



AEROSPACE MATERIAL SPECIFICATION

AMS-QQ-P-416™**REV. F**Issued 2000-07
Revised 2021-03

Superseding AMS-QQ-P-416E

(R) Plating, Cadmium (Electrodeposited)

RATIONALE

AMS-QQ-P-416F results from a Five-Year Review and complete revision of this specification.

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:

- AMS-QQ-P-416F
- Type (see 1.3.1)
- Class (see 1.3.2)
- Thickness of plating (see 3.3.1)
- Quantity of pieces to be plated
- Lot hydrogen embrittlement testing if required and sampling (see 4.4.2.3)
- Basis metal to be plated
- Tensile strength or hardness of the basis metal (see 5.2.5)
- Preplate stress relief to be performed by plating processor (time and temperature) if different from 3.2.1
- Stress and embrittlement relief temperature if the upper operating temperature is less than 275 °F (135 °C) (see 3.2.1.6 and 3.2.7.1)
- Special features, geometry, or processing present on components that requires special attention by the plating processor
- Hydrogen embrittlement relief to be performed by plating processor (parameters or reference document) if different from 3.3.4
- If steel components were machined, ground, cold formed or cold straightened after heat treatment (see 3.2.1)

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Full document details: SAE AMSQQP416F

For more information on this standard, visit
<https://www.sae.org/standards/content/AMSQQP416F>

Documents
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- Statement that all heat treatments and mechanical operations such as machining, brazing, welding, forming, and perforating have been completed prior to plating (see 3.2.3)
 - Optional: Fixture/electrical contact locations, when not specified (see 3.2.5)
 - Optional: Hydrogen embrittlement relief testing of each lot (see 4.4.2.3)
 - Optional: Process approval requirement (see 4.7.1)
 - Optional: Processing records requirement (see 4.7.2)
2. Components 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 component. 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 electrodeposited cadmium plating.

1.2 Application

The electrodeposited cadmium platings covered by this specification are intended for use as corrosion protective coatings. Unless otherwise specified, components heat treated to an ultimate tensile strength greater than 200 ksi (1379 MPa) or harder than 43 HRC should not be plated in accordance with this specification. Section 5 contains more information about the appropriateness of this process and the coating material. It also describes alternatives to cadmium plating.

1.3 Classification

Cadmium plating shall be of the following types and classes, as specified (see ordering information):

1.3.1 Types

- I - As plated
- II - With supplementary chromate treatment (see 3.2.9.1 and 3.2.9.2)
 - Grade A - Hexavalent chromate treatment, maximum service temperature 250 °F (121 °C)
 - Grade B - Hexavalent chrome free treatment, maximum service temperature 375 °F (191 °C)
- III - With supplementary phosphate treatment (see 3.2.9.3)

1.3.1.1 For Type II plating, if no grade is specified, Grade A shall be supplied. Processors shall have the option to use Grade B if permitted by the cognizant engineering organization.

1.3.1.2 Type II, Grade A may be listed as Type IIA and Type II Grade B may be listed as Type IIB; the terms are equivalent.

1.3.2 Classes

- 1 - 0.0005 inch (0.0127 mm), minimum
- 2 - 0.0003 inch (0.0076 mm), minimum
- 3 - 0.0002 inch (0.0051 mm), minimum

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 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
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 B244	Measurement of Thickness of Anodic Coatings on Aluminum and of other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
ASTM B487	Measurement of Metal and Oxide Coating Thicknesses 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 E29	Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E376	Measuring Coating Thickness by Magnetic-Field or Eddy Current (Electromagnetic) Testing Methods
ASTM F519	Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments

2.3 U.S. Government Publications

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

DD Form 1423

DI-NDTI-80809B

DOD FAR Supplement 215.470

MIL-DTL-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-STD-1916	DoD Preferred Methods for Acceptance of Product
TT-C-490	Chemical Conversion Coatings and Pretreatments for Metallic Substrates (Base for Organic Coatings)

2.4 AIA Publications

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

NASM1312-1	Fastener Test Methods - Method 1, Salt Spray
NASM1312-5	Fastener Test Methods - Method 5, Stress Durability
NASM1312-12	Fastener Test Methods - Method 12, Thickness of Metallic Coatings
NASM1312-14	Fastener Test Methods - Method 14, Stress Durability, Internally Threaded

3. REQUIREMENTS

3.1 Materials

The materials used shall be such as to produce platings that meet the requirements of this specification.

3.1.1 Inventory

Items in inventory that were plated prior to the issuance of this revision may be used until the supply is exhausted.

