

AEROSPACE MATERIAL SPECIFICATION

Submitted for recognition as an American National Standard



AMS 2411E

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Superseding AMS 2411D

(R)

Plating, Silver for High Temperature Applications

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for silver deposited on metal parts with a nickel strike between the basis metal and the silver deposit.

1.2 Application:

This process has been used typically to prevent galling or seizing of surfaces of parts, such as fasteners, made of low-alloy steel, corrosion and heat resistant steel, and nickel alloys for use up to 1400 °F (760 °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.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of referenced documents shall be the issue in effect on the date of the purchase order.

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2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

- AMS 2759/9 Hydrogen Embrittlement Relief (Baking) of Steel Parts
 AMS 5616 Steel, Corrosion and Heat Resistant, Bars, Wire, Forgings, Tubing and Rings, 13Cr - 2.0Ni - 3.0W, Annealed
 AMS 5640 Steel, Corrosion Resistant, Bars, Wire, and Forgings, 18Cr - 9.0Ni (SAE 30303, 30303Se, 30303Mod), Free Machining
 AMS 5643 Steel, Corrosion Resistant, Bars, Wire, Forgings, Tubing, and Rings, 16Cr - 4.0Ni - 0.30 (Cb + Ta) - 4.0Cu, Solution Heat Treated, Precipitation Hardenable
 AMS 5709 Nickel Alloy, Corrosion and Heat Resistant, Bars and Forgings, 58Ni - 19.5Cr - 13.5Co - 4.3Mo - 3.0Ti - 1.4Al, Consumable Electrode or Vacuum Induction Melted, 1975 °F (1080 °C) Solution, Stabilization, and Precipitation Heat Treated
 AMS 5732 Steel, Corrosion and Heat Resistant, Bars, Forgings, Tubing, and Rings, 15Cr - 25.5Ni - 1.3Mo - 2.1Ti - 0.006B - 0.30V, Consumable Electrode Melted, 1800 °F (980 °C) Solution and Precipitation Heat Treated
 AMS 6304 Steel, Low Alloy, Heat Resistant, Bars, Forgings, and Tubing, 0.95Cr - 0.55Mo - 0.30V (0.40 - 0.50C)

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 15248-2959.

- 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 the Thickness of Metallic Coatings by the Coulometric Method
 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 E 376 Measuring 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

2.3 ANSI Publications:

Available from American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

- ASME B46.1 Surface Texture

3. TECHNICAL REQUIREMENTS:

3.1 Preparation:

3.1.1 Surface texture of surfaces to be plated other than that of nuts shall be 80 microinches (2 μm) Ra or smoother determined in accordance with ASME B46.1.

3.1.2 Except for barrel plating, electrical contact points shall be as follows: for parts which are to be plated all over, locations shall be acceptable to purchaser; for parts which are not to be plated all over, locations shall be in areas on which plating is not required or other location acceptable to purchaser.

3.2 Procedure:

3.2.1 Silver shall be plated over a preliminary plating of nickel 0.0005 inch (13 μm) maximum.

3.2.1.1 When approved by purchaser, a substitute for the nickel strike is permitted.

3.2.2 Double plating and spotting in are prohibited.

3.3 Post Treatment:

3.3.1 Hydrogen embrittlement relief treatment of steel parts shall be in accordance with AMS 2759/9.

3.4 Properties:

Plated parts shall conform to the following requirements:

3.4.1 Thickness of the deposit shall be as specified on the drawing, determined in accordance with ASTM B 487, ASTM B 499, ASTM B 504, ASTM B 567, ASTM B 568, ASTM E 376, or other method acceptable to purchaser (See 8.6).

3.4.1.1 Where silver flash is specified, plate thickness shall be approximately 0.0001 inch (2.5 μm).

3.4.2 Composition of the deposit shall be not less than 99.9% silver determined by a method acceptable to the purchaser.

3.4.3 Adhesion: The deposit shall firmly adhere to the basis metal.

3.4.3.1 Parts or test panels to be adhesion tested shall be heated in an air atmosphere to the following applicable temperature, held at heat within ± 15 °F (± 8 °C) for not less than two hours, and cooled in still air.

WARNING: The following are destructive tests and parts so tested are not acceptable for shipment.

