SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2424D

Issued 30 JUN 1962
Revised 1 JUL 1993
Superseding AMS 2424C

Submitted for recognition as an American National Standard

PLATING, NICKEL
Low-Stressed Deposit

SAENORM.COM : Click to view the full PDF of ams2424d

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for electro-deposition 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 following publications form a part of this specification to the extent specified herein. The applicable issue of referenced publications shall be the issue in effect on the date of the purchase order.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright 1993 Society of Automotive Engineers, Inc.
All rights reserved.

Printed in U.S.A.

2.1 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 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 Adhesion 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 Testing of Plating Processes and Aircraft Maintenance Chemicals

2.2 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 (R) All fabrication-type operations, such as machining, forming, welding, shot peening, roll threading, and heat treating, shall be completed before parts are plated, unless otherwise permitted by purchaser.

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

3.1.3 (R) 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.

3.1.4 (R) Parts shall have clean surfaces, free from waterbreak, prior to immersion in the plating solution. Treatments which may produce hydrogen embrittlement shall be avoided.

SAENORM.COM : Click to view the full PDF of ams2424d

3.1.5 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 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 (R) On aluminum, magnesium, beryllium, and their alloys, a preliminary chemical coating, immersion plate, or metal flash is permissible.

3.3 (R) Post Treatment:

After plating, rinsing, and drying, ferrous metal parts, except those plated in preparation for brazing, shall be baked as in 3.3.1, 3.3.2, or 3.3.3, 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 minutes, after plating.

3.3.1 Except as follows, ferrous parts, including roll-threaded parts, cold worked after being heat treated by hardening and tempering, regardless of hardness, springs, and other ferrous-metal parts having hardness of 33 HRC or higher shall be heated to 375 °F ± 15 (191 °C ± 8) and held at heat for not less than three hours.

3.3.1.1 (R) Parts having hardness of 40 HRC or higher may require heating for up to 23 hours or as specified by the cognizant engineering organization.

3.3.1.2 (R) Parts, including carburized parts,. which will decrease in hardness by heating to 375 °F (191 °C) shall be heated to 275 °F ± 15 (135 °C ± 8) and held at heat for not less than five hours.

3.3.3 (R) Parts requiring special handling shall be post treated as specified by purchaser.

3.4 (R) Properties:

The deposited nickel shall conform to the following requirements except that the requirements of 3.4.1.1, 3.4.3, 3.4.6, and 3.4.7 shall not apply to parts plated in preparation for brazing:

SAENORM.COM : Click to view the full PDF of ams2424d

3.4.1 Thickness: Shall be as specified on the drawing, or as required to finish
(R) to required thickness, determined on actual parts where feasible. Representative parts may be substituted for actual parts if necessary. Test panels may be used when that is the only means for obtaining thickness data without damaging actual parts. 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. Plating thickness determination shall be done after machining where applicable.

3.4.1.1 For surfaces that will not be machined after plating, the plate shall be
(R) 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 Unless otherwise specified on the part drawing for specific areas,
(R) thickness shall apply to surfaces of parts that can be touched by a 0.75 inch (19 mm) sphere. Surfaces that cannot be touched by a 0.75 inch (19 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. Such surfaces shall exhibit visual evidence of 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 $CuSO_4 \cdot 5H_2O$, 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. 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 Stress: Shall be within the range 5000 psi (34.5 MPa) in compression to
(R) 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:

3.4.4.1 Specimens, as in 4.3.3, shall not show separation of the plate from the
(R) 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
(R) considered acceptable evidence of plating adhesion.

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

3.4.5 Heat Resistance: Plated parts, when specified by purchaser, or
(R) 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.

SAENORM.COM : Click to view the full PDF of ams2424d

3.4.6 Corrosion Resistance: Carbon or low-alloy steel plated parts, except parts
(R) 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 Embrittlement: The nickel plating process shall not cause hydrogen
(R) embrittlement in steel parts, after baking (See 3.3),determined in accordance with 4.3.4 using separate specimens.

3.5 Quality:
(R)

Plating, as received by purchaser, shall be smooth, continuous, adherent to the basis metal. and uniform in appearance and shall be visually free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to usage of parts. Slight staining or discoloration is permissible. Visual deficiencies in plating that will be subsequently machined are acceptable if they are removed by such machining. Standards for acceptance, if required, 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:
(R)

The processing vendor shall supply 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 (3.4.4.3) when
(R) specified, and quality (3.5) are acceptance tests and shall be performed on each lot.

SAENORM.COM : Click to view the full PDF of ams2424d

4.2.2 Periodic Tests: Tests to ensure that plating parameters used will (R) result in coatings which will conform to specified requirements for hardness (3.4.2), stress (3.4.3), adhesion (3.4.4.1), heat resistance (3.4.5), corrosion resistance (3.4.6), and embrittlement (3.4.7) 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 Tests: When specified, tests for all technical requirements (R) 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.

4.2.3.1 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:
(R)

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, and presented for vendor's inspection at one time.

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

TABLE 1 - Sampling

Number of Parts in Lot	Number of Parts Visually Sampled (randomly selected)	Sampled for Thickness (3.4.1) and Adhesion (3.4.4.3)
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 and Preproduction Tests: Test frequency shall be (R) acceptable to purchaser.

SAENORM.COM : Click to view the full PDF of ams2424d

4.3.3 When plated parts are of such configuration and size as to be not adaptable
(R) 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.

4.3.4 Specimens for embrittlement relief test shall be round, notched steel
(R) 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 3.1, 3.2, and 3.3. Plating thickness shall be not less than 0.005 inch (0.13 mm) 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 procedures, a preproduction sample part, or both,
(R) 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
(R) 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:

(R)
- Activation procedure(s)
- Composition limits of the plating bath
- Plating bath temperature
- Plating current (or voltage) limits
- Frequency of plating bath composition test
- Tooling and fixturing
- Frequency of periodic testing
- Time in cleaning, activation (pickling), and plating solutions
- Stress and embrittlement relief bake oven temperatures and times
- Method used to determine plating thickness

SAENORM.COM : Click to view the full PDF of ams2424d