



AEROSPACE MATERIAL SPECIFICATION

AMS2454™**REV. A**

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Revised 2021-12

Superseding AMS2454

(R) Plating, Electroless Nickel-Phosphorus,
Co-Deposited with Polytetrafluoroethylene (PTFE)

RATIONALE

AMS2454A is the result of a Fire-Year Review and update of this specification with changes to ordering information corresponding to changes in the document, added Type VI to be specified to Table 4, updated stress relief per GAB19AA (3.1.1), updated contact locations per GAB19AB (3.1.2, 4.4.3), added direct dimensional inspection of thickness (3.4.1), added minimum force to hardness testing to increase accuracy (3.4.3), clarified wording for composition (3.4.6), added paragraph dealing with acceptable imperfections in coating applied to casting and forgings (3.5.3), revised adhesion test requirements per GAB14AA (4.2.2, Table 5, 4.3.2, 4.3.3.6), moved and updated plating solution controls from 4.2.2.1 to 4.2.2.2, added 4.2.2.4 suspension of periodic testing for when plating is not performed, for preproduction tests (4.2.3) added that test are dependent of type of coating specified, updated Lot definition per GAB16AA (4.3.1), for corrosion testing added AMS4037 for specimen material (4.3.3.3) to align with other AMS's changed plating thickness to a minimum for hydrogen embrittlement test (4.3.3.4), and revised notes 8.7, 8.15, 8.17, 8.20, and 8.21.

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:

- AMS2454A, service class (Table 1), thickness grade number (Table 2), thickness grade letter (Table 3), and phosphorous type (Table 4).
- Optional: Plating thickness and underplate thickness other than that stated in Table 2 and Table 3 (see Table 2, Note 1 and Table 3, Note 2).
- Optional: Class of thermal treatment (1.3.4).
- Special features, geometry, or processing present on parts that requires special attention by the plating processor.
- Quantity of pieces to be plated.
- Basis metal to be plated.
- Tensile strength or hardness of the basis metal (applicable to steel alloys only).

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For more information on this standard, visit
<https://www.sae.org/standards/content/AMS2454A>

SAE WEB ADDRESS:

- If pre-plate stress relief is 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 treatment (3.1.1).
 - If steel parts have been shot peened (8.10), specify if required stress relief has been completed (3.1.1.3).
 - Optional: Requirement to prohibit hexavalent chromium use, when applicable (3.2.4).
 - Optional: Hydrogen embrittlement relief to be performed by plating processor, if different from 3.3.1.
 - Optional: Requirement to remove residual PTFE particles, if applicable, and method of removal, if desired (3.3.3, 3.5.1, and 8.13).
 - Optional: Specific requirement(s), test method(s) for color and/or gloss, when applicable (3.5.2).
 - Optional: Requirement for adhesion testing of parts by chisel-knife or other method, and frequency of test, if required (3.4.2.2 or 3.4.2.3).
 - Optional: Additional test requirements, when specified (e.g., see 8.17 through 8.20), including test and acceptance criteria.
 - Optional: Periodic testing, if required (4.2.2.2), for hardness of Class 2 plating (3.4.4), coefficient of friction (3.4.7), and/or adhesion testing of parts (3.4.2.1 or 3.4.2.2) and periodic test sample quantity, if different than 4.3.2.
2. Part 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.

1. SCOPE

1.1 Purpose

This specification covers the requirements for electroless nickel-phosphorus plate that is co-deposited with polytetrafluoroethylene (PTFE) over other materials.

1.2 Application

This deposit has been used typically to provide a uniform build-up on intricate shapes for improvement of wear resistance, low reflectivity, and/or as an electrically conductive finish with improved corrosion resistance, but usage is not limited to such applications. The deposit is generally dark and nonreflective. The deposit has been used in service up to 500 °F (260 °C), although wear and/or corrosion resistance may degrade as service temperature increases.

