AEROSPACE MATERIAL SPECIFICATION

AMS2428™	REV. A
Issued 2017-07 Revised 2021-12 Superseding AMS2428	

Plating, Cobalt-Phosphorus, Nanocrystalline

RATIONALE

AMS2428A is the result of a Five-Year Review and update of this specification with changes to ordering information corresponding to changes in technical requirements, changed stress relief treatment (3.1.1.1.3) to standard wording of when "specified" instead when "selected," revised fixture/electrical contact locations (3.1.3, 4.4.3) per GAB19AB, changed adhesion (3.4.3.2) to add make it applicable only when the processor is responsible for machining, deleted contact locations from quality (3.5) as this is now covered elsewhere, added that "special specimens" are to be provided by purchaser as that is the intent, revised adhesion (4.2.1, 4.2.2, Table 1, 4.3.2, 4.3.3.5) per GAB14AA, and revised definition of lot in sampling for tests (4.3) per GAB16AA.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the plating processor by the purchaser:

1. Purchase order shall specify not less than the following:

- AMS2428A
- Plating thickness desired (see 3.4.1)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal
- If preplate stress relief to be performed by plating processor and if different from 3.1.1, time and temperature are to be specified
- If steel parts were machined, ground, cold formed or cold straightened after heat treat (3.1.1)
- If steel parts have been shot peened, specify if required stress relief has been completed (3.1.1.1.3)
- Optional: Fixture/Electrical contact locations, when not specified (3.1.3)
- Special features, geometry or processing present on parts that requires special attention by the plating processor
- Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.3
- Minimum thickness on internal surfaces, if required (see 3.4.1.1)
- Quantity of pieces to be plated

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS2428A

2. Parts manufacturing operations such as heat treating, forming, joining and media finishing can affect the condition of the substrate for plating, or if performed after plating, could adversely affect the plated part. The sequencing of these types of operations should be specified by the cognizant engineering organization or purchaser and is not controlled by this specification, except as noted herein.

1. SCOPE

1.1 Purpose

This specification covers the requirements for electrodeposited nanocrystalline cobalt-phosphorus plating.

1.2 Application

This plating is typically used on parts for increasing corrosion resistance, increasing wear resistance and reconditioning worn or undersized parts, 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 that 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 issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2453 Low Stress Grinding of Steel Parts Heat Treated to 180 ksi or Over, and Low Stress Grinding of Chrome Plating Applied to Steel Parts Heat Treated to 180 ksi or Over

AMS2750 Pyrometry

AMS2759/9 Hydrogen Embrittlement Relief (Baking) of Steel Parts

ARP4992 Periodic Test for Processing Solutions

ARP1917 Clarification of Terms Used in Aerospace Metals Specifications

AS2390 Chemical Process Test Specimen Material

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B117 Operating Salt Spray (Fog) Apparatus

ASTM B242 Preparation of High-Carbon Steel for Electroplating

ASTM B253 Preparation of Aluminum Alloys for Electroplating

ASTM B322 Cleaning Metals Prior to Electroplating

ASTM B374 Standard Terminology Relating to Electroplating

ASTM B487 Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of Cross Section

ASTM B504 Measurement of Thickness of Metallic Coatings by the Coulometric Method

ASTM B568 Measurement of Coating Thickness by X-Ray Spectrometry

ASTM B571 Qualitative Adhesion Testing of Metallic Coatings

ASTM B578 Microhardness of Electroplated Coatings

ASTM B748 Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope

ASTM F519 Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Stress Relief Treatment

3.1.1.1 All steel parts having a hardness of 40 HRC and above and that are machined, ground, cold formed, or cold straightened after heat treatment shall be cleaned to remove surface contamination and thermally stress relieved before plating. (Residual tensile stresses have been found to be damaging during electrofinishing.) Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5, with Type D instrumentation. Temperatures to which parts are heated shall be such that stress relief is obtained while still maintaining hardness of parts within drawing limits. Unless otherwise specified, the following treatment temperatures and times shall be used:

3.1.1.1.1 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at 275 °F ± 25 °F (135 °C ± 14 °C) for 5 to 10 hours.

3.1.1.1.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at 375 °F ± 25 °F (191 °C ± 13 °C) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.1.1.1.3 For peened parts, if stress relief temperatures above 375 °F (191 °C) are specified, the stress relieve shall be performed prior to peening.

3.1.2 Cleanliness

Parts shall have clean surfaces, free of water break, prior to immersion in the plating solution. The cleaning procedure shall not produce pitting or intergranular attack of the basis metal and shall preserve dimensional requirements. Mechanical surface preparation, such as a dry or wet abrasive blast, if employed, shall be completed prior to application of a nickel strike, when used, and shall be accomplished in a manner that will not affect the appearance or quality of the finished part. Metal parts may be cleaned in accordance with ASTM B242, ASTM B253, or ASTM B322.

3.1.3 Fixture/Electrical Contact Locations

3.1.3.1 Except for barrel plating, for parts that are to be electroplated/coated all over, and contact locations are not specified, contact locations shall be at the discretion of the processor.

