

MIL-C-8837B
29 September 1983
SUPERSEDING
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MILITARY SPECIFICATION

COATING, CADMIUM (VACUUM DEPOSITED)

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for three types and three classes for vacuum deposited cadmium coating.

1.2 Classification. The cadmium coatings shall be of the following types and classes, as specified (see 6.2.1):

1.2.1 Types.

- I - As coated
- II - With supplementary chromate treatment (see 3.3.8)
- III - With supplementary phosphate treatment (see 3.3.9)

1.2.2 Classes.

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

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this specification to the extent specified herein.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Engineering Specifications and Standards Department (Code 93), Naval Air Engineering Center, Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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SPECIFICATIONS

FEDERAL

- QQ-A-671 - Anode, Cadmium.
- TT-C-490 - Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings.

STANDARDS

MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- MIL-STD-1312 - Fasteners, Test Methods.

(Copies of specifications, standards, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2 Other publications. The following documents form a part of this specification to the extent specified herein. The issues of the document which are indicated as DoD adopted shall be the issue listed in the current DoDISS and the supplement thereto, if applicable.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM B 117 - Salt Spray (Fog) Testing.
- ASTM B 499 - Coating Thickness by the Magnetic Method; Nonmagnetic Coatings on Magnetic Basis Metal, Measurement of.
- ASTM B 504 - Thickness of Metallic Coatings by the Coulometric Method, Measurement of.
- ASTM B 567 - Coating Thickness by the Beta Backscatter Method, Measurement of.
- ASTM B 568 - Coating Thickness by X-Ray Spectrometry, Measurement of.

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

(Industry association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

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

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3.1.1 Composition. The cadmium metal for production of the coating shall conform to the composition requirements of QQ-A-671. The coating composition shall contain not less than 99.90 percent cadmium by weight (see 6.4). When specified in the contract or order, the composition of the coating shall be determined (see 6.2.1).

3.2 Process. The process used to accomplish cadmium coating shall be such that a temperature rise above 232°C (450°F) in the parts shall not occur which will cause adverse action between the coating and the substrate.

3.3 General requirements.

3.3.1 Coating application. Unless otherwise specified, the coating 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.

3.3.2 Stress relief treatment. All steel parts shall be given a stress relief heat treatment at a minimum of $191^{\circ} \pm 14^{\circ}\text{C}$ ($375^{\circ} \pm 25^{\circ}\text{F}$) for 3 hours or more, prior to cleaning and coating, if they contain or are suspected of having residual tensile stresses caused by machining, grinding or cold forming operations. Parts which are cold straightened are considered to contain damaging residual tensile stresses (see 6.5). The temperature and time at temperature shall be such that maximum stress relief is obtained without reduction in hardness to less than the specified minimum.

3.3.3 Blast cleaning. Immediately prior to coating, surfaces to be coated shall be lightly dry abrasive blasted using new materials or materials that have not been used on any other metal and cleaned with oil-free dry air. The blasted surfaces shall not have a surface roughness greater than the finish specified in the contract, order or applicable drawing.

3.3.4 Undercoating. Unless otherwise specified, cadmium shall not be deposited directly on the basis metal without a preliminary coating of other metal.

3.3.5 Coverage. The coating shall completely cover all surfaces as stated in 3.4.1 and 3.4.1.1, including roots of threads, recesses and sharp corners.

3.3.6 Finish. Unless otherwise specified in the contract or order, the surfaces shall have light matte or semi-satin finish.

3.3.7 Chromate treatment (Type II). Unless otherwise specified in the contract or order, the chromate treatment required for conversion to Type II shall be a chemical treatment in or with an aqueous solution of salts, acids, or both, and contain hexavalent chromium and activating acid radical(s) which shall produce a continuous, smooth, distinct protective film, distinctly colored iridescent bronze to brown including olive drab and yellow. The articles so treated shall be thoroughly rinsed and dried in accordance with the requirements of the process used. Type II coating shall be similar in appearance to coatings on separate specimens which are capable of passing the salt-spray test (see 3.4.4, 4.4.2.4 and 4.6.4). Usual chromic and nitric acid bright dips are not chromate treatments. A Type II treatment shall not be applied to a Class 3 finish.

