



<b>AEROSPACE MATERIAL SPECIFICATION</b>	<b>AMS2413™</b>	<b>REV. G</b>
	Issued 1961-01 Reaffirmed 2019-01 Revised 2024-02	
Superseding AMS2413F		
Plating, Silver-Rhodium		

### RATIONALE

AMS2413G is the result of a Fire-Year Review and update of this specification with changes to Ordering Information, Stress Relief Treatment (see 3.1.2.3), Fixture/Electrical Contact Locations (see 3.2.1), Copper Strike with Copper Underplate (see 3.2.2), Silver Plating (see 3.2.3), Thickness (see 3.4.1), Periodic Tests (see 4.2.2), Acceptance Tests (see 4.3.1), Sampling for acceptance test (see Table 1), Periodic Tests (see 4.3.2), Adhesion Testing (see 4.3.3.2.1), and control factors (see 4.4.3).

### 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:

- AMS2413G
- Quantity of pieces to be plated
- Plating thickness desired (see 3.4.1)
- Minimum thickness on internal surfaces, if required (see 3.4.1.1)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal
- If preplate 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 treat (see 3.1.1)
- If steel parts have been shot peened, specify if required stress relief has been completed (see 3.1.1.3)
- Special features, geometry, or processing present on parts that requires special attention by the plating processor
- Hydrogen embrittlement relief to be performed by the plating processor (parameters or reference document) if different from 3.3
- Optional: fixture/Electrical contact locations, when not specified (see 3.2.1)

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- Optional: periodic testing frequency (see 4.2.2) and sample quantity (see 4.3.2)
  - If internal surfaces as defined in 3.4.1.4 are required to be plated to a specified thickness, notes on the drawing shall so specify
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.

## 1. SCOPE

### 1.1 Purpose

This specification covers the requirements for a layer of electrodeposited silver followed by a layer of electrodeposited rhodium.

### 1.2 Application

This electrodeposit has been used typically to provide a conductive surface for electrical contacts or a reflective coating for waveguide surfaces for parts operating up to 300 °F (149 °C), 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](http://www.sae.org).

AMS2750	Pyrometry
AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
ARP4992	Periodic Test for Processing Solutions
AS2390	Chemical Process Test Specimen Material
AS7766	Terms Used in Aerospace Metals Specifications

## 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](http://www.astm.org).

- ASTM B117 Operating Salt Spray (Fog) Apparatus
- ASTM B253 Guide for Preparation of Aluminum Alloys for Electroplating
- ASTM B374 Terminology Relating to Electroplating
- ASTM B487 Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- ASTM B568 Measurement of Coating Thickness by X-Ray Spectrometry
- ASTM B571 Qualitative Adhesion Testing of Metallic Coatings
- ASTM F519 Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.3 Terms used in AMS are defined in AS7766. ASTM B374 should be utilized as a reference and referee document when areas of design definition or technical interpretation arise.

## 3. TECHNICAL REQUIREMENTS

### 3.1 Preparation

3.1.1 Parts shall be within drawing dimension limits before plating. The cleaning procedure shall not produce pitting or intergranular attack of the basis metal and shall preserve dimensional requirements.

### 3.1.2 Stress Relief Treatment

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:

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

3.1.2.2 For parts having a hardness less than 55 HRC, stress relieve at 375 °F ± 25 °F (191 °C ± 14 °C) for a minimum of 4 hours. Nitrided parts fall into this category. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

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

3.1.3 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.

### 3.2 Procedure

Parts shall be plated in the following sequence, using the solution specified; parts shall be immersed in each plating solution with the current on:

#### 3.2.1 Fixture/Electrical Contact Locations

3.2.1.1 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.

3.2.1.2 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.

#### 3.2.2 Copper Strike with Copper Underplate

Except as specified in 3.2.2.1, a copper strike followed by a thin copper underplate shall be electrodeposited from a suitable copper plating solution. The combined thickness shall be as stated in 3.4.1.1.1.

3.2.2.1 When parts to be plated are made of a corrosion-resistant alloy or a nickel/cobalt alloy, a nickel strike followed by a thin nickel underplate shall be electrodeposited instead of the copper strike and underplate. The combined thickness shall be as stated in 3.4.1.1.1.

3.2.2.2 Parts made from aluminum alloys shall be zincate treated in accordance with ASTM B253 or other method acceptable to the cognizant engineering organization prior to the copper strike and underplate.

#### 3.2.3 Silver Plating

Parts shall be plated by electrodeposition of silver from a suitable silver plating solution directly onto the plated surfaces of 3.2.2 or 3.2.2.1. A silver strike may be deposited prior to the main silver deposit.

#### 3.2.4 Rhodium Plating

Parts shall be plated by electrodeposition of rhodium from a rhodium sulfate, rhodium phosphate, or other suitable rhodium plating solution onto the silver plating surfaces.

3.2.5 Spotting-in and double plating are not permitted.

### 3.3 Hydrogen Embrittlement Relief

After plating, rinsing, and drying, ferrous parts shall be treated in accordance with AMS2759/9 using the parameters specified for silver.

