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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-2416 REV G

Issued 1955-08-15
Revised 1990-10-01

Submitted for recognition as an American National Standard

Superseding AMS-2416F

NICKEL-CADMIUM PLATING
Diffused

1. SCOPE:

1.1 Purpose: This specification covers the engineering requirements for a diffused electrodeposit of cadmium into an electrodeposit of nickel on carbon, low-alloy, and corrosion-resistant steels and the properties of the diffused deposit.

1.2 Application: Primarily to prevent corrosion of carbon, low-alloy, and corrosion resistant steel parts which may operate in service up to 900°F (482°C). This process is not suitable for use on parts of complex shape where minimum nickel plate thickness requirements cannot be met and on parts whose hardness or strength would be reduced below drawing or specification requirements by heating to 640°F (338°C).

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.

1.3.1 Numerous scientific studies have determined that cadmium and hexavalent chromium present a health hazard to persons exposed to them.

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 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

2.2 U.S. Government Publications: Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.2.1 Military Standards:

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

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

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

3.1.2 Parts shall be within drawing dimension limits after plating.

3.1.3 Parts having hardness higher than 40 HRC, or equivalent, and which have been ground after heat treatment 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 Residual compressive stress-inducing operations, such as shot peening, if used, shall follow stress-relieving.

3.1.5 Parts shall have chemically clean surfaces, prepared with minimum abrasion, erosion, or pitting, prior to immersion in the plating solution.

3.1.5.1 Parts having hardness of 33 HRC or higher and parts roll threaded after heat treatment shall not be cleaned with inorganic acids such as hydrochloric or sulfuric, unless approved by purchaser. Cleaning of other parts with inorganic acids is not prohibited but permission to use such method on a particular part shall first be obtained from purchaser. In either case, a momentary dip in acid after alkaline cleaning is permissible.

3.1.6 Electrical contacts between the parts and power source shall be made in such a 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 Nickel Plating: Nickel shall be electrodeposited from a sulfamate Ø solution containing no addition agents which might have a detrimental effect on the properties of the plate or the basis metal; stress-reducing agents shall not be used unless authorized by purchaser. Other nickel plating solutions may be used when permitted by purchaser. The nickel shall be deposited directly on the basis metal without a preliminary strike or flash coating, except that on corrosion resistant steels or similarly passive materials a nickel strike is permissible.

3.2.1.1 After being nickel plated, parts shall be thoroughly rinsed, neutralized in alkaline solution, rinsed, and transferred directly to the cadmium plating solution. Parts to be used for determining thickness of the nickel plate shall be rinsed after neutralization in alkaline solution and dried. Parts shall be reactivated and cadmium plated as soon as possible after determination of nickel plate thickness.

3.2.1.2 Specimens to be used for determining stress in the nickel plate shall be processed in the same manner as specified for parts to be used for determining nickel plate thickness.

3.2.2 Cadmium Plating: Cadmium shall be electrodeposited from a cadmium cyanide, cadmium fluoborate, cadmium sulfamate, cadmium sulfate, or cadmium-sulfate-fluoborate solution. The cadmium shall be deposited directly on the nickel plate. Extreme care shall be exercised to avoid deposition of cadmium on any area not previously covered by nickel. Parts shall be thoroughly rinsed after plating to desired plate thickness.

3.2.3 Chromate Treatment: After rinsing following cadmium plating and without drying, parts may be treated by an approved chromate process which will prevent fingerprinting and staining. Parts shall then be thoroughly rinsed and dried. Parts which are not chromate treated shall be marked with a suitable dye which will change color during the diffusion treatment.

3.2.4 Diffusion Treatment: Parts, after chromate treatment or dyeing, shall be heated in air, preferably in a circulating-air furnace, to 630°F ± 10 (332°C ± 6), held at heat for not less than 30 minutes, and cooled in air.

3.3 Properties: The diffused nickel-cadmium shall conform to the following requirements:

3.3.1 Thickness:

3.3.1.1 Nickel Plate: Shall, except as specified in 3.3.1.1.1, be 0.0002 - 0.0004 inch (5 - 10 µm) thick on significant surfaces of parts and not less than 0.00005 inch (1.27 µm) thick on surfaces of parts on which a controlled deposit cannot be maintained, such as holes, grooves, recesses, etc; nickel plate thickness greater than 0.0004 inch (10 µm) will be permissible in high current density areas. Uncontrolled plate thickness areas are defined as those areas which cannot be touched by a 0.75-inch (19-mm) diameter sphere. Thickness of nickel plate shall be determined, prior to cadmium plating, in accordance with ASTM B 487, ASTM B 499, ASTM B 504, or other method acceptable to purchaser on representative parts, or on test panels processed and plated simultaneously with the parts or separately but in a similar manner.