- 1.2.1 Corrosion resistance is a function of substrate material and the type and thickness of underplate and the electroless nickel PTFE composite surface layer. See 8.15.
- 1.2.2 This plating is not specifically intended for applications requiring premium solderability or adhesive bondability. See 8.14.
- 1.2.3 Application of electroless nickel PTFE composite plating to steel parts having a hardness of 46 HRC (ultimate tensile strength of 220 ksi [1517 MPa] or higher) shall not be performed unless authorized by the design documentation or specific approval has been received from the cognizant engineering organization.

1.3 Classification

The cognizant engineering organization may assign one or more of the following classifications to specify plating requirements:

1.3.1 Service Class Designates Corrosion Resistance (see 3.4.3 and 8.15)

Table 1 - Corrosion resistance⁽¹⁾

Service Class	Duration of Salt Spray Test (Hours)
SC0	Not required
SC1	48
SC2	100
SC3	192
SC4	500
SC5	1000
SC6	2000

⁽¹⁾ Specifying a service class requires appropriate decisions for grade and type. See 8.15.

1.3.2 Grade Designates Thickness (see 3.4.1 and 8.16)

Table 2 - PTFE-nickel composite layer thickness (minimum)

Grade ⁽¹⁾	Inches	Microns
1	0.0001	2.5 µm
2	0.0003	7.6 µm
3	0.0007	18 µm

⁽¹⁾ Other thickness requirements shall be as-specified.

Table 3 - Underplate layer⁽¹⁾ thickness (minimum)

Grade ⁽²⁾	Inches	Microns
A	0.00005	1.25 µm
B	0.0001	2.5 µm
C	0.0002	5.0 µm
D	0.0003	7.5 µm
E	0.0005	12.5 µm
F	0.0007	17.5 µm
G	0.0010	25.0 µm
H	0.0014	30.0 µm

⁽¹⁾ Multiple underplate layers may be applied, as determined by plating processor.

⁽²⁾ Other thickness requirements shall be as-specified.

1.3.3 Type Designates Phosphorus Content of Plating (see 3.4.6, 8.7, and 8.15)

Table 4 - Phosphorus content of plating

Type	Phosphorus, % by Weight
I	No requirement
II	1 to 3
III	3 to 5
IV	5 to 9
V	9 and above
VI	Other (range must be specified)

1.3.4 Class Designates Thermal Treatment (see 3.3.2, 3.4.4, 8.5, and 8.11)

Class 1: Except for hydrogen embrittlement relief, no post plating thermal treatment.

Class 2: Thermal treatment at 450 °F (232 °C) to harden the deposit.

Class 3: Thermal treatment at 375 °F (191 °C).

Class 4: Thermal treatment at 250 °F (121 °C).

Unless a specific class is specified, Class 1 or Class 4 may be supplied.

1.4 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 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.

AMS2430	Shot Peening
AMS2432	Shot Peening, Computer Monitored
AMS2546	Laser Peening
AMS2750	Pyrometry
AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS4037	Aluminum Alloy, Sheet and Plate, 4.4Cu - 1.5Mg - 0.60Mn (2024; -T3 Flat Sheet, -T351 Plate), Solution Heat Treated
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
ARP4992	Periodic Test for Process Solutions
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 B374	Terminology Relating to Electroplating

ASTM B487	Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
ASTM B499	Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B567	Measurement of Coating Thickness by the Beta Backscatter 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 B636	Measurement of Internal Stress of Plated Metallic Coatings with the Spiral Contractometer
ASTM B748	Measurement of Thickness of Metallic Coatings by Measurement of Cross Section with a Scanning Electron Microscope
ASTM B764	Simultaneous Thickness and Electrode Potential Determination of Individual Layers in Multilayer Nickel Deposit (STEP Test)
ASTM D1894	Static and Kinetic Coefficient of Friction of Plastic Film and Sheeting
ASTM E384	Microindentation Hardness of Materials
ASTM E1097	Determination of Various Elements by Direct Current Plasma Atomic Emission Spectrometry
ASTM F519	Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.3 U.S. Government Publications

Copies of these specifications are available online at <https://quicksearch.dla.mil>.

