AEROSPACE MATERIAL SPECIFICATION

AMS-QQ-P-416™	REV. E
Issued 2000-07 Revised 2016-01 Superseding AMS-QQ-P-416D	

Plating, Cadmium (Electrodeposited)

RATIONALE

Revision E of AMS-QQ-P-416 corrects the errors in Table 1a and removes the “24 hours minimum” from the drying time requirement of 3.2.8.1.

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-416E
   - Type (see 1.1.1)
   - Class (see 1.1.2)
   - Lot hydrogen embrittlement testing if required (see 4.4.2) 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
   - Special features, geometry or processing present on parts 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
   - 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 purchaser and is not controlled by this specification.

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/AMSQQP416E

1. SCOPE

This specification covers the requirements for electrodeposited cadmium plating.

1.1 Classification

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

1.1.1 Types

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

1.1.2 Classes

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

1.2 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

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 a 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 http://quicksearch.dla.mil.

TT-C-490 Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

MIL-DTL-5002 Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems

MIL-STD-1916 DoD Preferred Methods of Acceptance of Product

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 amendment may be used until the supply is exhausted.

3.2 General Requirements

Unless otherwise specified (see Ordering Information) parts having an ultimate tensile strength of greater than 200 ksi (or HRC 43) shall not be plated in accordance with this specification.

3.2.1 Preplate Stress Relief

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

All parts shall be cleaned in accordance with MIL-DTL-5002. Fasteners heat treated to 160 ksi (or 36 HRC) or above, 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 (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

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

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

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

3.2.6 Hydrogen Embrittlement Relief Treatment

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 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 treatment (see Tables 1 and 1A), 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.

3.2.6.1 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.

3.2.7 Luster

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 3.2.6. Use of brighteners is allowed for those alloys listed in 3.2.6 that do not require embrittlement relief treatment.

3.2.7.1 Use of Brighteners with Bearings

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.

3.2.8 Supplementary Treatments

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 5.2.2 and 5.2.3).

3.2.8.1 Chromate Treatment

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 (see 5.2.2.2). Usual chromic and nitric acid bright dips for cadmium are not chromate treatments.

3.2.8.2 Phosphate Treatment

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. 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 1.1.2. 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 5.2.1.1.2).

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 4-10X, 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

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.

3.4 Environmental Requirements

All cadmium plating facilities and equipment shall comply with EPA and Federal, State, and local guidelines (see 5.7).

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.

3.5.2.1 Appearance after application of supplementary treatments (3.2.8) shall be essentially uniform in color and appearance. Superficial staining, which has been demonstrated as resulting from rinsing, or slight discoloration resulting from any drying or baking operations shall not be cause for rejection.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The processor 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 processor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser 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 Section 3. The inspection set forth in this specification shall become a part of the processors overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the processor of the responsibility of ensuring that all products or supplies submitted to the purchaser 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 purchaser 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 purchaser, 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, 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 (see 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 Ordering Information), hydrogen embrittlement testing shall be performed on each lot. Sampling shall be as specified (see Ordering Information). Unless otherwise specified, the test method shall be in accordance with 4.6.4.

4.4.3 Production Control Tests

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 (see 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 month 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 four (4) 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 four (4) 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 E376, ASTM B499, ASTM B244, ASTM B567 or ASTM B568 shall be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B487 or ASTM B504 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% solution of NaOH and scrubbing with a rubber policeman (usually takes from 10 to 15 minutes). Direct dimensional inspection is permissible in lieu of the above provided the resolution of the measuring instrument is ten times more precise than the attribute being measured.

4.6.1.1 Measure Method

Measurement of plating thickness shall use the Rounding Method as specified in ASTM E29.

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 4-10X magnification for evidence of non-adhesion. Alternatively, the article or specimen may be tested in accordance with ASTM B571 bend test – no mandrel, 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 4-10X 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 B117 (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 by the processor at room temperature for 24 hours minimum before submittal for salt spray testing.