- 3.4.3.1.1 Parts or test panels made of low-alloy steels, such as AMS 6304, and martensitic or precipitation-hardenable corrosion resistant steels, such as AMS 5616 or AMS 5643, shall be heated at 900 °F (482 °C).
- 3.4.3.1.2 Parts or test panels made of austenitic corrosion-resistant steels, such as AMS 5640, and precipitation-hardenable, corrosion and heat resistant steels, such as AMS 5732, shall be heated at 1200 °F (648 °C).
- 3.4.3.1.3 Parts or test panels made of precipitation-hardenable, corrosion and heat resistant nickel alloys, such as AMS 5709, shall be heated at 1400 °F (760 °C).
- 3.4.3.1.4 Parts or test panels made of materials of a type not listed in 3.4.3.1.1 through 3.4.3.1.3 shall be heated at the temperature specified on the drawing or as directed by the cognizant engineering organization.
- 3.4.3.2 After heating as in 3.4.3.1, parts or test panels shall be examined at 10X magnification. Parts shall be free of blisters and of indications of poor bond such as flaking and lifting of the plating. Small blisters are acceptable provided the parts meet the adherence requirements of 3.4.3.3. Blisters 0.015 inch (0.38 mm) and larger in diameter, measured under 10X magnification are not acceptable.
- 3.4.3.3 After visual examination as in 3.4.3.2, parts or test panels, shall be shear or chisel tested in accordance with ASTM B 571. There shall be no signs of peeling of the plating from the underlying metal except where the chiseling or whittling action cuts through blisters permitted by 3.4.3.2. If parts show lifting and/or peeling, or both, of the plating except where the cutting is through blisters, all parts of the lot represented shall be rejected unless there is indication of shearing or cutting effect on the plating adjacent to the area from which blisters have been removed.
- 3.4.4 Hydrogen Embrittlement: When steel parts 40 HRC or higher are plated, the plating process shall not cause hydrogen embrittlement after baking, determined in accordance with ASTM F 519 and 4.3.3.2.
- 3.5 Quality:
- 3.5.1 Plating, as received by purchaser, shall be smooth, continuous, adherent to basis metal, uniform in appearance and visually free from pin holes, blisters, nodules, pits, and other imperfections detrimental to usage of the parts. Slight staining or discoloration is permissible. There shall be no evidence of electrical arcing or local overheating. There shall be no evidence of spotting-in or double plating.
- 3.5.2 Abrasion of plating on corners and edges of threaded fasteners is acceptable but plate shall be continuous on threads. Marking of the cone section of self-locking nuts, produced in offsetting the locking beams or other deformation, is acceptable.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The processor shall supply all samples for processor's tests and shall be responsible for performance of all required tests. When parts are required for tests, such parts 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: Thickness (3.4.1), adhesion (3.4.3), and quality (3.5) are acceptance tests and shall be performed on parts, or samples representing parts when permitted, from each lot.

4.2.2 Periodic Tests: Composition (3.4.2), hydrogen embrittlement (3.4.4), and tests of cleaning and plating solutions (See 8.4) are periodic tests and shall be performed at a frequency selected by the processor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: All technical requirements are preproduction tests and shall be performed prior to production, when a significant change in ingredients and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.3 Sampling for testing 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 thicknesses in the same set of solutions in each consecutive 24 hours of operation, and presented for processor's inspection at one time.

4.3.1 Acceptance Tests: Test samples shall be randomly selected from all parts in the lot. The minimum number of samples shall be as shown in Table 1.

TABLE 1 - Sampling for Acceptance Tests

Number of Parts in Lot		Quality	Thickness and Adhesion
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
501 to	700	50	8
701 to	1200	75	10
Over	1200	125	15

- 4.3.2 Sample quantities for periodic tests and preproduction tests shall be selected at the discretion of the processor, unless otherwise specified.
- 4.3.3 Sample Configuration:
- 4.3.3.1 When plated parts are of such configuration or size as to be not readily adaptable to the specified tests, separate test specimens cleaned and plated with the parts represented may be used. For adhesion tests, such specimens shall be panels fabricated from a material generically similar to the parts being plated approximately 0.032 x 1 x 4 inch (1 x 25 x 102 mm) and for thickness tests shall be panels of annealed, low carbon steel approximately 0.032 x 1 x 4 inches (1 x 25 x 102 mm).
- 4.3.3.2 Hydrogen Embrittlement Relief Test: Test specimens shall conform to ASTM F 519 Type 1a plating shall not be less than 0.002 inch \pm 0.0002 (51 μ m \pm 5) thick on the unnotched surfaces with visual evidence of plating in the root of the notch. Specimens shall be stressed in tension under constant load.
- 4.4 Approval:
- 4.4.1 The process and control factors and/or a preproduction part, whichever is specified, shall be approved by the cognizant engineering organization before production parts are supplied.
- 4.4.2 The processor shall make no significant change to materials, processes, or control factors from those on which the approval was based, unless the change is approved by the cognizant engineering organization. A significant change is one which in the judgement of the cognizant engineering organization could affect the properties or performance of the parts.
- 4.4.3 Control factors shall include, but not be limited to, the following:
- Surface preparation and cleaning method
 - Plating bath composition and composition control limits
 - Plating bath temperature limits and controls
 - Thermal post treatment times and temperatures
 - Method for determining plating thickness
 - Stripping procedure, when applicable
 - Periodic test plan (See 8.4).
- 4.5 Reports:
- The processor of plated parts shall furnish with each shipment a report stating that the parts have been processed and tested in accordance with the specified requirements and that they conform to the acceptance test requirements. This report shall include the purchase order number, AMS 2411E, part number, and quantity.