

Plating, Cadmium (Electrodeposited)

RATIONALE

AMS-QQ-P-416C was issued to correct a publishing error related to hydrogen embrittlement testing.

1. SCOPE AND CLASSIFICATION

1.1 Scope

This specification covers the requirements for electrodeposited cadmium plating.

1.2 Classification

Cadmium plating shall be of the following types and classes, as specified (See 6.2):

1.2.1 Types

- I - As plated
- II - With supplementary chromate treatment (See 3.2.8.1)
- III - With supplementary phosphate treatment (See 3.2.8.2)

1.2.2 Classes

- 1 - 0.0005 inch, minimum
- 2 - 0.0003 inch, minimum
- 3 - 0.0002 inch, minimum

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.

1.4 Warning

This document includes cadmium as a plating material. The use of cadmium has been restricted and/or banned for use in many countries due to environmental and health concerns. The user should consult with local officials on applicable health and environmental regulations regarding its use.

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 reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2009 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
SAE WEB ADDRESS: http://www.sae.org

SAE values your input. To provide feedback on this Technical Report, please visit
<http://www.sae.org/technical/standards/AMSQQP416C>

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 724-776-4970 (outside USA), www.sae.org.

AMS2750	Pyrometry
AMS6414	Steel Bars, Forgings, and Tubing, 0.80Cr - 1.8Ni - 0.25Mo (0.38-0.43C), (SAE 4340), Vacuum Consumable Electrode Remelted
AMS6415	Steel, Bars, Forgings, and Tubing, 0.80Cr - 1.8Ni - 0.25Mo (0.38-0.43C) (SAE 4340)

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 B 117	Salt Spray (Fog) Testing
ASTM B 244	Measurement of Thickness of Anodic Coatings on Aluminum and of other Nonconductive Coatings on Nonmagnetic Basis Metals with Eddy-Current Instruments
ASTM B 487	Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section
ASTM B 499	Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals
ASTM B 504	Measurement of Thickness of Metallic Coatings by the Coulometric Method
ASTM B 567	Measurement of Coating Thickness by the Beta Backscatter Method
ASTM B 568	Measurement of Coating Thickness by X-Ray Spectrometry
ASTM E 8	Tension Testing of Metallic Materials
ASTM E 29	Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
ASTM E 376	Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Examination Methods

2.3 U.S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://assist.daps.dla.mil/quicksearch/>.

TT-C-490	Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings
MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-STD-1916	DoD Preferred Methods of Acceptance of Product

2.4 National Aerospace Standards:

Available from AIA, Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928 or <http://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 Fasteners)

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 amendment may be used until the supply is exhausted.

3.2 General Requirements

3.2.1 Preplate Stress Relief

Unless otherwise specified by purchaser (6.2e), steel parts which have been machined, ground, cold-formed, or cold-straightened after heat treatment, shall be stress relieved in accordance with Table 1 or Table 1A, as applicable. Stress relief shall precede shot peening, cleaning, and plating for relief of damaging residual tensile stresses. 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

Unless otherwise specified (See 6.2), all parts shall be cleaned in accordance with MIL-S-5002. Fasteners heat treated to 160 ksi (or 36 HRC) or above, shall be cleaned in accordance with MIL-S-5002 and the following:

- a. Abrasive cleaning shall be used for removal of heat treat scale and oxidation as applicable (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 part 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 part in an inhibited acid is acceptable for purposes of plating adhesion.

3.2.3 Plating Application

Unless otherwise specified (See 6.2), 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.

3.2.4 Underplating

Unless otherwise specified (See 6.2), cadmium shall be deposited on the basis metal without a preliminary plating of other metal, except in the case of parts made of corrosion resistant alloys on which a preliminary plating of nickel or copper may be necessary, or on parts made of aluminum on which a preliminary treatment, such as the zincate process or preliminary plating of copper or electroless nickel, may be necessary.

3.2.5 Coverage

Unless otherwise specified (See 6.2), the plating shall cover all surfaces as stated in 3.3.1, including roots of threads, corners, and recesses.

