INCH-POUND

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FEDERAL SPECIFICATION

PLATING, CADMIUM (ELECTRODEPOSITED)

This specification has been approved by the Commissioner, Federal Supply Service, General Services Administration, for use by all Federal Agencies.

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 3.2.9.1)
III - With supplementary phosphate treatment (see 3.2.9.2)

1.2.2 Classes.

1	-	0.00050 inch minimum
2	-	0.00030 inch minimum
3	-	0.00020 inch minimum

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Air Engineering Center, Systems Engineering and Standardization Department (Code 5312), Lakehurst, NJ 08733-5100, by using the attached Standardization Document Improvement Proposal (DD Form 1426), or by letter.

AMSC N/A

AREA MFFP

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SPECIFICATIONS

FEDERAL

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

MILITARY

MIL-S-5000	-	Steel, Chrome-Nickel-Molybdenum, (E4340), Bars and Reforging Stock
MIL-S-5002	-	Surface Treatments and Inorganic Coatings for Metal Surfaces of Weapons Systems
MIL-S-8844	-	Steel Bars, Reforging Stock, and Mechanical Tubing, Low Alloy, Premium Quality
MIL-C-81562	-	Coating, Cadmium, Tin Cadmium and Zinc (Mechanically Deposited)

STANDARDS

FEDERAL

FED-STD-151	-	Metals; Test Methods

MILITARY

MIL-STD-105	Sampling Procedure and Tables for Inspection by Attributes
MIL-STD-1312-1	Fastener Test Methods - Method 1, Salt Spray
MIL-STD-1312-5	Fastener Test Methods - Method 5, Stress Durability
MIL-STD-1312-12	Fastener Test Methods - Method 12, Thickness of Metallic Coatings
MIL-STD-1312-14	Fastener Test Methods - Method 14, Stress Durability (Internally Threaded Fasteners)

(Unless otherwise indicated, copies of federal and military specifications and standards are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM B117	-	Salt Spray (Fog) Testing
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 E8 - Tension Testing of Metallic Materials

(Application for copies should be addressed to the American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103-1187.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

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

3.2 General requirements.

3.2.1 High tensile strength parts. Unless otherwise specified (see 6.2), parts having an ultimate tensile strength of greater than 200 ksi (or HRC 43) shall not be plated in accordance with this specification.

3.2.2 Stress relief treatment. Unless otherwise specified (see 6.2), parts which have been machined, ground, cold formed, or cold straightened after heat treatment, shall receive a stress relief treatment in accordance with Table I or Table IA, as applicable, prior to shot peening, cleaning, and plating for the relief of damaging residual tensile stresses. For fastener hardware, cold working of the head-to-shank fillet radius and thread rolling after heat treat produce compressive stresses and a stress relief treatment is not required on parts thus affected.

3.2.3 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 HRC 36) 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.

3.2.4 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.

3.2.5 Underplating. Unless otherwise specified (see 6.2), cadmium shall be deposited directly 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, may be necessary.

3.2.6 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.

3.2.7 Luster. Unless otherwise specified in the engineering drawing or procurement specification (or in 3.2.7.1), the use of brightening agents, or other additives which produce brightened deposits, in the plating solution is prohibited on components with an ultimate tensile strength of 160 ksi (or HRC 36) or higher. Either a bright (not caused by brightening agents) or dull luster shall be acceptable (see 6.2).

3.2.7.1 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.

3.2.8 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 I or Table IA, 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).

3.2.9 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).

3.2.9.1 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 throughly 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.

3.2.9.2 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. Unless otherwise specified (see 6.2), the minimum thicknesses of cadmium plating shall be as specified for each class in Table II. If not specified, the maximum shall be the minimum plus 0.0003 inch. When a class is not specified, it shall be Class 2. For Types II and III, the minimum cadmium thickness requirements shall be met after the supplementary treatment. Internal surfaces, including parts with internal threads, shall not be subject to thickness requirements due to processing limitations that may result in incomplete coverage. When corrosion protection is required on internal surfaces, the method of protection shall be specified (see 6.1.1.1.2 and 6.2).