3.3.1.1.1 If nickel plate thickness greater than 0.0002 - 0.0004 inch (5 - 10 µm) is desired, such thickness may be specified by this specification number followed by a dash and a number indicating the minimum nickel plate thickness in ten-thousandths of an inch; a tolerance of +0.0002 inch (5 µm) will be permitted when the minimum thickness is 0.0003 inch (7.6 µm) and +0.0003 inch (7.6 µm) will be permitted when the minimum thickness is 0.0004 inch (10 µm) or more. Thus, AMS-2416-3 indicates nickel plate thickness of 0.0003 - 0.0005 inch (7.5 - 12.5 µm) and AMS-2416-5 indicates nickel plate thickness of 0.0005 - 0.0008 inch (12.7 - 20 µm).

3.3.1.2 Cadmium Plate: Shall be 0.0001 - 0.0003 inch (2.5 - 7.6 µm) thick. Routine determination of cadmium plate thickness is not required; the process of plating, however, shall be controlled to produce the specified thickness.

3.3.2 Heat Resistance: Representative parts or specimens as in 4.3.3 shall show no cracks or blisters in the plate after being heated in air, preferably in a circulating-air furnace, as specified in 3.3.2.1 and 3.3.2.2. The presence of weakly adhering products are acceptable. Only the test of 3.3.2.1 is required for routine inspection.

3.3.2.1 Heat to 700°F ± 10 (371°C ± 6), hold at heat for 23 hours ± 0.5, transfer without intentional cooling to a furnace at 1000°F ± 10 (538°C ± 6), hold at heat for 60 minutes ± 5, and cool to room temperature.

3.3.2.2 Heat to 700°F ± 10 (371°C ± 6), hold at heat for 2 hours ± 0.25, transfer without intentional cooling to a furnace at 1000°F ± 10 (538°C ± 6), hold at heat for 2 hours ± 0.25, and cool to room temperature.

3.3.3 Corrosion Resistance: Representative parts or specimens as in 4.3.3 shall show no visual evidence of corrosion of the basis metal after being subjected for not less than 96 hours to continuous salt spray corrosion test conducted in accordance with ASTM B 117. This requirement applies to parts or specimens both after diffusion heating as in 3.2.4 and after heat resistance test of 3.3.2.1.

3.3.4 Nickel Plate Stress: Shall be in the range of 5000 psi (34 MPa) in compression to 15,000 psi (103 MPa) in tension, determined on specimens having nickel plate thickness of 0.0003 inch (7.6 µm) or greater; stress shall be calculated from spiral contractometer reading (Ref. 35th Annual Proceedings, American Electroplaters Society, p. 53 - 89) or other instrument acceptable to purchaser.

3.4 Quality:

3.4.1 Nickel Plate: Shall be firmly and continuously bonded to the basis metal and shall be smooth, uniform in appearance on areas of equivalent hardness and surface finish, and free from frosty areas, pin holes, nodules, blisters, and other imperfections detrimental to performance of the plate. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4.2 Cadmium Plate: Shall be firmly and continuously bonded to the nickel plate and shall be uniform in appearance and free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to performance of the plate. Standards for acceptance shall be as agreed upon by purchaser and vendor.

3.4.3 Diffused Nickel-Cadmium Plate: Shall have a smooth dull matte finish, shall be free from balling when examined under magnification up to 10X, and shall be smooth to the touch. Color of chromate treated parts may vary from olive drab through gray to black. Color need not be uniform on any one part but mottled, blotched, or sharply streaked areas are not acceptable. Color of dye marking shall be characteristic of the dye used.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: The processing vendor shall supply all Ø 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 (3.3.1) and quality (3.4) are acceptance tests and shall be performed to represent each consecutive 24 hours of operation of the same set of solutions.

4.2.2 Periodic Tests: Tests for heat resistance (3.3.2), corrosion resistance (3.3.3), and nickel plate stress (3.3.4) and tests of cleaning 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 of this specification 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 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 not less than the following: a lot shall be Ø all parts of the same part number plated to the same specified thickness range, processed in a continuous operation or within a 24-hour period, and presented for vendor's inspection at one time:

4.3.1 For Acceptance Tests:

4.3.1.1 Thickness: Three parts for each consecutive 24 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: As agreed upon by purchaser and vendor.

4.3.3 When plated parts are of such configuration or size as to be not readily Ø adaptable to the specified tests, separate test specimens cleaned, plated, and diffused with the parts represented may be used. For the thickness and quality tests such specimens shall be annealed carbon or low-alloy steel panels 0.032 x 4 x 1 inch (0.81 x 102 x 25 mm) or bars approximately 0.5 inch (13 mm) in diameter and 4 inches (102 mm) long. For corrosion and heat resistance tests, specimens shall be annealed carbon or low-alloy steel panels 0.062 - 0.125 inch (1.57 - 3.18 mm) in nominal thickness and not less than 4 inches (102 mm) by 3 inches (76 mm) wide.

4.4 Approval:

4.4.1 Plated parts and, when specified, plating fixtures 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 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 and/or test panels. Production parts plated by the revised procedure shall not be shipped prior to receipt of reapproval.