3.2.6 Luster

Unless otherwise specified in the engineering drawing or procurement documentation (or in 3.2.6.1), the use of brightening agents, or other additives which produce brightened deposits in the plating solution, is prohibited on components with a specified heat treatment of 180 ksi minimum tensile strength (or 40 HRC) and higher. Either a bright (not caused by brightening agents) or dull luster shall be acceptable. Brighteners may be used with the alloys listed in 3.2.7.

3.2.6.1 Use of Brighteners with Bearings

Unless otherwise specified in the engineering drawing or procurement specification, the use of brighteners is permitted for annular bearings. For rod end bearing bodies, track roller studs, and end washers of needle track roller bearings, the amount of brightener added to the plating bath shall be limited to 20% of the normal charge.

3.2.7 Hydrogen Embrittlement Relief Treatment

Unless otherwise specified in the contract or order (See 6.2), or stated in the end product specification or drawing, all parts shall be baked within 4 hours after the plating operation is completed as specified in Table 1 or Table 1A, as applicable. Plated springs and other parts subject to flexure shall not be flexed prior to hydrogen embrittlement relief treatment. In the case of Types II and III treated parts 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 II supplementary chromate treatment (See 6.5). The following alloys are not considered susceptible to hydrogen embrittlement from the cadmium plating process, and therefore do not require the hydrogen embrittlement relief treatment (See Tables I and IA), 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

3.2.7.1 Baking Procedure Control

The bake furnace pyrometry shall conform to AMS2750. All parts shall be baked continuously at temperature, within the specified range. Interruptions for loading and unloading parts shall be permitted provided the time between the opening of the furnace door, and the re-establishment of the specified baking temperature, is not used to determine the total cumulative bake time. The specified baking temperature shall be considered to be re-established when all control, indicating and recording thermocouples reach the specified baking temperature.

3.2.8 Supplementary Treatments

Unless otherwise specified in the contract or order (See 6.2), the cadmium plating shall be Type II on parts that will not subsequently be completely coated and Type III on parts that will subsequently be completely coated (See 6.1.2 and 6.1.3).

3.2.8.1 Chromate Treatment

Unless otherwise specified in the contract or order (See 6.2), the chromate treatment required for conversion to Type II shall be a treatment in or with an aqueous solution of salts, acids, or both, to produce a continuous smooth, distinct protective film, distinctly colored iridescent bronze to brown including olive drab, yellow, and forest green. The articles so treated shall be thoroughly rinsed and dried in accordance with the requirements of the process used. Usual chromic and nitric acid bright dips for cadmium are not chromate treatments.

3.2.8.2 Phosphate Treatment

Unless otherwise specified in the contract or order (See 6.2), the phosphate treatment required for conversion to Type III shall produce a tightly adherent film conforming to Type I of TT-C-490.

3.3 Detail Requirements

3.3.1 Thickness of Plating:

- a. Unless otherwise specified (See 6.2), for surfaces that can be touched by a sphere 0.75 inches in diameter, including external threads, the minimum thickness of cadmium plating shall be as specified for each class in 1.2.2. If not specified, the maximum shall be the minimum plus 0.0003 inch.

- b. For internally threaded parts, a maximum limit of 0.0005 inch above the minimum shall be allowed on the external surfaces.
- c. For surfaces that cannot be touched by a 0.75 inch 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. See 6.1.1.1.2.
- d. The plating thickness shall be uniform in thickness on surfaces that can be touched by a 0.75 inch sphere except that slight buildup on exterior corners and edges will be permitted provided the finished engineering drawing dimensions are met.
- e. The preliminary plating shall be considered part of the cadmium plating thickness requirement.

3.3.2 Adhesion

The adhesion of the plating shall be such that when examined at a magnification of 4 to 10 diameters, the plating shall not show separation from the basis metal nor from any underplating at the interface, nor shall any underplate show separation from the basis metal at the interface when subjected to the tests described in 4.6.2 and Table 2. The interface between the underplate and the basis metal is the surface before plating. The formation of cracks in the plating caused by rupture of the basis metal, the underplate or combination of both which do not result in flaking, peeling or blistering of the plating shall not be considered as nonconformance to this requirement.