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3.3.8 Phosphate treatment (Type III). Unless otherwise specified in the contract or order, the phosphate treatment required for conversion to Type III shall be a chemical treatment in an aqueous solution of phosphoric acid, phosphates and accelerating chemicals to produce a tightly adherent film conforming to Type I of TT-C-490 and consisting essentially of water-insoluble zinc phosphates (see 3.4.5). A Type III treatment shall not be applied to a Class 3 finish. In addition, the Type III coating should be applied only with an immersion process that has a minimum of 0.2 percent ferrous iron.

3.4 Detail requirements.

3.4.1 Thickness of coating. Unless otherwise specified in the contract or order, the thickness of the cadmium coating shall be as specified in Table I on all visible surfaces which can be touched by a ball 0.75 inch in diameter. Where Class 1 is specified, all other visible surfaces shall be Class 2 minimum thickness. If the maximum thickness for Class 1 is not specified in the contract, order or applicable drawing, the thickness shall not exceed 0.0008 inch (0.8 mil). Where Class 2 is specified, all other visible surfaces shall be Class 3 minimum thickness. Where Class 3 is specified, all other visible surfaces shall be not less than 0.00015 inch minimum thickness.

3.4.1.1 Fastening hardware. The cadmium coating shall be Class 1 thickness unless otherwise specified in the contract or order or controlled by the following exceptions (see 6.9):

- a. Bolts, studs, washers and articles with portions externally threaded. These parts shall have a minimum of Class 2 thickness at the measured locations.
- b. Holes and other openings, and internal threads from which the external environment is completely excluded shall not be subject to a thickness requirement but shall show evidence of coating. There shall be no bare areas.

3.4.2 Types. Unless otherwise specified in the contract or order, the cadmium coating shall be Type II. For use on surfaces to be painted, the cadmium coating shall be either Type II or Type III (see 6.1.2 and 6.1.3).

3.4.3 Adhesion. The adhesion of the coating shall be such that when examined at a magnification of approximately 4 diameters, the coating shall not show separation from the basis metal at the interface when subjected to the tests described in 4.6.3. The interface between the coating and the basis metal is the surface of the basis metal before coating. The formation of cracks in the coating caused by rupture of the basis metal which do not result in flaking, peeling, or blistering of the coating shall not be considered as nonconformance to this requirement.

3.4.4 Corrosion resistance. Cadmium coating with the Type II treatment shall show neither white corrosion products of cadmium nor basis metal corrosion products

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at the end of 96 hours when tested by continuous exposure to the salt spray in accordance with 4.6.4. The appearance of corrosion products, visible to the unaided eye at normal reading distance, shall be cause for rejection, except that white corrosion products at the edges of specimens shall not constitute failure.

3.4.5 Water resistance. Paint coatings applied to surfaces with the supplementary chromate (Type II) or phosphate (Type III) treatment shall show no blistering after the water resistance test described in 4.6.5. When specified in the contract or order, the water resistance of the Type II or Type III coating shall be determined (see 6.2.1).

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 coating. The basis metal shall be subject to such cleaning and coating procedures as necessary and as specified herein to yield deposits as herein specified.

3.5.2 Coating. The cadmium coating shall be smooth, fine grained, adherent, uniform in appearance, free from staining, pits, burning and other defects. The coating shall show no indication of contamination or improper operation of equipment used to produce the cadmium deposit, such as excessively powdered or darkened coatings. All details of workmanship shall conform to the best practice for high quality coating.

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 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 the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspection. The inspection requirements specified herein are classified as quality conformance inspection.

4.3 Lot. A lot shall consist of coated articles of the same material, type and class, coated and treated under the same conditions, and approximately the same size and shape submitted for inspection at one time.

4.4 Sampling.

4.4.1 For visual examination and nondestructive tests. Sampling for visual examination and nondestructive tests shall be conducted in accordance with either MIL-STD-105 or Table II, whichever is preferred by the contractor. A sample of the coated parts or articles shall be drawn, by taking at random from each lot, the number of articles in accordance with MIL-STD-105, Inspection Level II, Acceptable Quality Level (AQL) of 1.5 percent defective, or as indicated in Table II. The lot shall be accepted or rejected according to the procedures of 4.4.1.1 for visual examination, and 4.4.1.2 for coating thickness (nondestructive tests).

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4.4.1.1 Visual examination. Samples selected in accordance with 4.4.1 shall be examined for compliance with the requirements of 3.5.2 after coating. If the number of nonconforming articles exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

4.4.1.2 Thickness of coating (nondestructive tests). Samples selected in accordance with 4.4.1 shall be inspected and the coating thickness measured by the applicable tests detailed in 4.6.2 at locations on each article as defined in 3.4.1 for compliance with the requirements. Measurements on fastening hardware (see 3.4.1.1) shall be made at locations defined in MIL-STD-1312, Test 12. The articles 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 measurements unless a need has been demonstrated.

