AEROSPACE MATERIAL SPECIFICATION

AMS2461™	REV. B
Issued 2020-11 Revised 2025-03 Superseding AMS2461A	

Plating, Zinc-Nickel Alloy (12 to 16% Ni)

RATIONALE

AMS2461B changes Procedure (see 3.2.1.3) and Quality (see 3.5.1).

NOTICE

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

1. The purchase order shall specify not less than the following:

   - AMS2461
   - Class, Type, and Grade designation (see 1.3)
   - Color of Grade A or B conversion coating (see 1.3.1)
   - Basis metal to be plated
   - For steel alloys: tensile strength or hardness of the basis metal
   - If pre-plate stress relief is to be performed by the plating processor and if different from 3.1.2, time and temperature are to be specified
   - If steel parts were machined, ground, cold formed, or straightened after heat treatment (see 3.1.2)
   - If steel parts have been shot peened, specify if required stress relief has been completed (see 3.1.2.3)
   - Fixture contact locations, if specified by the cognizant engineering organization (see 3.1.5)
   - Optional: fixture contact locations, when not specified (see 3.1.5)
   - Special features, geometry, or processing present on parts that require 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
   - Minimum thickness on internal surfaces, if required (see 3.4.2)

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/AMS2461B/

- Optional: periodic testing frequency (see 4.2.2) and sample quantity (see 4.3.2)
- Quantity of pieces to be plated
- Lot testing of fasteners for hydrogen embrittlement if required (see 4.2.1 and 4.3.1)

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 purchaser and is not controlled by this specification.

3. The parts manufacturer should ensure that surfaces of metal parts supplied to the processor are free from blemishes, pits, tool marks, and other irregularities that will affect the quality of the finished parts (see 8.2).

1. SCOPE

1.1 Purpose

This specification covers the requirements for electrodeposited zinc-nickel on metal parts, including fasteners and other standard parts.

1.2 Application

This process has been used typically to provide corrosion resistance to metal parts, but usage is not limited to such applications.

1.3 Classification

1.3.1 Types

Type I: As plated without supplementary treatment, service temperature 500 °F (260 °C) maximum.

Type II: As plated with supplementary conversion coating treatment, service temperature 500 °F (260 °C) maximum. Color, including transparent and clear, shall be as specified.

Grade A: Trivalent chromium treatment

Grade B: Trivalent chromium treatment without cobalt additives

Type III: As plated with supplementary phosphate treatment, service temperature 350 °F (177 °C) maximum.

1.3.1.1 Unless a type is specified, Type II shall be supplied.

1.3.1.2 For Type II plating, if no grade is specified, Grade A shall be supplied.

1.3.1.3 For Grade A or B, if no color is specified, the color may be nonuniform and shades of, or mixtures of, blue, purple, green, iridescent, olive-green, gray, or black.

1.3.2 Classes

Class 1: 0.0005-inch (12.7-µm) minimum thickness

Class 2: 0.0003-inch (7.6-µm) minimum thickness

Class 3: 0.0002-inch (5.1-µm) minimum thickness

1.3.2.1 Unless a class is specified, Class 2 shall 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 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.

AMS2417	Plating, Zinc-Nickel Alloy
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 B117	Operating Salt Spray (Fog) Apparatus
ASTM B253	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 B499	Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B504	Measurement of Thickness of Metallic Coatings by the Coulometric Method
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 E376	Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods

ASTM E1417/E1417M Liquid Penetrant Testing

ASTM E1444/E1444M Magnetic Particle Testing for Aerospace

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

2.3 AIA Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM1312 Fastener Test Methods

2.4 Definitions

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, except as specified in 3.1.1.1.

3.1.1.1 Parts having part numbers with the prefix MIL, NAS, AN, MA, MS, or AS and required to be plated in accordance with this specification, or parts where the drawing specifies that dimensions apply after plating, shall be made to such dimension that parts will be within drawing limits after plating. Undercutting before plating shall not be permitted unless specifically authorized by specifications referenced on the applicable drawing.

3.1.2 Stress-Relief Treatment

Residual tensile stresses have been found to be damaging during electrofinishing.

3.1.2.1 All steel parts having a hardness of 36 HRC and over 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.

3.1.2.2 All steel threaded fasteners 34 HRC and over 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. The exception to this is that if all cold working is limited to the head-to-shank fillet and thread rolling, stress relief is not required.

3.1.2.3 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 maximum 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:

3.1.2.3.1 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.

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

3.1.2.4 For Peened Parts

If stress-relief temperatures above 375 °F (191 °C) are specified, the stress relief shall be performed prior to peening.

3.1.3 Any specified residual compressive stress-inducing operations, such as shot peening, shall precede plating.

3.1.4 Cleaning

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

3.1.4.1 Alkaline cleaning of steel parts may be done with anodic current, but steel parts over 36 HRC and steel threaded fasteners over 34 HRC shall not be cathodically cleaned.