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 III. 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 III. 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 HRC 36) 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 defect. 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-105, inspection Level II with an acceptable quality level (AQL) of 1.5 percent defective, or as indicated in Table IV. The sampling chosen shall be the option of the plater. Barrel plated parts or articles shall be sampled in accordance with inspection level S-3 of MIL-STD-105 with an AQL of 4.0 percent defective. 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 several 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 MIL-STD-1312-12. 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 measurements.

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 III. 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 III 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 III 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. Separate specimens for the embrittlement relief test shall be four round notched specimens, one or more heats of alloy steel 4340 conforming to MIL-S-5000 or MIL-S-8844, Class 1, or the same material as the part being represented, heat treated to the same tensile strength or higher than the parts represented. The configuration shall be in accordance with Figure 8 of ASTM E8 for rounded specimens. Specimens shall have a 60 degree V-notch located approximately at the center of the gage length. The cross section area at the root of the vee shall be approximately equal to half the area of the full cross section area of the specimen's reduced section. The vee shall have a 0.010 ± 0.0005 inch radius of curvature at the base of the notch. Specimens plated with the part lot to represent the parts for testing purposes shall be prepared so that the load is applied in the longitudinal grain direction.

4.6 Tests.

4.6.1 Thickness (Lot by lot inspection). For nondestructive measuring of plating thickness, procedures in accordance with FED-STD-151, method 520 (electronic test), ASTM B499 (magnetic test), ASTM B244 (eddy current), ASTM B567 (test by beta radiation backscatter principle) or ASTM B568 (X-ray spectrometry) shall be used. For destructive measuring of plating thickness, procedures in accordance with ASTM B487 (microscopic) or ASTM B504 (coulometric) shall be used. In addition to the above, the other procedures embodied in MIL-STD-1312-12 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).

4.6.2 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. Alternately, 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 B117 (salt spray test) for 96 hours or, for fastener hardware, in accordance with MIL-STD-1312-1. To secure uniformity of results, Type II supplementary coatings shall be aged at room temperature for 24 hours minimum before subjection to the salt spray.

4.6.4 Hydrogen embrittlement relief test.

4.6.4.1 Specimens. Specimens (4.5.3) plated with the parts lot shall have the same supplementary treatment as the parts and shall be subjected to a sustained tensile load equal to 75 percent of the notched ultimate tensile strength of the material. The specimens shall be subjected to the sustained load for not less than 200 hours, then examined for compliance with 3.3.4.

4.6.4.2 Fasteners. Externally threaded or grooved fasteners which 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 MIL-STD-1312-5. 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 MIL-STD-1312-14. 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 4.5.3 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 which 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

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

6.1 Intended use.

6.1.1 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 HRC 36) or greater, should be such that hydrogen embrittlement is minimized.

6.1.1.1 Limitations.

6.1.1.1.1 Temperatures. Cadmium plating should not be used on parts for space applications or on parts which in service reach a temperature of 450°F (232°C) or higher or come in contact with other parts which 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.

6.1.1.1.2 Plating of internal diameters. When process limitations will not allow cadmium to be deposited on internal diameters that require corrosion protection, an alternate method of protection should be specified in a drawing or acquisition document.

6.1.1.2 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 MIL-C-81562 and ASTM B696.)

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

6.1.2.1 Type II temperature limitations. Chromate treatments (Type II) should not be used on plated parts that will not be coated and which 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, these treatments may be used to prevent finger marking and corrosion which may occur at room temperature during assembly and storage.

6.1.2.2 Type II handling precaution. Chromate treatments (Type II), which involve only dipping in chemical solutions, normally require 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; and it is important with such coatings that the workmanship be such that the coating is not excessively damaged while wet. Type II platings should be dry for 24 hours before painting.