3.3.3 Corrosion Resistance

Type II areas required to be covered (See 3.3.1) shall not show white corrosion products of cadmium, pitting, or basis metal corrosion products at the end of 96 hours when tested by continuous exposure to the salt spray in accordance with 4.6.3 and Table 2. The appearance of corrosion products visible to the unaided eye shall be cause for rejection, except that white corrosion products at the edges of specimens (See 4.5.2) shall not constitute failure.

3.3.4 Hydrogen Embrittlement Relief Test

Unless otherwise specified, hydrogen embrittlement testing is required for parts heat treated to 160 ksi (or 36 HRC) or above, but is not required for bearings, except rod end bearing bodies, track roller bearing studs, and end washers on needle track roller bearings. Unless otherwise specified in the product specification or drawing, testing shall be in accordance with 4.6.4 as specified in 4.4.2.3 and 4.4.3. Rod end bearing bodies, track roller bearing studs and end washers of needle track roller bearings shall be tested as specified in 4.6.4.3. There shall be no cracking or fracture of the plated parts or the prepared test specimens.

3.4 Environmental Requirements

All cadmium plating facilities and equipment shall comply with EPA and Federal, State, and local guidelines (See 6.6).

3.5 Workmanship

3.5.1 Basis Metal

The basis metal shall be free from visible defects that will be detrimental to the appearance or protective value of the plating.

3.5.2 Appearance

The cadmium plating shall be smooth, adherent, uniform in appearance, free from blisters, pits, nodules, burning, and other defects when examined visually without magnification. The plating shall show no indication of contamination or improper operation of equipment used to produce the cadmium deposit, such as excessively powdered or darkened plating. Superficial staining, which has been demonstrated as resulting from rinsing, or slight discoloration resulting from any drying or baking operations as specified shall not be cause for rejection.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in this specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance

All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Classification of Inspections

The inspection requirements specified herein are classified as quality conformance inspections and tests (See 4.4).

4.3 Inspection Conditions

All inspections shall be performed in accordance with the test conditions specified in the applicable test method or applicable paragraph in this specification.

4.4 Quality Conformance Inspection and Tests

The quality conformance inspection shall consist of the following:

- a. Process control inspection (4.4.1)
- b. Lot sampling inspection (4.4.2)
- c. Production control testing (4.4.3)

4.4.1 Process Control Inspection

4.4.1.1 Control Records

The processor shall maintain a record of the history of each processing bath, showing all additions of chemicals or treatment solutions to the unit, and the results of all chemical analyses performed. Upon request of the acquisition activity or government inspector, such records, as well as reports of the test results, shall be made available. These records shall be maintained for not less than one year after completion of the contract or purchase order.

4.4.2 Lot Sampling Inspection

The lot sampling inspection shall consist of the examinations and tests specified in 4.4.2.2. When specified in the contract or order (See 6.2), hydrogen embrittlement testing shall be conducted as specified in 4.4.2.3.

4.4.2.1 Lot

A lot shall consist of plated articles of the same basis metal composition, class, and type plated and treated under the same conditions and submitted for inspection at one time.

4.4.2.2 Sampling for Visual Examination and Thickness of Plating

Sampling for visual examination and thickness of plating tests shall be conducted. A sample of plated parts or articles, except for those barrel plated, shall be taken at random from each lot, the number of articles in accordance with MIL-STD-1916, VL = II, or as indicated in Table 3, or as specified by purchaser. Unless specified otherwise, the sampling chosen shall be the option of the plater. Barrel plated parts or articles shall be sampled in accordance with MIL-STD-1916, VL = I, or as specified by purchaser. The lot shall be accepted or rejected according to the procedures in 4.4.2.2.1 for visual examination and 4.4.2.2.2 for plating thickness.

4.4.2.2.1 Visual Examination

Samples selected in accordance with 4.4.2.2 shall be examined for compliance with requirements of 3.5.2 after plating. If the number of nonconforming items exceeds the acceptance number for the sample, the lot represented by the sample shall be rejected. Separate specimens (4.5) shall not be used for visual examination tests.