3.1.5 Fixture/Electrical Contact Locations

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

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

3.2 Procedure

3.2.1 Parts shall be plated by electrodeposition of zinc-nickel from a suitable alkaline zinc-nickel plating solution that will meet the plate composition requirement (see 3.4.1).

3.2.1.1 The zinc-nickel shall be deposited directly on the basis metal without a prior strike coating of other metal, such as copper or nickel, underneath. In the case of parts, assemblies, and weldments made wholly or in part of corrosion-resistant steel or similarly passive materials, a preliminary strike of nickel or other suitable metal is permissible.

3.2.1.2 Aluminum alloys shall be zincate treated in accordance with ASTM B253 or other method acceptable to the cognizant engineering organization prior to plating.

3.2.1.3 Brighteners shall not be permitted in the plating solution when plating carbon steel, low-alloy steel, and martensitic stainless steel parts 40 HRC and higher.

3.2.2 Supplementary Surface Treatments

3.2.2.1 Type II Grade A or B

After rinsing in water, and without allowing parts to dry, plated parts shall be given a supplementary conversion coating treatment using a commercial trivalent chromium treatment. Such parts shall meet the color requirements of 1.3.1. When plated parts require hydrogen-embrittlement relief, as in 3.3, the supplementary treatment may be applied before or after the hydrogen-relief bake. Parts may require reactivation prior to application of the conversion coating (see 8.5).

3.2.2.2 Type III

After hydrogen-embrittlement-relief baking (see 3.3), or after plating if baking is not required, parts shall receive a supplementary phosphate treatment using a commercial phosphate treatment process. Phosphate coating shall not show smut, powder, or white stains. Parts requiring a post-thermal treatment as in 3.3 may require reactivation prior to application of the phosphate treatment (see 8.5).

3.3 Hydrogen-Embrittlement Relief (Baking)

Hydrogen-embrittlement relief of steel parts 36 HRC and higher and threaded steel fasteners 34 HRC and higher is required and shall be performed in accordance with AMS2759/9.

3.4 Properties

3.4.1 Composition

The electrodeposit shall contain 12 to 16% by weight nickel with the balance being essentially zinc determined by direct measurement using X-ray fluorescence techniques or energy dispersive X-ray spectroscopy, or determined by digestion and analysis using atomic absorption spectrophotometry or inductively coupled plasma mass spectroscopy, or determined by a method acceptable to the cognizant engineering organization. Testing shall be performed on zinc-nickel test specimens as defined in 4.3.3.4 with no supplementary surface treatments.

3.4.2 Thickness

Shall be as specified by the class (see 1.3.2) and determined on representative parts or as allowed in 4.3.3.1 on test specimens in accordance with any of the following methods as applicable: ASTM B487, ASTM B499, ASTM B504, ASTM B567, ASTM B568, ASTM E376, direct dimensional inspection provided the resolution of the measuring instrument is at least ten times more precise than the attribute being measured, or other method permitted by the cognizant engineering organization.

3.4.2.1 For surfaces that can be touched by a sphere 0.75 inch (19.0 mm) in diameter, including external threads, the minimum thickness of zinc-nickel plating shall be as specified for each class in 1.3.2. If not specified, the maximum shall be the minimum plus 0.0003 inch (7.6 µm).

3.4.2.2 For internally threaded parts, a maximum limit of 0.0005 inch (12.7 µm) above the minimum shall be allowed on the external surfaces.

3.4.2.3 For surfaces that cannot be touched by a 0.75-inch (19.0-mm) sphere, including internal threads, no thickness requirements are established, but such areas shall show evidence of coating. There shall be no bare areas except for areas beyond a hole depth of 2.5 times the hole diameter.

3.4.2.4 The plating thickness shall be uniform in thickness on surfaces that can be touched by a 0.75-inch (19.0-mm) sphere except that slight buildup on exterior corners and edges will be permitted provided the finished engineering drawing dimensions are met.

3.4.2.5 If used, the strike plating shall be considered part of the zinc-nickel plating thickness requirement. When used, strike plating shall be 0.0001 inch (2.5 µm) maximum (see 3.2.1.1).

3.4.2.6 If surfaces as defined in 3.4.2.3 are required to be plated to a specified thickness, notes on the drawing will so specify.

3.4.3 Adhesion

3.4.3.1 Plating shall firmly adhere to the basis metal when subjected to the bend test, burnishing test, draw test, or heat-quench test of ASTM B571.

3.4.4 Corrosion Resistance

3.4.4.1 Type II Grade A or B parts, regardless of base alloy, or representative test specimens conforming to 4.3.3.2 shall show no visual evidence of white corrosion products after 96 hours exposure to continuous salt spray corrosion testing conducted in accordance with ASTM B117.

