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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE

AMS 2441

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Submitted for recognition as an American National Standard

SELECTIVE (BRUSH) NICKEL PLATING
Low-Stressed, Low Hardness Deposit

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for selective (brush) 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 and dimensional build-up and restoration of parts, which may operate in service up to 700 °F (371 °C), and requiring low tensile stress in the deposit 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.

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 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 567 Measurement of Coating Thickness by the Beta Backscatter Method
ASTM B 568 Measurement of Coating Thickness by X-Ray Spectrometry
ASTM B 571 Adhesion of Metallic Coatings
ASTM B 578 Microhardness of Electroplated Coatings
ASTM E 92 Vickers Hardness of Metallic Materials
ASTM E 290 Semi-Guided Bend Test for Ductility of Metallic Materials

2.2 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-865 Selective (Brush Plating), Electrodeposition
MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 All forming, machining, heat treating, brazing, welding, and surface prestressing shall be completed before parts are plated, unless otherwise permitted by purchaser.

3.1.2 Surfaces of parts to be plated shall be smooth and free from blemishes, pits, tool marks, and other irregularities.

3.1.3 Steel 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 stress-relieved before plating. Temperatures to which parts are heated shall be such that maximum stress-relief is obtained without reducing hardness or parts below drawing limits.

3.1.4 Parts, prior to selective plating, shall have chemically clean surfaces prepared with minimum abrasion, erosion, or pitting. Treatments which may promote hydrogen embrittlement shall be avoided.

3.1.5 Electrical contacts between the parts and power source shall be made to ensure that neither chemical or immersion deposition nor electrical arcing or overheating will occur.

3.2 Procedure:

3.2.1 Parts shall be plated by selective (brush) 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 preplate coating of metal other than nickel.

3.2.1.1 On aluminum and aluminum alloys, a preliminary chemical coating, immersion plate, or metal preplate is permissible.

3.2.2 Equipment used to process samples, specimens, and parts shall be in accordance with MIL-STD-865.

3.2.3 Samples, specimens, and parts shall only be processed by qualified operators who have been certified by purchaser's Quality Assurance activity as holding a valid certification for the specific plating solution/basis material combination being processed. Certification shall be provided only to those trained operators who have successfully demonstrated a general knowledge of the selective plating process, a knowledge of the process requirements of this specification, and have shown their ability to process parts by successfully processing suitable specimens. As a minimum, operators shall demonstrate their ability to plate to the thickness required and provide specimens capable of meeting the hardness, stress, adhesion, heat resistance, corrosion resistance, and quality requirements. Operators shall be recertified at least annually.

3.2.4 The plate parts shall be rinsed thoroughly and dried immediately after plating.

3.3 Post Treatment:

After plating, rinsing, and drying, parts, except those plated in preparation for brazing, shall be baked 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 one hour, 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 °F ± 15 (191 °C ± 8) and held at heat for not less than three hours.

3.3.2 Parts, 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 °F ± 15 (135 °C ± 8) and held at heat for not less than five hours.

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

3.4 Properties:

The deposited nickel 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 B 487, ASTM B 504, ASTM B 530, ASTM B 567, ASTM B 568, or other method acceptable to purchaser.

3.4.1.1 The plate 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 Resultant thickness shall be considered only when such surfaces of parts can be touched by a sphere 0.75 inch (19 mm) in diameter.

3.4.2 Hardness: Shall be not higher than 300 HV, or equivalent, determined in accordance with ASTM B 578 or ASTM E 92 on deposits 0.005 inch (0.13 mm) and over in thickness (See 8.1).

3.4.3 Stress: Shall be within the range 5000 psi (34.5 MPa) in compression to 15,000 psi (103 MPa) in tension, determined on specimens having plate thickness of 0.0003 inch (7.6 µm) or greater. Stress shall be calculated by a method or instrument acceptable to purchaser.

3.4.4 Adhesion: Specimens as in 4.3.1 shall show no separation of the plating from the basis metal, when examined at approximately 4X 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, peeling, or blistering of the plating is acceptable.

3.4.5 Heat Resistance: Plated ferrous and corrosion-resistant parts or representative test panels shall withstand, without blistering or cracking, being heated in air, preferably in a circulating-air furnace, to 700 °F ± 15 (371 °C ± 8) and held at heat for not less than 23 hours, followed by heating to 1000 °F ± 15 (538 °C ± 8) and holding at heat for not less than 60 minutes. Plated aluminum and aluminum alloy parts, copper or copper alloy parts or their respective representative test panels shall meet the heat-quench test requirements of ASTM B 571.

