± 8) for 60 minutes ± 5.

3.4.4 Corrosion Resistance

Steel parts or representative test panels having specified minimum plating thickness of 0.001 inch (25 µm) or more, 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.

3.4.5 Hydrogen Embrittlement

The plating process after baking shall not cause hydrogen embrittlement in steel parts. The hydrogen embrittlement test shall be in accordance with ASTM F519 Type 1a.1 using round notched specimens, unless a different specimen is specified by the cognizant engineering organization, stressed in tension under sustained load. For test purposes, the plating thickness shall be 0.0005 to 0.0007 inch (13 to 18 um) measured on the smooth section of the specimen, with visual evidence of plating at the root of the notch. Testing beyond the 200 hour test period is not required.

3.5 Quality

Plated surfaces 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.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processing vendor shall supply all samples for vendor's tests and shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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 to determine conformance to requirements for thickness (3.4.2) and quality (3.5) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests

Tests to determine conformance to requirements for composition (3.4.1), adhesion (3.4.3) and corrosion resistance (3.4.4) 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 and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by the cognizant engineering organization. Hydrogen embrittlement (3.4.5) is a periodic test and shall be performed at least once in each month that steel parts 36 HRC and over are plated unless frequency of testing is specified by the cognizant engineering organization.

4.2.3 Preproduction Tests

Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the initial shipment of plated parts to a purchaser, when a change in material or processing, or both, requires reapproval as in 4.4.2, and when the cognizant engineering organization 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, the contracting officer, or the request for procurement.

4.3 Sampling

Shall be not less than the following:

4.3.1 For Acceptance Tests

4.3.1.1 Thickness

Three parts for each consecutive 8 hours of operation of the same set of solutions, except as specified in 4.3.3.

4.3.1.2 Quality

As agreed upon by purchaser and vendor.

4.3.2 For Periodic Tests and Preproduction Tests

Sampling for hydrogen embrittlement shall be as specified in ASTM F519 unless otherwise specified by the cognizant engineering organization. Sampling for other tests shall be at the discretion of the processor unless otherwise specified by the cognizant engineering organization or herein.