3.4.4.2 Type I, Type II Grade A and B, and Type III, ferrous metal parts or representative test specimens conforming to 4.3.3.2 shall show no visual evidence of red rust corrosion products on the basis metal in controlled thickness areas after 500 hours exposure to continuous salt spray corrosion testing conducted in accordance with ASTM B117.

3.4.5 Hydrogen Embrittlement

The plating process after baking shall not cause hydrogen embrittlement in steel parts and fasteners 36 HRC and over.

3.4.5.1 Parts, Except Fasteners

Hydrogen-embrittlement testing shall be in accordance with the requirements of ASTM F519 using Type 1a.1 notched round bar stressed in tension under sustained load. For test purposes, plating thickness shall be 0.0005 inch (13 µm) minimum, measured on the smooth unnotched sections of the specimen but with visual plating at the root of the notch. Testing beyond the 200-hour test period is not required. The test specimens shall be exposed to all steps of the documented plating process, including stress relief, surface preparation, strike (if applicable), electroplating, bake, and post-treatment.

3.4.5.2 Fasteners

3.4.5.2.1 Externally threaded or grooved fasteners that can be loaded in tension by an axial application of a load up to 20000 pounds (9072 kg [8896 N]), or reasonable load limits of test equipment, shall be hydrogen-embrittlement tested as specified in NASM1312-5. If the load requirement is greater than the reasonable limits of the test equipment, the notched specimen procedure in 3.4.5.1 shall be used. The minimum test load shall be 85% of the minimum ultimate tension load specified in the product specification (this is in lieu of the 75 to 80% load stated in NAS1312-5).

3.4.5.2.2 Internally threaded fasteners shall be tested as specified in NASM1312-14.

3.4.5.2.3 For all fasteners tested, the load shall be sustained for a minimum of 72 hours. At the completion of testing, the test specimens shall be disassembled and inspected for the presence of cracks in accordance with ASTM E1444/E1444M for magnetic materials or ASTM E1417/E1417M for other materials. If found, these cracks shall constitute failure of the test. Fasteners used for embrittlement testing shall be scrapped at completion of testing.

3.5 Quality

Plating, as received by the purchaser, shall be smooth, continuous, adherent to basis metal, uniform in appearance with color variations as allowed for Grades A and B (see 1.3.1.3), and visually free from pin holes, porosity, blisters, nodules, pits, and other imperfections detrimental to usage of the plating. There shall be no evidence of electrical arcing or local overheating. Slight staining or discoloration is permissible.

3.5.1 Carbon steel, low-alloy steel, and martensitic stainless steel parts heat treated to a hardness of 40 HRC and higher shall have a dull to matte luster or appearance (see 3.2.1.3).

3.5.2 The color of the finished plated parts with the supplementary chromate treatment shall be as specified in 1.3.1.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor shall supply all specimens for the processor's tests and shall be responsible for the performance of all required tests. Where parts are to be tested, the 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 specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

Thickness (see 3.4.2) and quality (see 3.5) are acceptance tests and shall be performed on parts, or specimens, from each lot. When specified (see Ordering Information), hydrogen embrittlement (see 3.4.5) is an acceptance test and shall be performed on each lot.

4.2.2 Periodic Tests

Composition (see 3.4.1) is a periodic test and shall be performed at least quarterly unless frequency of testing is specified. Adhesion (see 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. Corrosion resistance (white corrosion) (see 3.4.4.1) is a periodic test and shall be performed at least monthly unless frequency of testing is specified. Corrosion resistance (red corrosion) (see 3.4.4.2) is a periodic test and shall be performed at least annually unless frequency of testing is specified. Tests of strike thickness (see 3.4.2.5) and cleaning and processing solutions are periodic tests and shall be performed at a frequency established by the processor unless frequency of testing is specified (see 4.4.3, 8.5, and 8.6). Hydrogen embrittlement (see 3.4.5) is a periodic test and shall be performed at least once in each month that steel parts and fasteners 36 HRC and over are plated unless frequency of testing is specified.

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

4.3 Sampling for Testing

4.3.1 Acceptance Tests

Test samples shall be selected randomly 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 that 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 supplies a sampling plan, the minimum number of samples shall be as shown in Table 1. If lot testing of fasteners for hydrogen embrittlement is specified (see Ordering Information) and a sampling plan is not provided, then the sample size shall be a minimum of two specimens per lot.

Table 1 - Sampling for acceptance tests

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

(1) Whichever is less.

4.3.2 Periodic Tests

Sample quantities shall be two for corrosion resistance. For hydrogen embrittlement of parts other than fasteners, the number of specimens shall be as specified in ASTM F519. For hydrogen embrittlement of fasteners, four representative samples shall be taken from a production lot of 36 HRC and over ferrous fasteners processed during the month. For adhesion tests, sample quantity shall be 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 quantities for other tests shall be at the discretion of the processor unless otherwise specified by the cognizant engineering organization.