### 3.4 Properties

The silver-rhodium plating shall conform to the following requirements:

#### 3.4.1 Thickness

Thickness of plating shall be as specified on the drawing, determined in accordance with any of the following methods as applicable: ASTM B487, ASTM B568, direct dimensional inspection provided the resolution of the measuring instrument is ten times more precise than the attribute being measured, or other method permitted by the cognizant engineering organization.

3.4.1.1 Minimum plating thickness shall be as follows:

3.4.1.1.1 Copper or Nickel Strikes and Underplates

Not less than 0.0001 inch (3  $\mu\text{m}$ ).

3.4.1.1.2 Silver Plate

Not less than 0.0005 inch (13  $\mu\text{m}$ ).

3.4.1.1.3 Rhodium Flash

Not less than 0.00002 inch (0.5  $\mu\text{m}$ ).

3.4.1.2 Thickness requirements apply to surfaces that can be touched by a sphere 0.75 inch (19.1 mm) in diameter. Plating thickness in such areas shall be substantially uniform, except that that slight build-up on exterior corners or edges is permitted if within drawing dimensional requirements.

3.4.1.3 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.

3.4.1.4 If internal surfaces as defined in 3.4.1.3 are required to be plated to a specified thickness, notes on the drawing shall specify thickness.

3.4.2 Adhesion

Plating shall be firmly and continuously bonded to the underlying metal, determined on representative parts or test panels in accordance with a method described in ASTM B571. A test shall be selected from ASTM B571 from those specified for silver electrodeposits.

3.4.3 Corrosion Resistance

Ferrous metal parts or representative test specimens as in 4.3.3 shall show no evidence of corrosion of the basis metal, determined by exposure for 100 hours to salt spray corrosion test conducted in accordance with ASTM B117.

3.4.4 Hydrogen Embrittlement

The plating process after baking shall not cause hydrogen embrittlement in steel parts determined in accordance with 4.3.3.2.3.

3.5 Quality

Plating, as received by the purchaser, shall be sound, smooth, continuous, adherent to the basis metal, uniform in color, and free from blisters and other imperfections detrimental to usage of the plating.

## 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all samples for the processor's tests and shall be responsible for the performance of all required tests. When actual parts are required for tests, such parts shall be supplied by the purchaser. The cognizant engineering organization 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 (see 3.4.1), and quality (see 3.5) are acceptance tests and shall be performed on parts, or specimens representing parts when permitted herein from each lot (see 4.3.3).

### 4.2.2 Periodic Tests

Adhesion (see 3.4.2) 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. Corrosion resistance (see 3.4.3) is a periodic test and shall be performed at least monthly unless frequency of testing is specified by the cognizant engineering organization. Hydrogen embrittlement when required (see 3.4.4) 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. 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 8.5).

4.2.2.1 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 quality organization upon resumption of processing.

### 4.2.3 Preproduction Tests

All property verification tests (see 3.4) are preproduction tests and shall be performed prior to production and when the cognizant engineering organization requires confirmatory testing.

## 4.3 Sampling for Testing

### 4.3.1 Acceptance Tests

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. Unless the cognizant engineering organization provides a sampling plan, the minimum number of samples shall be as shown in Table 1.

**Table 1 - Sampling for acceptance test**

Number of Parts in Lot		Quality	Thickness
1 to	6	all	3 or all*
7 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

\* Whichever is less.

### 4.3.2 Periodic Tests

Sample quantity shall be four for corrosion resistance. For hydrogen embrittlement, sample quantity shall be as specified in ASTM F519 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

Nondestructive testing shall be performed wherever practical. Except as noted, 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.

#### 4.3.3.1 Representative Test Specimens

Representative test specimens may be used in lieu of parts 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
- It is not economically acceptable to perform destructive tests on actual parts

4.3.3.2 Except as specified below, representative 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 represented.

##### 4.3.3.2.1 Adhesion Testing

Test specimens for adhesion testing in 3.4.2 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 (0.64 mm) minimum thickness and not less than 1 x 4 inches (25 x 102 mm).

##### 4.3.3.2.2 Corrosion Testing

When ferrous alloy parts are processed within the test period (quarter), representative test specimens shall be low carbon or low alloy steel 0.025-inch (0.64-mm) minimum thickness and not less than 4 x 6 inches (103 x 152 mm) or bars approximately 0.5 inch (13 mm) in diameter and 4 inches (102 mm) long having a surface roughness not to exceed 40 microinches (1  $\mu$ m) AA. Representative test specimens for aluminum alloy parts (same specimen size as for steel) shall be made of either 2024-T3 or the same generic class of alloy as the parts processed within the test period when aluminum alloy parts are plated. Representative test specimens, made of the predominant generic class of alloy as the parts and plated within the test period may be used when permitted by the cognizant engineering organization. Alternative alloy or configuration may be used when permitted by the cognizant engineering organization. Plating thickness shall be 0.0005 inch (13  $\mu$ m) maximum.

##### 4.3.3.2.3 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 measured on the smooth section of the specimen shall be 0.0005 to 0.0007 inch (13 to 18  $\mu$ m). Specimen shall show visual plating coverage at the root of the notch.

### 4.4 Approval

4.4.1 The process and control factors, a preproduction sample, 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 that, in the judgment of the cognizant engineering organization, could affect the properties or performance of the plated parts.