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

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification
b. Type and class required (see 1.2, 3.2.9, 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 3.2.1, 3.2.4, 3.2.6 and 3.3.1)
e. Stress relief treatment, if other than specified (see 3.2.2)
f. Cleaning of steel, if other than specified (see 3.2.3)
g. Underplating required, if other than specified (see 3.2.5)
h. Luster required, if other than specified (see 3.2.7)
i. Hydrogen embrittlement relief treatment, if other than specified (see 3.2.8)
j. Type of chromate treatment required for conversion to Type II, if other than specified - for example, colorless (see 3.2.9.1)
k. Type of phosphate treatment required for conversion to Type III, if other than specified (see 3.2.9.2)
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 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.

6.4 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 prior to cleaning and plating (see 3.2.2).

6.5 Reactivation. Surfaces of cadmium plating intended for conversion to Type II and which 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.

6.6 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 which may be subjected to heat from welding, brazing or soldering operations should be so labeled because of the danger from poisonous vapors during operations.

6.6.1 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)
Zinc (electrodeposition; mechanical plating; diffusion)
Zn-Cd (electrodeposition)
Zn-Ni (electrodeposition)
Acrylic (spray; brush)

Ni-Cd (electrodeposition)
Tin (mechanical plating; electroless deposition)
Sn-Cd (electrodeposition; mechanical plating)
Sn-Ni (electrodeposition)
Sn-Zn (electrodeposition; mechanical plating)

Epoxy (spray; brush; electrostatic spray)
Fluorocarbons (dip; spray; electrostatic spray; fuse)
Nylon (fluidized bed; electrostatic spray; fuse)
Polyester (electrostatic spray)
Polyurethane (spray; brush)

6.7 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.

6.8 Subject term (key word) listing.

Bearings
Chromate
Corrosion Resistance
Embrittlement Relief
Fasteners
Hydrogen Embrittlement
Phosphate
Supplementary Treatments
Toxic
Vapors, poisonous

6.9 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

TABLE I. 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/

Type of Part	Tensile Strength (ksi) / Hardness (RC)	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/	RC 55 and over	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	160 ksi and above (or RC 36 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
	below 160 ksi (below RC 36)	375°F ± 25°F (190°C ± 14°C)	4 hours minimum	No requirement		
	below 150 ksi (below 34 RC)	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 requirements.

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 baked at an 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 one hour per inch of thickness.

7/ IA. Stress and embrittlement relief requirements for parts other than those covered in Table I. 1/

Type of Part	Strength Level (ksi) / Hardness (RC)	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/	RC 55 and over	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 (or RC 46 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 ksi and above (or RC 36 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)	8 hours minimum
	below 160 ksi (below RC 36)	375°F ± 25°F (190°C ± 14°C)	4 hours minimum	No requirement		
	below 150 ksi (below 34 RC)	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 requirements.

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 baked at an 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 one hour per inch of thickness.

TABLE II. Plating Thickness

Class	Minimum Thickness 1/			
	For external surfaces which can be touched by a ball 0.75 inch in diameter		For external surfaces which can not be touched by a ball 0.75 inch in diameter	
	inch	micrometers (approximate)	inch	micrometers (approximate)
1	0.00050	13	0.00030	8
2	0.00030	8	0.00020	5
3	0.00020	5	0.00015	4

1/ 0.001 inch = 1 mil = 25.4 micrometers (microns)

TABLE III. 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 IV. 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.

MILITARY INTEREST:

Custodians

Army - MR
Navy - AS
Air Force - 11

Review Activities

Army - AL, AR, ER, GL
Navy - SH
Air Force - 70, 99, 82, 84
DLA - IS(E)

User Activities

Army - AT, ME, MI
Navy - MC, YD

CIVIL AGENCY COORDINATING ACTIVITIES:

GSA - FSS
COM - NBS

PREPARING ACTIVITY:

NAVY - AS

DOD Project MFFP-0377

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER	2. DOCUMENT DATE (YYMMDD)
	QQ-P-416F	91 October 1

3. DOCUMENT TITLE
PLATING, CADMIUM (ELECTRODEPOSITED)

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

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