MIL-DTL-38999 General Specification for Connectors

3. TECHNICAL REQUIREMENTS

3.1 Preparation

3.1.1 Stress Relief Treatment

Steel parts having a hardness of 40 HRC (180 ksi) or 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. Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5 and 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 For parts, excluding nitrided parts, having a hardness of 55 HRC and above, and for carburized and induction hardened parts, stress relieve at $275^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($135^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for 5 to 10 hours.
- 3.1.1.2 For parts having a hardness less than 55 HRC, and for nitrided parts, stress relieve at $375^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($191^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.
- 3.1.1.3 For peened parts (see 8.10), if stress relief temperatures above 375°F (191°C) are specified, the stress relieve shall be performed prior to peening.

3.1.2 Fixture/Electrical Contact Location

- 3.1.2.1 Except for barrel plating, for parts that are to be plated all over, and contact locations are not specified, contact locations shall be at the discretion of the processor.
- 3.1.2.2 For parts that are not to be plated all over, and contact locations are not specified, locations shall be in areas on which coating is not required.

3.1.3 Cleaning

The plating shall be applied over a surface free from water breaks. The cleaning procedure shall not produce pitting or intergranular attack of the basis metal and shall preserve dimensional requirements. See 8.4 and 8.6.

3.2 Procedure

3.2.1 Plating shall be performed by chemical deposition of a nickel-phosphorus PTFE composite onto a properly prepared surface. The deposit may consist of a single layer of nickel-phosphorus PTFE composite plating or of multilayer plating containing an external layer that includes electroless nickel PTFE composite. Underplate composition, if applied, shall be as selected by the plating processor, see 8.15.

3.2.1.1 Multilayer plating shall be conducted without interruption to ensure good layer to layer adhesion.

3.2.2 Plated parts shall be removed from the plating solution, thoroughly rinsed, and dried.

3.2.3 Double plating and spotting in are prohibited. See 8.8.1.

3.2.4 When specified by the cognizant engineering organization, the plating process shall not include hexavalent chromium.

3.3 Post Treatment

3.3.1 Hydrogen Embrittlement Relief

Hydrogen embrittlement relief treatment of steel parts shall be in accordance with AMS2759/9. Other metals and alloys do not require hydrogen embrittlement relief baking.

3.3.2 Heat Treatment for Hardness or Adhesion Enhancement

When Class 2, 3, or 4 is specified (see 8.11), parts shall be thermally treated after plating, rinsing, and drying.

3.3.2.1 When Class 2 is specified, parts shall be heated to $450^{\circ}\text{F} \pm 15^{\circ}\text{F}$ ($232^{\circ}\text{C} \pm 8^{\circ}\text{C}$) for a minimum of 4 hours to increase hardness of the deposit. See 3.4.4 and 8.5. Hydrogen embrittlement relief (3.3.1) may be omitted if Class 2 hardening is accomplished within 4 hours after plating.

3.3.2.2 When Class 3 is specified, parts shall be heated to $375^{\circ}\text{F} \pm 15^{\circ}\text{F}$ ($191^{\circ}\text{C} \pm 8^{\circ}\text{C}$) for 1 to 2 hours.

3.3.2.3 When Class 4 is specified, parts shall be heated to $250^{\circ}\text{F} \pm 10^{\circ}\text{F}$ ($121^{\circ}\text{C} \pm 6^{\circ}\text{C}$) for 1 to 2 hours.

3.3.3 When specified, residual PTFE particles loosely bonded to the surface shall be removed using a method permitted by the cognizant engineering organization. See 3.5.1 and 8.13.

3.4 Properties

Plating shall conform to the following requirements:

3.4.1 Thickness

Unless otherwise specified, thickness shall meet the requirements of Tables 2 and 3, determined in accordance with any of the following methods as applicable: ASTM B487, ASTM B499, ASTM B567, ASTM B568, ASTM B748, ASTM B764, direct dimensional inspection provided the resolution of the measuring instrument is ten times more precise than the attribute being measured, or other method acceptable to the cognizant engineering organization. See 8.16.