4.4.2.2.2 Thickness of Plating

Samples selected in accordance with 4.4.2.2 shall be inspected and the plating thickness measured by the applicable test detailed in 4.6.1 at one or more locations on each article in order to ensure compliance with the requirements of 3.3.1. Measurements on fastener hardware shall be made at locations defined in NASM1312-12. The part or article shall be considered nonconforming if one or more measurements fail to meet the specified minimum thickness. If the number of defective items in any sample exceeds the acceptance number for the specified sample, the lot represented by the sample shall be rejected. Separate specimens (4.5) shall not be used for thickness requirements.

4.4.2.3 Hydrogen Embrittlement Relief Test (Lot Testing)

When specified in the contract or order (See 6.2), hydrogen embrittlement testing shall be performed on each lot. Sampling shall be as specified (See 6.2). Unless otherwise specified, the test method shall be in accordance with 4.6.4.

4.4.3 Production Control Tests

Unless otherwise specified, production control tests shall consist of all the tests specified in Table 2. If hydrogen embrittlement relief testing is performed on each lot (4.4.2.3) and the lot size is such that the frequency of testing is greater than that detailed in 4.4.3.2, the production control test for hydrogen embrittlement may be waived.

4.4.3.1 Sampling for Production Control Tests

Four plated parts or prepared test specimens (4.5) for each of the required tests specified in Table 2 shall be sampled from production at the times specified in 4.4.3.2.

4.4.3.2 Frequency of Tests

The production control test schedule shall be as follows:

- a. The first products or specimens plated at start of first, second and third week of production shall be tested.
- b. The first products or specimens plated at start of fifth and seventh week of production and then at the start of production every four weeks thereafter shall be tested.
- c. Any failure shall immediately halt production. All parts produced since the last acceptable test shall be considered suspect. The reason for failure shall be determined and corrected before production resumes. The lots of platings produced using the faulty procedure or material shall not be acceptable.

4.4.3.3 Procedure for Follow on Contracts

When a processor is in continuous production of plating from contract to contract; and there have been no failures in production control tests, the processor may continue testing at his current frequency of test level to start the new contract.

4.5 Separate Specimen Preparation

When the plated articles are of such form, shape, size, or value as to prohibit use thereof, or are not readily adaptable to a test specified herein, or when destructive tests of small lot sizes are required, the test shall be made by the use of separate specimens plated concurrently with the articles represented. The specimens shall be as specified in 4.5.1, 4.5.2, 4.5.3, and Table 2 and shall be distributed such that the tests are performed on each plating bath. When it is impractical to forge separate test specimens, hot-rolled steel specimens may be used to represent forged steel articles. When ferrous alloy castings are being plated, the separate specimens may be cut from scrap castings.

4.5.1 Specimens for Adhesion Tests

If separate specimens for adhesion tests are required, they shall be strips approximately 1 inch wide, 4 inches long, and 0.04 inch thick.

4.5.2 Specimens for Corrosion Resistance Tests

If separate specimens for corrosion resistance test are required, they shall be panels not less than 6 inches in length, 4 inches in width, and approximately 0.04 inch thick.

4.5.3 Specimens for Embrittlement Relief Test

See 4.6.4.1.

4.6 Tests

4.6.1 Thickness (Lot by Lot Inspection)

For nondestructive measuring of plating thickness, procedures in accordance with ASTM E 376, ASTM B 499 (magnetic test), ASTM B 244 (eddy current), ASTM B 567 (test by beta radiation backscatter principle) or ASTM B 568 (X-ray spectrometry) shall be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B 487 (microscopic) or ASTM B 504 (coulometric) shall be used. In addition to the above, the other procedures embodied in NASM1312-12 may be used for thickness measurement of plating fastener hardware. Thickness measurements of cadmium platings, Types II and III, shall be made after application of the supplementary treatments. When the coulometric test is used, the supplementary treatment shall be removed prior to testing. The chromate film may be removed from the Type II coating by using a very mild abrasive (a paste of levigated alumina rubbed on with the finger). The phosphate coating may be removed from the Type III coating by immersing the specimen in a 10 percent solution of NaOH and scrubbing with a rubber policeman (usually takes from 10 to 15 minutes).