3.1.3.2 For parts that are not to be electroplated/coated all over, and contact locations are not specified, contact locations shall be in areas on which plate/coating is not required.

3.2 Procedure

3.2.1 Parts shall be plated by electrodeposition of a cobalt-phosphorus alloy plating onto a properly prepared surface.

3.2.1.1 On magnesium, aluminum, and corrosion-resistant steels or similarly passive materials, a preliminary chemical coating, immersion plate, or metal flash acceptable to the cognizant engineering organization is permissible.

3.3 Hydrogen Embrittlement Relief

Treatment of steel parts shall be in accordance with AMS2759/9.

3.4 Properties

3.4.1 Thickness

If not specified, the minimum thickness shall be 0.002 inch (51 µm) determined in accordance with ASTM B487, ASTM B504, ASTM B568, ASTM B748 or other method acceptable to purchaser.

3.4.1.1 All surfaces of the part, except those which cannot be touched by a sphere 0.75 inch (19 mm) in diameter, shall be plated to the specified thickness. Unless otherwise specified, surfaces such as holes, recesses, threads, and other areas where a controlled deposit cannot be obtained under normal plating conditions, may be under the specified limit provided they show visual plating coverage. The plate shall be substantially uniform in thickness on significant surfaces except that build-up at exterior corners or edges shall be permitted provided finished drawing dimensions are met.

3.4.1.2 For surfaces that will not be machined after plating, the plate shall be substantially uniform in thickness on significant surfaces except that slight buildup on exterior corners or edges will be permitted provided finished drawing dimensions are met.

3.4.1.3 For selective plating, specific areas to be plated shall be as specified on the engineering drawing.

3.4.1.3.1 The engineering drawing shall specify if any internal surfaces are required to be plated to a thickness requirement.

3.4.2 Hardness

Hardness shall be not lower than 510 HV100, or equivalent, determined in accordance with ASTM B578. For parts with deposits less than 0.002 inch (51 µm) in thickness, separate specimens may be utilized with cobalt-phosphorus plating sufficiently thick to allow valid microhardness tests to be performed.

3.4.3 Adhesion

Shall conform to one of the following:

3.4.3.1 Adhesion shall meet the requirements of ASTM B571 bend test method with the specimen bent repeatedly back and forth through an angle of 180 degrees until failure of the basis metal occurs. Examine the region at low magnification for separation, for example, 10X, for separation or peeling of the coating. Formation of crack that do not result in flaking or blistering of the plate is acceptable.

3.4.3.2 If the processor is responsible for finish machining, adhesion of plating after finish machining of the plating will be considered acceptable evidence of plating adhesion.

3.4.3.3 There shall be no blisters or other evidence of poor adhesion when parts are subjected to the heat-quench test of ASTM B571.

3.4.4 Corrosion Resistance

Carbon and low-alloy steel parts when required by cognizant engineering organization, or test specimen, shall show no visual evidence of corrosion after being subjected for not less than 200 hours to a continuous salt spray corrosion test conducted in accordance with ASTM B117.

3.4.5 Hydrogen Embrittlement

The plating process after baking shall not cause embrittlement in steel parts 36 HRC and over, determined in accordance with 4.3.3.4.

3.5 Quality

The deposits shall be smooth, adherent, and free from visible blisters, pits, porosity, cracks, and other defects. The plating shall show no indication of contamination or improper operation of equipment used to produce the deposit, such as excessively powdered or darkened plating, build-up, and other defects. The size and number of contact marks shall be at a minimum, consistent with good practice. Superficial staining, which has been demonstrated as resulting from rinsing, or slight discoloration resulting from baking operations to relieve hydrogen embrittlement, as specified above (see 3.3), shall not be cause for rejection. All details of workmanship shall conform to the best practice for high quality plating.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all specimens for processor tests and shall be responsible for the performance of all required tests. When parts or special specimens are to be tested, the parts and special specimens shall be supplied by purchaser. The cognizant engineering organization reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (3.4.1), hardness (3.4.2), and quality (3.5) are acceptance tests and shall be performed on parts, or specimens representing parts when permitted herein (see 4.3.3), from each lot.

4.2.2 Periodic Tests

Corrosion resistance (3.4.4) is a periodic test and shall be performed at least quarterly unless frequency of testing is specified by the cognizant engineering organization. Hydrogen embrittlement (3.4.5) is a periodic test and shall be performed in accordance with 4.3.3.4 at least once in each month that steel parts 36 HRC and over are plated unless frequency of testing is specified by the cognizant engineering organization. Adhesion (3.4.3) is a periodic test that shall be performed no less than daily for each generic class of alloy as defined by AS2390 processed during that day. Tests of cleaning and plating solutions are periodic tests and shall be performed at a frequency established by the processor unless frequency of testing is specified by the cognizant engineering organization (see 4.4.3 and 8.7).