3.4.2 Adhesion

3.4.2.1 Adhesion on representative test specimens shall meet the requirements of ASTM B571, using the 180 degree bend test method with a 4T mandrel.

3.4.2.2 When specified, adhesion on parts shall meet the requirements of ASTM B571 using the chisel-knife test method.

3.4.2.3 When specified by the cognizant engineering organization, adhesion may be tested by other test method appropriate to the part configuration and product application; for example, crush testing of connectors with adhesion at the fracture interface evaluated as in 3.4.2.2.

3.4.3 Corrosion Resistance

Representative plated test specimens in accordance with 4.3.3.3 shall show no lifting of the plating, no exposure of the basis metal, and no visual evidence of corrosion of the basis metal after being subjected to the continuous salt spray corrosion test conducted in accordance with ASTM B117. Duration of test shall be in accordance with the specified service class shown in Table 1. See 8.15.

3.4.4 Hardness

Class 2 nickel-PTFE plating hardness shall be not lower than 300 HK, or equivalent, with a minimum force load of 25 g, determined in accordance with ASTM E384 or ASTM B578. See 3.3.2.1.

3.4.5 Hydrogen Embrittlement

The plating process shall not cause hydrogen embrittlement in steel parts, after baking, determined in accordance with 4.3.3.4.

3.4.6 Composition

Unless otherwise specified, the phosphorus content, after separation of the co-deposited PTFE material, shall be as shown in Table 4 determined in accordance with ASTM E1097 or other method acceptable to the cognizant engineering organization. Other than nickel and the phosphorous, residual metals and nonmetals in the deposit shall not exceed 1% total by weight after separation of the co-deposited PTFE material. Other composition requirements shall be as specified by cognizant engineering organization.

3.4.7 Coefficient of Friction

The coated specimens (4.3.3.5) tested in accordance with ASTM D1894, or other method permitted by the cognizant engineering organization shall have a maximum coefficient of friction of 0.20.

3.5 Quality

Plating, as received by purchaser, shall be smooth, continuous, and uniform in appearance and shall be free from frosty areas, pinholes, blisters, and other imperfections detrimental to usage of the plate. Water marks from rinsing, slight staining, or discoloration is permissible. Class 2 plating may discolor from thermal treatment.

- 3.5.1 The surface may contain loose, unbounded PTFE particles, unless the cognizant engineering organization specified that no surface particles may remain. See 3.3.3 and 8.13.
- 3.5.2 Color shall be dark and nonreflective. Specific characteristics for color and/or gloss shall apply when requirement and test method is specified.
- 3.5.3 Differences in the plated coating appearance on castings or wrought components due to welds, or cast vs. machined surface textures, or macro grain size and other inherent metallurgical artifacts shall not be cause for rejection of the coating. See 8.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all samples for processor's test and shall be responsible for the performance of all required tests. Parts, if required for tests, 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 plating conforms to specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (3.4.1) and quality (3.5) are acceptance tests and shall be performed on parts, or specimens representing parts when permitted herein on each lot. See 4.3.1.

4.2.2 Periodic Tests

Adhesion on test specimens (3.4.2.1) 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.

4.2.2.1 The following are periodic tests to be conducted at least once each month when plating is performed:

- a. Corrosion resistance (3.4.3): When a service class (1.3.1) requires salt fog duration longer than 30 days, the plating processor may elect to initiate that corrosion resistance test at a frequency equal to the duration of the test (e.g., every 42 days for 1000 hour SC5 or every 84 days for 2000 hour SC6).
- b. Hydrogen embrittlement (3.4.5), applicable when steel parts 36 HRC and over are plated.
- c. Composition (3.4.6).