4.6.1.1 Measure Method

Measurement of plating thickness shall use the Rounding Method as specified in ASTM E 29.

4.6.2 Adhesion (Production Control Test)

Adhesion shall be determined by scraping the surface or shearing with a sharp edge, knife, or razor through the plating to the basis metal and examining at four to ten diameters magnification for evidence of non-adhesion. Alternatively, the article or specimen may be clamped in a vise and the projecting portion bent back and forth until rupture of the basis metal and/or plating occurs. If the edge of the ruptured plating can be peeled back or if separation between the plating and basis metal can be seen at the point of rupture when examined at four diameter magnification, adhesion is not satisfactory. If adhesion is not satisfactory, the pre-plating, cleaning, and plating processes, as well as the materials, shall be evaluated and the cause of failure eliminated.

4.6.3 Corrosion Resistance (Production Control Test)

Corrosion resistance shall be conducted in accordance with ASTM B 117 (salt spray test) for 96 hours or, for fastener hardware, in accordance with NASM1312-1. To secure uniformity of results, Type II supplementary coatings shall be aged at room temperature for 24 hours minimum before subjected to the salt spray.

4.6.4 Hydrogen Embrittlement Relief Test

4.6.4.1 Specimens

Test shall be in accordance with the requirements of ASTM F 519 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 plating thickness shall be Class 1, 0.0005 inch minimum measured on the smooth section of the specimen, but with visual evidence of plating at the root of the notch. In lieu of the ASTM F 519 required 260-280 ksi heat treat strength level, specimens may be heat treated to the same tensile strength or higher than the parts represented. Specimens plated with the parts lot shall have the same supplementary treatment as the parts.

4.6.4.2 Fasteners

Externally threaded or grooved fasteners that can be loaded in tension by an axial application of a load up to 20,000 pounds or reasonable load limits of test equipment, shall be tested as specified in NASM1312-5. When the load requirement is greater than the reasonable limits of the test equipment, the notched specimen procedure (4.6.4.1) shall be used. Internally threaded fasteners shall be tested as specified in NASM1312-14. The minimum test load shall be 85 percent of the minimum ultimate tension load specified in the end product specification. The load shall be sustained for not less than 72 hours. The fasteners shall be examined for conformance to 3.3.4.

4.6.4.3 Bearings

Test pieces for rod end bearing bodies, track roller bearing studs, and end washers of needle track roller bearings shall be either the plated bearing component or notched specimens, at the option of the bearing manufacturer. Notched specimens shall conform to 4.6.4.1 and shall be plated with the bearing parts lot they represent. They shall be subjected to a sustained tensile load equal to 75 percent of its notched ultimate tensile strength. The bearing component shall be loaded in tension to produce a stress level of 75 percent of its ultimate tensile strength. Loads shall be maintained for not less than 72 hours and specimens or bearings shall be examined for compliance with 3.3.4. At the bearing manufacturer's option, end washers may be tested simultaneously with the needle bearing track roller stud.

4.6.4.4 Other Parts or Articles

Parts such as spring pins, lock rings, etc., which are installed in holes or rods, shall be similarly assembled using the applicable parts specifications or drawing tolerances that impose the maximum sustained load on the plated part. The articles or parts shall be subjected to the sustained load for not less than 200 hours then examined for conformance to 3.3.4.

5. PACKAGING

(This section is not applicable to this specification).

6. NOTES

NOTICE

This document references a part which contains cadmium as a plating material. Consult local officials if you have questions concerning cadmium's use.

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

6.2 Intended Use

6.2.1 General Usage

The electrodeposited cadmium platings covered by this specification are intended for use as corrosion protective coatings. Processes used for cleaning and cadmium deposition on parts heat-treated to, or having ultimate tensile strength of 160 ksi (or 36 HRC) or greater, should be such that hydrogen embrittlement is minimized. Unless otherwise specified in the purchase order, engineering drawing, parts standard, or procurement specification, parts heat treated to an ultimate tensile strength greater than 200 ksi (or 43 HRC), should not be plated in accordance with this specification.