4.6.4 Hydrogen Embrittlement Relief Test

4.6.4.1 Specimens

Testing shall be in accordance with the requirements of ASTM F519 Type 1a.1 using four (4) round notched specimens, stressed in tension under sustained 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. The notch and 0.5 inch on both sides of the notch sample shall be plated. Testing beyond the 200 hour test period is not required. The test samples shall be exposed to all steps of the documented plating process including stress relieve, surface preparation (reagent, electro-cleaning, or abrasive blasting as applicable) In lieu of the ASTM F519 required 260 to 280 ksi heat treat strength level, specimens may be heat treated to the same tensile strength or higher than the parts represented. Specimens representing a parts lot (see 4.4.2) 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% 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% of its notched ultimate tensile strength. The bearing component shall be loaded in tension to produce a stress level of 75% 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. 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.)

5.1 Revision Indicator

A change bar (l) 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.

5.2 Intended Use

5.2.1 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 incorporate practices and procedures to minimize hydrogen embrittlement. Unless otherwise specified on the, engineering drawing, Standard parts or hardware drawing, 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.

5.2.1.1 Limitations

5.2.1.1.1 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.

5.2.1.1.2 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.

5.2.1.2 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 B696.)

5.2.2 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.

5.2.2.1 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.

5.2.2.2 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 to 90 °F (21 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.

5.2.3 Type III Treatment

The prime purpose of phosphate finish (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.

5.2.4 Brighteners

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

5.2.5 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.

5.3 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 215.470 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title
4.4.1.1	DI-NDTI-80809B	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.

5.4 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 of damaging tensile stresses prior to cleaning and plating (see 3.2.1).

5.5 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.

5.6 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.

5.6.1 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)
Cd-Ti (electrodeposition)
Lead (electrodeposition)
Nickel (electroless deposition)
Ni-Cd (electrodeposition)
Tin (mechanical plating; electroless deposition)
Sn-Cd (electrodeposition; mechanical plating)
Sn-Ni (electrodeposition)
Sn-Zn (electrodeposition; mechanical plating)
Zinc (electrodeposition; mechanical plating; diffusion)
Zn-Cd (electrodeposition)
Zn-Ni (electrodeposition)
Acrylic (spray; brush)
Epoxy (spray; brush; electro-static spray)
Fluorocarbons (dip; spray; electro- static spray; fuse)
Nylon (fluidized bed; electrostatic spray; fuse)
Polyester (electrostatic spray)
Polyurethane (spray; brush)

5.7 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.

5.8 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.

5.9 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. Revision C incorporated Amendment 3 with editorial changes, adds warning statements 1.3 and 1.4, and updates several reference documents. The current revision contains numerous updates and clarifications in requirements and testing protocols.

Table 1 - Stress relief and embrittlement relief requirements for fasteners, rod end bearing bodies, track roller bearing studs, and end washers of needle track roller bearings. 1/, 6/

Type of Part	Tensile Strength (Equivalent Hardness) or Hardness	Stress Relief 5/ (Before Plating)		Embrittlement Relief (After Plating)		
		Temperature for Stress Relief	Time for Stress Relief	Time Between Plating and Baking	Temperature for Baking	Time for Baking
2/	HRC 55 and over	275 °F ± 25 °F 3/	5 hours minimum	Shall not exceed 4 hours	275 °F ± 25 °F 4/	23 hours minimum
All Other Parts	150 ksi and above (or HRC 33 and above)	375 °F ± 25 °F	4 hours minimum	Shall not exceed 4 hours	375 °F ± 25 °F	23 hours minimum
	Below 150 ksi (below 33 HRC)	No requirement		No requirement		

1/ Stress and embrittlement relief requirements contained in engineering drawings, part standards, procurement specifications or contract/purchase orders shall take precedence over these requires.

2/ Parts, including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating to 375 °F.

