



AEROSPACE MATERIAL SPECIFICATION	AMS2423™	REV. F
	Issued 1962-06 Reaffirmed 2009-06 Revised 2022-07	
Superseding AMS2423E		
Plating, Nickel Hard Deposit		

RATIONALE

AMS2423F is the result of a Five-Year Review and update with the addition of preplate stress relief and electrical contact locations to ordering information and 3.1.3, update wording to include application to new or overhauled parts and deleted statement regarding diffusion as it is not applicable (1.2), updated wording for stress relief treatment (3.1.1.1.3), addition of pretreatments for other basis metals (3.2.1), addition of standard wording for direct dimensional measurement of thickness (3.4.1), revision of adhesion test method to agree with that used in similar specifications (3.4.4.1), addition of ASTM B571 grind-saw test for adhesion of higher thicknesses as it is a better test (3.4.4.1), rewording of machined adhesion test to agree with that used in similar specifications (3.4.4.2), addition of hardness limit for hydrogen embrittlement to agree with similar specifications (3.4.5), change hardness from acceptance test to periodic test to agree with similar specifications (4.2.1 and 4.2.2), added standard wording for suspension of periodic testing (4.2.2.1), revision of definition of lot, moved hydrogen embrittlement test method from 3.4.5 to 4.3.3.1, updated wording for Approval (4.4), and added fixture/contact locations to control factors.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the plating processor by the cognizant engineering organization.

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

- AMS2423F
- Plating thickness desired (see 3.4.1)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal
- 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 treat (3.1.1)
 - If steel parts have been shot peened, specify if required stress relief has been completed (3.1.1.3)
- Special features, geometry, or processing present on parts that requires special attention by the plating processor

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2022 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

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
http://www.sae.org

SAE WEB ADDRESS:

For more information on this standard, visit
<https://www.sae.org/standards/content/AMS2423F/>

- Optional: Fixture/electrical contact locations when not specified (3.1.3)
 - Hydrogen embrittlement relief (baking) to be performed by plating processor after plating (parameters or reference document) if different from 3.3
 - Quantity of pieces to be plated
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 the cognizant engineering organization and is not controlled by this specification.

1. SCOPE

1.1 Purpose

This specification covers the engineering requirements for electrodeposition of a hard nickel and the properties of the deposit.

1.2 Application

This process has been used typically to provide good wear resistance to either new manufacture parts or overhauled parts, which may operate in service up to 450 °F (232 °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 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 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).

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.

- ASTM B253 Preparation of Aluminum Alloys for Electroplating
- ASTM B487 Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of Cross Section
- ASTM B504 Measurement of Thickness of Metallic Coatings by the Coulometric Method
- ASTM B530 Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates
- 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 B636 Measurement of Internal Stress of Plated Metallic Coatings with the Spiral Contractometer
- ASTM E376 Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods
- ASTM E384 Microindentation Hardness of Materials
- 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 (see 8.9). 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 $275\text{ °F} \pm 25\text{ °F}$ ($135\text{ °C} \pm 14\text{ °C}$) 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 $375\text{ °F} \pm 25\text{ °F}$ ($191\text{ °C} \pm 14\text{ °C}$) for a minimum of 4 hours. Higher temperatures shall be used only when specified or approved by the cognizant engineering organization.

3.1.1.1.3 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 Parts shall have clean surfaces, free of water break, prior to immersion in the plating solution.

3.1.3 Electrical Contact

3.1.3.1 For parts which are to be plated all over, and fixture contact points are not specified, contact locations shall be at the discretion of the processor.

3.1.3.2 For parts which are not to be plated all over, and fixture contact locations are not specified, locations shall be in areas on which plate is not required.

3.1.4 Parts shall be within drawing limits after plating and machining.

3.2 Procedure

3.2.1 Nickel shall be electrodeposited from a chloride, sulfate/chloride, sulfamate or other suitable plating solution containing addition agents to produce the specified hardness. Nickel shall be deposited directly on the basis metal without a prior strike coating of metal other than nickel, except as listed below.

3.2.1.1 Aluminum alloys may be zincate treated and copper strike plated in accordance with ASTM B253 before plating.

3.2.1.2 Alloys containing copper or zinc may be preceded by a copper strike.

3.2.1.3 Parts made of magnesium alloy may be zincated and copper strike plated in accordance with ASTM B480.

3.2.1.4 For other alloys, an alternative strike plating is permitted when approved by the cognizant engineering organization.

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

3.3 Post Treatment

Hydrogen embrittlement relief (baking) of steel parts shall be in accordance with AMS2759/9.

3.4 Properties

Plating shall conform to the following requirements.

3.4.1 Thickness

Shall be as specified, determined on representative parts or test panels in accordance with ASTM B487, ASTM B504, ASTM B530, ASTM E567, ASTM B568, ASTM E376, or by 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.