6.2.1.1 Limitations

6.2.1.1.1 Temperatures

Cadmium plating should not be used on parts for space applications or on parts that in service reach a temperature of 450 °F (232 °C) or higher or come in contact with other parts that reach those temperatures. Cadmium plating should not be used on titanium parts, and cadmium plated parts should not be used in contact with titanium parts.

6.2.1.1.2 Plating of Internal Diameters

When process limitations will not allow cadmium to be deposited on internal diameters that require corrosion protection, an alternative method of protection should be specified in a drawing or acquisition document. For example, it is difficult to obtain complete plating coverage in areas beyond a hole depth of 2.5 times the hole diameter for holes equal to, or smaller than, 0.75 inch in diameter.

6.2.1.2 Mechanical Deposition

To avoid problems of hydrogen embrittlement on hardened steel parts, such as chains and springs, it may be helpful to use the mechanical deposition method of cadmium plating. (This process is covered in AMS-C-81562 and ASTM B 696.)

6.2.2 Type II Treatment

The prime purpose of chromate treatment (Type II) on electrodeposited cadmium plating is to retard or prevent the formation of white corrosion products on surfaces exposed to stagnant water, high humidity atmosphere, salt water, marine atmosphere, or cyclic condensation and drying. Type II treatment is preferred for parts that will not subsequently be completely coated.

6.2.2.1 Type II Temperature Limitations

Chromate treatment (Type II) should not be used on plated parts that will not be coated and that will be continuously exposed to temperatures in excess of 150 °F (66 °C) or intermittently exposed for short periods to temperatures of approximately 300 °F (149 °C) or more. However, this treatment may be used to prevent finger marking and corrosion which may occur at room temperature during assembly and storage.

6.2.2.2 Type II Handling Precaution

Chromate treatment (Type II), which involves only dipping in chemical solutions, normally requires a sufficient period of drying, approximately 24 hours at 70 °F to 90 °F (21 °C to 32 °C), to render the parts suitable for handling without damage to the coating while in gelatinous forms. It is important with such coatings that the workmanship be such that the coating is not excessively damaged while wet. Type II treatment should be dried for 24 hours before painting.

6.2.3 Type III Treatment

The prime purpose of phosphate finishes (Type III) on electrodeposited cadmium plating is to form a coating base. Because of the enhanced adhesion properties, the phosphate finish is preferred for parts that will subsequently be completely coated.

6.2.4 Brighteners

Brighteners are organic or metallic compounds that when added to alkaline cyanide cadmium plating baths, influence the formation of the electrodeposited cadmium crystals.

6.2.5 Tensile Strength and Hardness Values

The heat treated material tensile strength and hardness values as specified in this document represent the minimum values specified in the procurement specification or end product drawing. They do not represent the values obtained from actual hardness or tensile testing of the component, or calculations of tensile strength based on actual tested values and various stress areas.

6.3 Acquisition Requirements

Acquisition documents must specify the following:

- a. Title, number, and date of the specification.
- b. Type and class required (See 1.2, 3.2.8, and 3.3.1).
- c. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (See 2.1 and 2.2).
- d. When plating is to be applied and areas to be covered, if other than specified (See 3.2.3, 3.2.5 and 3.3.1).
- e. Preplate stress relief treatment if different from 3.2.1 or if already performed by purchaser.
- f. Cleaning of steel, if other than specified (See 3.2.2).
- g. Underplating required, if other than specified (See 3.2.4).
- h. Luster required, if other than specified (See 3.2.6).
- i. Hydrogen embrittlement relief treatment, if other than specified (See 3.2.7).
- j. Type of chromate treatment required for conversion to Type II, if other than specified - for example, colorless (See 3.2.8.1).
- k. Type of phosphate treatment required for conversion to Type III, if other than specified (See 3.2.8.2).
- l. Thickness of plating, if other than specified (See 3.3.1).
- m. Lot hydrogen embrittlement testing if required (See 4.4.2) and sampling (See 4.4.2.3).