3/ Parts with upper operating temperature limits of less than 275 °F shall be stress relieved in at appropriate temperature for not less than 5 hours.

4/ Parts with upper operating temperature limits of less than 275 °F shall be baked at an appropriate temperature for not less than 23 hours.

5/ Stress relieving may also be accomplished by heating to a temperature no higher than 50 °F below the tempering temperature for a time period no less than 1 hour per inch of thickness.

6/ Embrittlement relief baking and stress relieving are not required for the materials listed in 3.2.6.

Table 1A - Stress and embrittlement relief requirements for parts other than those covered in Table 1 1/, 6/

Type of Part	Strength Level (Equivalent Hardness) or Hardness	Stress Relief (Before Plating) 5/		Embrittlement Relief (After Plating)		
		Temperature for Stress Relief	Time for Stress Relief	Time Between Plating and Baking	Temperature for Baking	Time for Baking
2/	55 HRC and above	275 °F ± 25 °F (135 °C ± 14 °C) 3/	5 hours minimum	Shall not exceed 4 hours	275 °F ± 25 °F (135 °C ± 14 °C) 4/	23 hours minimum
All Other Steel Parts	220 ksi and above (46 HRC and above)	375 °F ± 25 °F (190 °C ± 14 °C)	4 hours minimum	Shall not exceed 4 hours	375 °F ± 25 °F (190 °C ± 14 °C)	23 hours minimum
	160 up to 220 ksi (36 up to 46 HRC)	375 °F ± 25 °F (190 °C ± 14 °C)	4 hours minimum	Shall not exceed 4 hours	375 °F ± 25 °F (190 °C ± 14 °C)	8 hours minimum
	150 up to 160 ksi (34 up to 36 HRC)	375 °F ± 25 °F (190 °C ± 14 °C)	4 hours minimum	No requirement		
	Below 150 ksi (Below 34 HRC)	No requirement		No requirement		

1/ These are general requirements. Stress and embrittlement relief requirements contained in Military Standard drawings or contract/purchase orders shall take precedence over these requires.

2/ Parts, including carburized parts, which will decrease in hardness or be otherwise deleteriously affected by heating to 375 °F.

3/ Parts with upper operating temperature limits of less the 275 °F shall be baked in at appropriate temperature for not less than 5 hours.

4/ Parts with upper operating temperature limits of less the 275 °F shall be baked in at appropriate temperature for not less than 23 hours.

5/ Stress relieving may also be accomplished by heating to a temperature no higher than 50 °F below the tempering temperature for a time period no less than 1 hour per inch of thickness.

6/ Embrittlement relief baking and stress relieving are not required for the materials listed in 3.2.6.

Table 2 – Production control tests and specimens 2/

Test	Reference Paragraph		
	Requirement	Specimen Preparation	Test Method
Adhesion	3.3.2	4.5 and 4.5.1 1/	4.6.2
Corrosion Resistance	3.3.3	4.5 and 4.5.2 1/	4.6.3
Hydrogen Embrittlement	3.3.4	4.5 and 4.5.3	4.6.4

1/ Standard alloy steel shall be used for production control specimens. Alloy steels such as AISI or SAE number 4130 heat treated to the same tensile strength or higher than the parts being represented shall be used.

2/ Tests are for all types, except for corrosion resistance which is for Type II only.

Table 3 - Sampling for visual examination and nondestructive tests

Number of Items in Lot	Number of Items in Samples (Randomly Selected) 1/	Acceptance Number (maximum number of sample items nonconforming to any test)
15 or less	7	0
16 to 40	10	0
41 to 110	15	0
111 to 300	25	1
301 to 500	35	1
501 to 700	50	2
701 to 1200	75	2
1201 and over	125	3

1/ If the number of items in the inspection lot is 7 or less, the number of items in the sample shall equal the number of items in the inspection lot.

PREPARED BY AMS COMMITTEE “B”