4.4.2 For destructive tests. A random sample of four coated parts or articles shall be taken from each lot or four separately coated specimens shall be prepared in accordance with 4.5 to represent each lot. If the number of articles in the lot is four or less, the number of articles in the sample shall be specified by the contracting agency.

4.4.2.1 Composition (destructive tests). Samples selected in accordance with 4.4.2 shall be tested for coating composition as specified in 4.6.1 for compliance with the requirements of 3.1.1.

4.4.2.2 Thickness of coating (destructive tests). If sampling and testing for thickness of coating by nondestructive testing is not applicable, samples selected in accordance with 4.4.2 shall be measured for coating thickness by the applicable tests detailed in 4.6.2 at several locations on each article as defined in 3.4.1 for compliance with the specified requirements. Measurements on threaded articles, such as screws, nuts, bolts and other fasteners, shall be made on the shank or other smooth surfaces as close to the threads as possible. If the coating thickness at any place on any article or specimen is less than the specified minimum thickness, the lot shall be rejected. Separate specimens (see 4.5) shall not be used for thickness measurements unless a need has been demonstrated.

4.4.2.3 Adhesion (destructive tests). The articles or specimens used for the destructive thickness test (see 4.4.2.1), if of suitable size and form, may be used as the specimens for the adhesion test to determine compliance with the requirements of 3.4.3. Failure of one or more of the test specimens shall constitute failure of the lot.

4.4.2.4 Corrosion resistance (destructive tests). A set of four separate test specimens, prepared in accordance with 4.5 and 4.5.2, in lieu of treated coated articles, shall be tested to determine compliance with the requirements for corrosion resistance (see 3.4.4). Failure of one or more test specimens shall reject the lot.

4.4.2.5 Water resistance (destructive tests). A set of four separate test specimens, prepared in accordance with 4.5 and 4.5.2, in lieu of the treated coated articles, shall be tested to determine compliance with the requirements for water resistance (see 3.4.5). Failure of one or more of the test specimens shall reject the lot.

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4.5 Specimen preparation. When the coated articles are of such form, shape, size and 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 coated concurrently with the articles represented. The separate specimens shall be of a basis metal equivalent to that of the articles represented. "Equivalent" basis metal includes chemical composition, grade, heat treated condition and finish of surface prior to coating. For example, a cold-rolled steel surface should not be used to represent a hot-rolled steel surface. Due to the impracticality of forging or casting separate test specimens, hot-rolled steel specimens may be used to represent forged and cast-steel articles. The separate specimens may be also cut from scrap castings when ferrous alloy castings are being coated. These separate specimens shall be introduced into a lot at regular intervals, prior to the cleaning operations preliminary to coating and shall not be separated therefrom until after completion of coating. Conditions affecting the coating of specimens including the spacing, coating media, residual air pressure, temperature, etc. in respect to other objects being coated shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented. Separate specimens shall not be used for thickness measurements, however, unless the necessity for their use has been demonstrated.

4.5.1 Specimens for composition, thickness and adhesion tests. If separate specimens for composition, thickness and 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 and water resistance tests. If separate specimens for corrosion resistance and water resistance tests are required, they shall be panels not less than 6 inches in length, 4 inches in width and approximately 0.04 inch thick.

4.6 Tests.

4.6.1 Composition. The composition of the coating shall be determined by using chemical, electrochemical, spectrochemical or X-ray fluorescence procedures and techniques (see 6.4).

4.6.2 Thickness. For nondestructive measuring of coating thickness, procedures in accordance with ASTM B 499 (magnetic test for non-magnetic coatings on magnetic metals), ASTM B 567 (test for beta radiation, backscatter principle) or ASTM B 568 (X-ray spectrometry) may be used. For destructive measuring of coating thickness of fastening hardware, thickness measurements of cadmium coatings, Types II and III, shall be made after application of the supplementary treatments. For destructive measuring of coating thickness, either ASTM B 499 or ASTM B 504 may be used. When the coulometric test is used (see ASTM B 504), the supplementary treatments shall be removed, prior to testing. The chromate film may be removed from Type II coatings by using a very mild abrasive (a paste of levigated alumina rubbed on with the finger). The phosphate coating may be removed from Type III coatings by immersing the specimen in a ten percent solution of NaOH and scrubbing with a rubber policeman (usually takes from ten to fifteen minutes).