6.3.1 The manufacturer of the parts should provide the plating facility with the following data:

- a. The minimum specified heat treated tensile strength or hardness of steel parts (See 6.1.5).
- b. Heat treatment for stress relief, whether it has been performed or required (See 3.2.1).
- c. Tensile loads required for embrittlement relief test, if applicable (See 4.6.4).

6.4 Consideration of Data Requirements

The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/provided and that the DID's are tailored to reflect the requirements for the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title
4.4.1.1	DI-MISC-80653	Test Reports

The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.

6.5 Stress Relief

There is a hazard that hardened and tempered cold-worked or cold-straightened steel parts may crack during cleaning and plating. Such parts should have a suitable heat treatment for stress relief prior to cleaning and plating (See 3.2.1).

6.6 Reactivation

Surfaces of cadmium plating intended for conversion to Type II and that have become passive as a result of the baking operation may be reactivated by brief immersion in dilute acid. For example, if the chromating solution is acidified with sulfuric acid, then the reactivating solution should be 1 part sulfuric acid (sp. gr. 1.83) by volume added to 99 parts water, or if the chromating solution is acidified with hydrochloric acid, then the activating solution should be 1 part hydrochloric acid (sp. gr. 1.16) by volume added to 99 parts water. The duration of immersion should be as brief as is consistent of the nature of the work. For example, a perforated container of barrel-plated parts would be expected to be reactivated in approximately 15 seconds and separately racked items in approximately 5 seconds. The surfaces should be reactivated as soon as possible following baking operation and should be handled carefully to avoid contamination by dirt or grease.

6.7 Toxicity

Cadmium, because of its toxicity, should not be employed as a plating for any object intended for use as a food container, cooking utensil, or for any object likely to come in contact with food. Cadmium plated sheets and any other structural shapes that may be subjected to heat from welding, brazing or soldering operations should be so labeled because of the danger from poisonous vapors during operations.

6.7.1 Alternative Coatings

Because of the hazards involved with cadmium use, alternative coatings should be considered when possible. The advantages and disadvantages of substitution should be carefully examined for each unique application. Some possible alternative coatings are:

Aluminum (vapor deposition)	Zinc (electrodeposition; mechanical plating; diffusion)
Cd-Ti (electrodeposition)	Zn-Cd (electrodeposition)
Lead (electrodeposition)	Zn-Ni (electrodeposition)
Nickel (electroless deposition)	Acrylic (spray; brush)
Ni-Cd (electrodeposition)	Epoxy (spray; brush; electro-static spray)
Tin (mechanical plating; electroless deposition)	Fluorocarbons (dip; spray; electro-static spray; fuse)
Sn-Cd (electrodeposition; mechanical plating)	Nylon (fluidized bed; electrostatic spray; fuse)
Sn-Ni (electrodeposition)	Polyester (electrostatic spray)
Sn-Zn (electrodeposition; mechanical plating)	Polyurethane (spray; brush)

6.8 Packaging Limitations

Cadmium plated articles should not be packed in non-ventilated containers, either together or in contact with electrical equipment, because of the danger of deleterious effect on cadmium plating from unstable organic electrical insulation. In addition to organic electrical insulation, phenolic resinous substances and others containing unsaturated carbon-to-carbon linkages, such as oil, paint and impregnated paper, etc., cause an abnormal attack on cadmium by setting free, in the presence of moisture, formic acid, butyric acid, etc. Corrosion of cadmium coatings and steel basis metal has been noted when cadmium plated articles have been packaged in direct contact with container materials such as wood or cardboard. Corrosion has been especially severe if the container materials have become wet or have been stored under conditions of high humidity.

6.9 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary: dimensions and properties in SI units and the Celsius temperatures are shown as the approximate equivalents of the primary units and are presented only for information.

6.10 The original issue of AMS-QQ-P-416 was taken directly from Federal Specification QQ-P-416F, Amendment 2 and contained only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. This, the current issue, incorporates Amendment 3 with editorial changes, adds warning statements 1.3 and 1.4, and updates several reference documents.

PREPARED BY AMS COMMITTEE "B"