4.2.2.2 The following are periodic tests to be conducted at least once each month when specified:

- a. Adhesion on parts (3.4.2.2 or 3.4.2.3).
- b. Hardness of Class 2 plating (3.4.4).
- c. Coefficient of friction (3.4.7).

4.2.2.3 Tests of cleaning and processing 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 8.3.

4.2.2.4 Periodic testing may be suspended in any test period when parts are not processed but shall be performed before or at time such processing is resumed. Preproduction testing may be required by the cognizant engineering organization, upon resumption of processing.

4.2.3 Preproduction Tests

All property verification tests (3.4), for the service class, grades, type, and thermal treatment class specified, are preproduction tests and shall be performed prior to or on the initial shipment of plated parts to a purchaser and when the cognizant engineering organization requires confirmatory testing.

4.3 Sampling for Testing

4.3.1 Acceptance Test Sample Quantity

Test samples shall be randomly selected from all parts in the lot. 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. The minimum number of sampled parts shall be as shown in Table 5.

Table 5 - Sampling for acceptance tests

Number of Parts in Lot	Quality	Thickness
Up to 7	All	All or 3 ⁽¹⁾
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

⁽¹⁾ Whichever is less.

4.3.2 Periodic Test Sample Quantity

Sample size shall be four for corrosion resistance. For hydrogen embrittlement, sample size as specified in ASTM F519 unless otherwise specified by the cognizant engineering organization. For adhesion testing in 3.4.2.1, 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. Sample quantity for other periodic tests shall be at the discretion of the processor unless otherwise specified by the cognizant engineering organization or specified otherwise herein.

4.3.3 Specimen Configuration

4.3.3.1 Nondestructive testing shall be performed wherever practical. Except as noted below, actual parts shall be selected as samples for tests. When representative specimens are used for acceptance testing, values so obtained shall be correlated with those of parts since properties, such as thickness, may differ between parts and representative test specimens.

4.3.3.2 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. Separate test specimens shall be used when plated parts are of such configuration or size as to be not readily adaptable to specified tests, when nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive tests on actual parts.

4.3.3.3 Corrosion Testing

In any month (or other specified test period) that ferrous alloy parts are plated, test specimens shall be low carbon or low alloy steel 0.025 inch (0.64 mm) minimum thickness and not less than 4 inches (102 mm) wide by 6 inches (152 mm) long. Aluminum alloy test specimens (same specimen size as for steel) made of either AMS4037 (2024-T3) or the same generic class of alloy as the parts being plated, shall be used in any month (or other specified test period) when aluminum alloy parts are plated.

4.3.3.4 Hydrogen Embrittlement Test

Test shall be in accordance with the requirements of 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 minimum plating thickness shall be 0.0007 inch (18 µm) measured on the smooth section of the test specimen, but with visual evidence of plating at the root of the notch.

4.3.3.5 Coefficient of Friction Test

Coefficient of friction (3.4.7) test specimens shall be either 0.04 x 5 x 10 inches (1.0 x 127 x 254 mm) or other suitable configuration to ensure accurate measurement. Specimens shall be fabricated from AMS4037 (2024-T3) aluminum alloy sheet or the predominant alloy being processed. Testing shall be in accordance with ASTM D1894 or other method permitted by the cognizant engineering organization.

4.3.3.6 Adhesion Testing

Test specimens for adhesion testing (3.4.2.1) 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 factors, a preproduction 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. A significant change is one which in the judgment 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:

- Substrate alloy and heat treat condition or temper
- Fixture/electrical contact locations when approval is required by the cognizant engineering organization
- Surface preparation, including precleaning, pretreatment(s), strike, and/or underplate type and thickness, if used
- Plating bath composition and composition control limits
- Plating bath temperature limits and controls
- PTFE particle size, volume fraction, and method of control
- Thermal post treatment times and temperatures
- Method for testing plate thickness
- Method for testing plate adhesion
- Method of stripping for rework
- Periodic test plan for cleaning and processing solutions (see 8.3)

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 specified requirements and that they conform to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS2454A, part number, and quantity.