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400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE MATERIAL SPECIFICATION

AMS 2416F
Superseding AMS 2416E

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NICKEL-CADMIUM PLATING
Diffused

1. SCOPE:

1.1 Purpose: This specification covers the engineering requirements for a diffused electrodeposit of cadmium onto 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 (480°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 (340°C).

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 SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

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 Thickness of Metallic Coatings by the Coulometric Method

2.3 U.S. 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 forming, machining, heat treating, brazing, and welding shall be ø completed before parts are plated.

3.1.2 Parts shall be within drawing dimension limits after plating, unless ø otherwise specified.

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 ø 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 ø 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 dip in acid after alkaline cleaning is permissible.

3.1.6 Electrical contacts between the parts and power source shall be made in Ø 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.

3.2.1.1 After being nickel plated, parts shall be thoroughly rinsed, neutralized in alkaline solution, 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 Ø 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 (330°C ± 5), held at heat for not less than 30 min., 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 in. (5 - 10 µm) thick on significant surfaces of parts and not less than 0.00005 in. (1.25 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 in. (10 µm) will be permissible in high current density areas. Unless otherwise specified, uncontrolled plate thickness areas are defined as those areas which cannot be touched by a 0.75-in. (19-mm) diameter sphere. Thickness of nickel plate shall be determined, prior to cadmium plating, in accordance with ASTM B487, ASTM B499, ASTM B504, or other suitable method agreed upon by purchaser and vendor 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 in. (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 in. (5 µm) will be permitted when the minimum thickness is 0.0003 in. (7.5 µm) and +0.0003 in. (7.5 µm) will be permitted when the minimum thickness is 0.0004 in. (10 µm) or more. Thus, AMS 2416-3 indicates nickel plate thickness of 0.0003 - 0.0005 in. (7.5 - 12.5 µm) and AMS 2416-5 indicates nickel plate thickness of 0.0005 - 0.0008 in. (12.5 - 20 µm).

3.3.1.2 Cadmium Plate: Shall be approximately 0.0001 - 0.0003 in. (2.5 - 7.5 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 (370°C ± 5), hold at heat for 23 hr ± 0.5, transfer without intentional cooling to a furnace at 1000°F ± 10 (540°C ± 5), hold at heat for 60 min. ± 5, and cool to room temperature.

3.3.2.2 Heat to 700°F + 10 (370°C ± 5), hold at heat for 2 hr ± 0.25, transfer without intentional cooling to a furnace at 1000°F + 10 (540°C ± 5), hold at heat for 2 hr ± 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 on significant surfaces and no appreciable corrosion of the basis metal after being subjected for not less than 96 hr to continuous salt spray corrosion test conducted in accordance with ASTM B117. 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 5000 psi (34 MPa) in compression to 15,000 psi (105 MPa) in tension, determined on specimens having nickel plate thickness of 0.0003 in. (7.5 µm) or greater; stress shall be calculated from spiral contractometer reading (Ref. 35th Annual Proceedings, American Electroplaters Society, p. 53 - 89) or other instrument agreed upon by purchaser and vendor.

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 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 (3.3.1), and quality (3.4) are classified as acceptance tests and shall be performed to represent each consecutive 24 hr of operation of the same set of solutions.

4.2.2 Periodic Tests: Tests to determine conformance to requirements 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 classified as 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 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 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, the contracting officer, or the request for procurement.

4.3 Sampling: Shall be not less than the following; a lot shall be all parts of the same part number plated to the same specified thickness range, processed in a continuous operation or within a 24-hr 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 hr 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 adaptable to the specified tests, separate test specimens cleaned, plated, and diffused with the parts represented may be used. For adhesion tests, such specimens shall be panels of annealed, low-carbon steel approximately 0.032 x 4 x 1 in. (1 x 100 x 25 mm) and for thickness and quality tests shall be panels of the same size and type or shall be bars approximately 0.5 in. (10 mm) in diameter and 4 in. (100 mm) long. For corrosion and heat resistance tests, specimens shall be panels 0.062 - 0.125 in. (1.5 - 3 mm) in nominal thickness and not less than 4 in. (100 mm) long by 3 in. (75 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 Ø 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, test panels, or both. 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 three copies of a report stating that the parts have been processed and tested in accordance with the requirements of this specification and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS 2416F, part number, and quantity.

4.6 Ø 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 parts or specimens for each original nonconforming part or specimen. Except as specified in 4.6.1, failure of any retest part or specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. 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 parts in that lot may be stripped by a method approved by purchaser which does not roughen, pit, or embrittle the basis metal, replated, diffused, and retested.

5. PREPARATION FOR DELIVERY:

5.1 Ø Parts shall be handled and packaged in such a manner as will ensure that the required physical characteristics and properties of the plating are preserved.

5.2 Ø Packages of 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. Packaging shall conform to carrier rules and regulations applicable to the mode of transportation.

5.3 Ø For direct U.S. Military procurement, packaging shall be in accordance with MIL-STD-794, Level A or Level C, as specified in the request for procurement. Commercial packaging as in 5.1 and 5.2 will be acceptable if it meets the requirements of Level C.

6. ACKNOWLEDGMENT: A vendor shall mention this specification number and its revision letter in all quotations and when acknowledging purchase orders.