4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the initial shipment of plated parts to a purchase, when a change in material and/or processing requires reapproval by the cognizant engineering organization (see 4.4.2), and when purchaser deems confirmatory testing to be required.

4.2.4 The processor shall maintain a record of each processing bath, showing all additions of chemicals or treatments to the bath, the results of all tests and chemical analysis performed, and the quantity of parts plated during operation. These records shall be maintained and made available for review for not less than one year after completion of the contract or purchase order.

4.3 Sampling for Tests

Sampling for testing shall not be less than the following; A lot is a group of parts, all of the same part number, processed through the same chemical solutions in the same tanks under the same conditions, which have completed the chemical processing within a period of 24 hours of each other and are presented to inspection at the same time.

4.3.1 Acceptance Tests

Test specimens shall be selected randomly from all parts in the lot. Unless the cognizant engineering organization supplies a sampling plan, the minimum number of specimens shall be as shown in Table 1.

Table 1 - Sampling for acceptance tests

Number of Parts in Lot	Quality	Thickness	Hardness
Up to 7	All	3 or all[(1)]	1
8 to 15	7	4	1
16 to 40	10	4	1
41 to 110	15	5	1
111 to 300	25	6	1
301 to 500	35	7	1
Over 500	50	8	1

NOTE:
(1) Whichever is less.

4.3.2 Periodic Tests

Specimen quantities shall be one for hardness, four for corrosion resistance, and as specified in ASTM F519 for hydrogen embrittlement unless otherwise specified by the cognizant engineering organization. When test specimens are used for adhesion testing, four test specimens of each generic class of alloy, as defined by AS2390, that have been processed through the same cleaning and plating operations as the parts that they represent. These adhesion test specimens shall be processed prior to the first production lot of parts or with the first production lot of parts.

4.3.3 Specimen Configuration

4.3.3.1 Separate test specimens may be used under any one of the following circumstances: The plated parts are of such configuration or size as to be not readily adaptable to specified tests, nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive test on actual parts. Except as specified below, acceptance test specimens shall be made of the same generic class of alloy as the parts, established in accordance with AS2390, distributed within the lot, cleaned, plated, and post treated with the parts.

4.3.3.2 Separate test specimens for thickness, and hardness tests shall be approximately 1 x 4 x 0.040 inches (25 x 100 x 1 mm).

4.3.3.3 Separate test specimens for corrosion resistance tests shall be approximately 4 x 6 x 0.040 inches (100 x 150 x 1 mm).

4.3.3.4 Hydrogen embrittlement test shall be performed in accordance with ASTM F519 Type 1a.1 using round notched specimens, unless a different specimen is specified by the cognizant engineering organization, stressed in tension under constant load. For test purposes, the plating thickness shall be 0.001 to 0.002 inch (25 to 51 µm) measured on the smooth section of the specimen, but with visual plating at the root of the notch.

4.3.3.5 Adhesion Testing

Test specimens for adhesion testing in 3.4.3.1 shall be made of the same generic class of alloy as defined by AS2390 as the parts processed. The test specimens shall be 0.025 inch (0.6 mm) minimum thickness and not less than 1 x 4 inches (25 x 102 mm).

4.4 Approval

4.4.1 The process and control procedures, a preproduction specimen part, or both, whichever is specified, shall be approved by the cognizant engineering organization before production parts are supplied.

4.4.2 If the processor makes a significant change to any material, process, or control factor from that which was used for process approval, all preproduction tests shall be performed and the results submitted to the cognizant engineering organization for process reapproval, unless the change is approved by the cognizant engineering organization. A significant change is one which, in the judgement of the cognizant engineering organization, would affect properties or performance of the parts.

4.4.3 Control factors shall include, but not be limited to, the following:

- Activation procedure(s)
- Fixture/Electrical contact locations when approval is required by the cognizant engineering organization
- Composition limits of the plating bath
- Plating bath temperature
- Plating current (or voltage) limits or other electrical parameters
- Frequency of plating bath composition test
- Tooling and fixturing
- Time in cleaning, activation (pickling) and plating solutions
- Stress and embrittlement relief bake oven temperatures and times
- Method for determining plating thickness
- Periodic test plan for cleaning and processing solutions

4.5 Reports

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

4.6 Resampling and Retesting

4.6.1 If results of any acceptance test fail to meet specified requirements, the parts in that lot may be stripped by a method acceptable to cognizant engineering organization that does not roughen, pit, or chemically embrittle the basis metal, pretreated, plated, post treated as defined herein, and tested. Alternatively, all parts in the lot may be inspected for the nonconforming attribute, and the nonconforming parts may be stripped by a method acceptable to cognizant engineering organization that does not roughen, pit, or embrittle the basis metal, pretreated, plated, post treated as defined herein, and tested.

4.6.2 If the results of any periodic test fail to meet specified test requirements, the process is nonconforming. No additional parts shall be plated until the process is corrected and specimens plated and retested. Results of all tests shall be recorded and, when requested, reported. Purchaser shall be notified of all parts plated since the last acceptable test.