3.2 General Requirements

3.2.1 Preplate Stress Relief

Steel components having a hardness of 34 HRC and higher that have been machined, ground, cold-formed, or cold-straightened after heat treatment, shall be cleaned as required to remove surface contamination and thermally stress relieved prior to plating. Stress relief is optional for components with hardness below 34 HRC (see 5.10).

- 3.2.1.1 All components having a hardness from 34 to 55 HRC, including nitrided components, shall be thermally stress relieved at $375^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($191^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for 4 to 10 hours prior to plating.
- 3.2.1.2 Carburized components and components with hardness higher than 55 HRC shall be stress relieved at $275^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($135^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for 5 to 10 hours prior to plating.
- 3.2.1.3 Stress relief shall precede shot peening, cleaning, and plating for relief of damaging residual tensile stresses.
- 3.2.1.4 For components being overhauled, previously shot peened surfaces may be stress relieved but shall not be baked at temperatures above $375^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($191^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for components up to 55 HRC or $275^{\circ}\text{F} \pm 25^{\circ}\text{F}$ ($135^{\circ}\text{C} \pm 14^{\circ}\text{C}$) for components heat treated above 55 HRC.
- 3.2.1.5 Furnaces used for stress relief shall be controlled per AMS2750; the minimum requirements shall be Class 5 and Type D instrumentation.
- 3.2.1.6 Components with upper operating temperature limits of less than 275°F (135°C) shall be stress relieved at a specified temperature for not less than 5 hours (see ordering information).
- 3.2.1.7 Stress relief is not required for fasteners if all cold working is limited to cold working of the head-to-shank fillet and thread rolling after heat treatment.

3.2.2 Cleaning

All components shall be cleaned in accordance with MIL-DTL-5002. Fasteners heat treated to 160 ksi (1103 MPa) tensile strength or 36 HRC, or higher, shall be cleaned in accordance with MIL-DTL-5002 and the following:

- a. Abrasive cleaning shall be used for removal of heat treat scale and oxidation as applicable. Acid pickling is not permitted.
- b. Alkaline cleaning shall be used as applicable with anodic (reverse) current or no current. Cathodic (direct) current cleaning with the component serving as the cathode shall not be used.
- c. A clean water rinse shall be used as applicable following each cleaning or plating operation.
- d. Surface activation of the component in an inhibited acid is acceptable for purposes of plating adhesion.

3.2.3 Plating Application

The plating shall be applied after all basis metal heat treatments and mechanical operations, such as machining, brazing, welding, forming, and perforating of the article, have been completed. It is the responsibility of the customer to ensure that all basis metal heat treatments and mechanical operations such as machining, brazing, welding, forming, and perforating have been completed prior to plating. The basis metal shall be free from visible defects that will be detrimental to the appearance or protective value of the plating.

3.2.4 Strike

Cadmium shall be deposited on the basis metal without a strike of other metal, except in the case of components made of corrosion resistant alloys on which a strike of nickel or copper may be necessary, or on components made of aluminum on which a preliminary treatment, such as the zincate process or a strike of copper or electroless nickel, may be necessary.

3.2.5 Fixture/Electrical Contact Locations

- 3.2.5.1 Except for barrel plating, for components that are to be electroplated all over, and contact locations are not specified, contact locations shall be at the discretion of the processor.
- 3.2.5.2 For components 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.

3.2.6 Coverage

The plating shall cover all surfaces as stated in 3.3.1, including roots of threads, corners, and recesses.

3.2.7 Hydrogen Embrittlement Relief

All components shall be baked within 4 hours after the plating operation in accordance with AMS2759/9 except threaded fasteners between 150 ksi and 220 ksi (1034 MPa and 1517 MPa) tensile strength shall be baked for 23 hours minimum and steel components between 160 ksi and 180 ksi (1103 MPa and 1241 MPa) tensile strength shall be baked for 8 hours minimum. Components with hardness of 55 HRC and higher shall be baked for 23 hours minimum at 275 °F ± 25 °F (135 °C ± 14 °C). Plated springs and other components subject to flexure shall not be flexed prior to hydrogen embrittlement relief treatment. In the case of Type IIA, Type IIB, and Type III treated components which require baking, the baking treatment shall be done prior to the application of the supplementary coatings. Cadmium plated surfaces passivated as a result of the baking operation shall be reactivated prior to receiving the Type IIA or Type IIB supplementary treatment (see 5.5). The following alloys are not considered susceptible to hydrogen embrittlement from the cadmium plating process, and therefore do not require the hydrogen embrittlement relief or the hydrogen embrittlement relief test of 3.3.4:

- a. UNS S66286, UNS N07718, UNS R30159, UNS R30035, UNS N04400, UNS N06600, UNS N07750
- b. 300 series austenitic stainless steels
- c. Aluminum and aluminum alloys