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

3.4.1.2 Thickness requirements apply to surfaces that can be touched by a sphere 0.75 inch (19 mm) in diameter. Other areas such as surfaces of holes, recesses, internal threads, or contact areas of parts plated all over, where a controlled deposit cannot be obtained under normal plating conditions, shall show evidence of plating.

3.4.2 Hardness

Shall be a minimum of 400 HV or equivalent, determined in accordance with ASTM E384, on deposits 0.004 inch (0.10 mm) and over in thickness.

3.4.3 Internal Stress

Shall be within the range 0 to 15.0 ksi (0 to 103 MPa) in compression, determined on a plate thickness of 0.0003 inch (7.6 µm) or greater by calculation from spiral contractometer reading in accordance with ASTM B636 or another instrument acceptable to the cognizant engineering organization.

3.4.4 Adhesion shall conform to one of the following:

3.4.4.1 Adhesion shall be tested for in accordance with the ASTM B571 multiple bend test method with the specimens, as in 4.3.3, bent repeatedly back and forth through an angle of 180 degrees until failure of the basis metal occurs (see 8.8). Examine the region at low magnification for separation, for example 4X, for separation or peeling of the coating. Formation of cracks that do not result in flaking or blistering of the plate is acceptable. For plating thicknesses 0.004 inch and greater, ASTM B571 grind-saw test may be used in lieu of the multiple bend test. Other adhesion test methods specified in ASTM B571 may be used when permitted by the cognizant engineering organization.

3.4.4.2 Machined Plating

Adhesion of plating after finish machining of the plating will be considered acceptable evidence of plating adhesion in lieu of the periodic adhesion test specified in 3.4.4.1.

3.4.5 Hydrogen Embrittlement

The plating process after baking shall not cause hydrogen embrittlement in steel alloys HRC 36 and above when tested as in 4.3.3.1.

3.5 Quality

Plated surfaces, as received by purchaser, shall be smooth, continuous, uniform in appearance, and essentially free from frosty areas, pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to usage of nickel plate. If the nickel is to be machined these conditions apply after machining. Slight staining or discoloration is acceptable. Double plating and spotting-in after plating are not permitted.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all samples for processor's tests and shall be responsible for the performance of all required tests. Where actual parts are to be tested, such parts shall be supplied by either the purchaser or the cognizant engineering organization. The purchaser and the cognizant engineering organization reserve the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to the 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 each lot.

4.2.2 Periodic Tests

Hardness (3.4.2), internal stress (3.4.3), and tests of cleaning and plating solutions to ensure that the deposited metal will conform to the requirements of this specification are periodic tests and shall be performed at least monthly unless frequency of testing is specified by the cognizant engineering organization. Adhesion (3.4.4) 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. Hydrogen embrittlement (3.4.5) is a periodic test and shall be performed 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.

4.2.2.1 Periodic testing may be suspended in any test period when parts are not processed; however preproduction testing may be required by the cognizant quality organization upon resumption of processing.

4.2.3 Preproduction Tests

All technical requirements are preproduction tests and shall be performed prior to or on the first-article shipment of plated parts to a purchaser, when a change in bath composition and/or processing requires reapproval as in 4.4.2, and when the cognizant quality or engineering organization deems confirmatory testing to be required.

4.3 Sampling and Testing

Shall be not 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 For Acceptance Tests

Shall be as shown in Table 1. Test samples shall be randomly selected from all parts in the lot.

Table 1 - Sampling for acceptance tests

Number of Parts in Lot	Quality	Thickness
1 to 6	All	3
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

4.3.2 For Periodic Tests

Sample quantities shall be one for hardness, internal stress, and as specified in ASTM F519 for hydrogen embrittlement unless otherwise specified by the cognizant engineering organization. When test specimens are used for adhesion tests, 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 Sample Configuration and Testing

Nondestructive testing shall be performed wherever practical and authorized herein. Except as noted, actual parts shall be selected as samples for tests. Separate test panels of the same generic class of alloy as the parts, distributed throughout the lot, cleaned, plated, and post treated with the parts represented shall be used when plated parts are of such configuration or size as to be not readily adaptable to the specified tests or when nondestructive testing is not practical on actual parts, or it is not economically acceptable to perform destructive test on actual parts.

4.3.3.1 Hydrogen Embrittlement

Test shall be in accordance with the requirements of ASTM F519, Type 1a.1, using notched round specimens, unless a different specimen is specified by the cognizant engineering organization, stressed in tension under sustained load. For test purposes, the plating thickness shall be a minimum of 0.002 inch (51 µm) measured on the smooth unnotched sections of the specimen, but with visual evidence of plating in the root of the notch. Testing beyond the 200 hour test period is not required.

4.3.3.2 Adhesion

For adhesion tests, specimens shall be made of the same generic class of alloy as defined by AS2390 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).