3.4.6 Corrosion Resistance: 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 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 over, 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, if required, as in 3.3.

3.4.6.2 When specified minimum plate thickness is 0.0005 to 0.002 inch (0.013 to 0.05 mm), exclusive, parts or panels shall withstand the test only after the heat resistance test of 3.4.5 following embrittlement relief, if required, as in 3.3.

3.5 Quality

Plating, as received by purchaser, shall be smooth, continuous, adherent to the basis metal, uniform in appearance, and not coarsely crystalline and shall be essentially free from pinholes, porosity, blisters, nodules, pits, and other imperfections detrimental to performance of the plating. Slight staining or discoloration is permissible.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The plating vendor shall be responsible for performing all required tests. Representative test panels 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: Tests for thickness (3.4.1) and quality (3.5) are acceptance tests and shall be performed to represent each lot.

4.2.2 Periodic Tests: Tests for hardness (3.4.2), stress (3.4.3), adhesion (3.4.4), heat resistance (3.4.5), and corrosion resistance (3.4.6) and tests of preparatory and plating solutions to ensure that the deposited metal will conform to the requirements of this specification 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: 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 processing requires reapproval 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:

Shall be as agreed upon by purchaser and vendor.

4.3.1 When plated parts are of such configuration and size not readily adaptable to the specified test, separate specimens prepared, plated, and post-treated with the parts represented may be used. Specimens shall be provided by purchaser and shall be representative samples of the basis material being plated. Specimens shall be plated as necessary to produce the plate thickness required for hardness, stress, and corrosion resistance tests. For hardness and adhesion tests, specimens shall be panels, approximately 0.032 x 1 x 4 inches (0.81 x 25 x 102 mm). For thickness and quality tests, panels of the same size or bars or tubes approximately 1 inch (25 mm) in diameter and 4 inches (102 mm) long shall be used. For 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 3 inches (76 mm) wide by 4 inches (102 mm) long.

4.4 Approval:

4.4.1 Sample plated parts and, when specified, plating and masking fixtures and procedures shall be approved by purchaser before parts for production use are supplied, unless such approval be waived by purchaser. 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 necessary to make any change in type of equipment, fixturing, or in established operating conditions or process solutions, vendor shall submit for reapproval a statement of the proposed changes in processing and, when requested, sample plated parts and/or test panels. Production parts plated by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Reports:

The vendor of plated parts shall furnish with each shipment a report stating that the parts have been processed and tested in accordance with this specification and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS 2441, part number, and quantity.

4.6 Resampling and Retesting:

If any specimen used in the above tests fails to meet the specified requirements, disposition of the parts may be based on the results of testing three additional specimens for each original nonconforming specimen. Except as permitted in 4.6.1, failure of any retest specimen to meet the specified requirement shall be cause for rejection of the parts represented. Results of all tests shall be reported.

4.6.1 If any part fails to meet the specified requirements, either on the original sampling as in 4.3 or upon resampling as in 4.6, the plating may be removed by stripping or other method acceptable to purchaser which does not roughen, pit, or embrittle the basis metal, replated, post treated, and retested.

5. PREPARATION FOR DELIVERY:

5.1 Parts shall be handled and packaged to ensure that the required physical characteristics and properties of the plating are preserved.

5.2 Packages of plated parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the plated parts to ensure carrier acceptance and safe delivery.

5.3 For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-2073-1, Commercial Level, unless Level A is specified in the request for procurement.

6. ACKNOWLEDGMENT:

A vendor shall mention this specification number in all quotations and when acknowledging purchase orders.

7. REJECTIONS:

Parts on which plating does not conform to this specification, or to modifications authorized by purchaser, will be subject to rejection.

8. NOTES:

8.1 Hardness conversion tables for metals are presented in ASTM E 140.

8.2 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as the aporoximate equivalents of the primary units and are presented only for information.

8.3 For direct U.S. Military procurement, purchase documents should specify not less than the following:

Title, number, and date of this specification
Plate thickness desired
Quantity of pieces to be plated
Level A packaging, if required (See 5.3).

8.4 Plating meeting the requirements of this specification has been classified under Federal Standardization Area Symbol "MFFP".