4.6.3 Adhesion. Adhesion may be determined by scraping the surface or shearing with a sharp edge, knife, or razor through the coating down to the basis metal and examining at four diameters magnification for evidence of nonadhesion. Alternately the article may be clamped in a vise and the projecting portion bent back and forth until rupture occurs. If the edge of the ruptured coating can be peeled back or if

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separation between the coating and the basis metal can be seen at the point of rupture when examined at four diameters magnification, adhesion is not satisfactory.

4.6.4 Corrosion resistance. Corrosion resistance shall be conducted in accordance with ASTM B 117. To secure uniformity of results, Type II coatings shall be aged at room temperature for 24 hours before subjection to the salt spray.

4.6.5 Water resistance. The samples, after receiving the supplementary treatment with the lot represented, shall be coated with 0.7 - 1.2 mils (dry film thickness) of the primer, topcoat, or primer-topcoat system intended for use on the article. The coated specimens shall be dried in conformance with the requirements of the finish coating materials, either by air drying for 90 hours or by baking at the required temperature for the required period of time followed by 24 hours air drying. The specimens shall then be immersed in distilled water at pH 5.0 to 7.0 at $24^{\circ} \pm 1^{\circ}\text{C}$ ($75^{\circ} \pm 2^{\circ}\text{F}$) for 24 hours. The appearance of blisters in the paint coating shall be cause for rejection.

5. PACKAGING

5.1 Preservation and packing. Preservation and packing methods for vacuum deposited cadmium parts or articles employed by a supplier shall be such as to preclude damaging during shipment and handling.

6. NOTES

6.1 Intended use.

6.1.1 General. The vacuum deposited cadmium coatings covered by this specification are intended for use as corrosion protective coatings on ferrous parts. Because of application procedures used, such parts are free from hydrogen contamination and resultant hydrogen embrittlement thereof. Cadmium deposition by vacuum technology is recommended to be used on steels heat treated to or having an ultimate strength of 200,000 psi or above (approximately Rockwell hardness C 43) rather than electrodeposited cadmium plating in accordance with QQ-P-416.

6.1.2 Type II treatment. The prime purpose of chromate finishes (Type II) on vacuum deposited cadmium coatings 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. Some types of chromate coatings have proved satisfactory as a base for paints.

6.1.3 Type III treatment. The prime purpose of phosphate finishes (Type III) on vacuum deposited cadmium coatings is to form a paint base.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number and date of this specification.
- b. Type and class required (see 1.2.1, 1.2.2 and 3.4.2).

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- c. Whether test for composition is required (see 3.1.1).
- d. When coating is to be applied, if other than specified (see 3.3.1).
- e. Undercoating required (see 3.3.5).
- f. Finish required, if other than specified (see 3.3.7).
- g. Type of chromate treatment required for conversion to Type II, if other than specified (see 3.3.8).
- h. Type of phosphate treatment required for conversion to Type III, if other than specified (see 3.3.9).
- i. Thickness of coating if other than specified (see 3.4.1 and 3.4.1.1).
- j. Whether water resistance test is required (see 3.4.5).
- ~~k. Sampling for visual examination and nondestructive tests (see 4.4.1).~~

6.3 Limitations. Cadmium coatings should not be used on parts which in service reach a temperature of 233°C (450°F) or higher or come in contact with other parts which reach those temperatures. MIL-S-5002 contains additional warning where the cadmium coating shall not be used for weapons systems applications.

6.4 Composition. The composition of the cadmium coating has been specified in order to indicate the purity of the cadmium material that is to be used for processing. Although no simple method exists for determining the cadmium and residual contents of a cadmium deposition, the X-ray fluorescence technique can be used.

6.5 Stress relief. There is a hazard that cold-worked or cold-straightened steel parts may crack during cleaning and coating. Such parts should have a suitable heat treatment for stress relief, prior to cleaning and coating (see 3.3.2 and 3.3.3).

6.6 Threaded parts. As heavier coatings are required for satisfactory corrosion resistance than Class 3, allowance should be made in the manufacture of most threaded articles, such as nuts, bolts and similar fasteners with complementary threads for dimensional tolerances to obtain necessary coating build-up. Certain recessed areas, such as root diameters of threads, have a tendency to exhibit lack of build-up with vacuum deposited coatings like electroplated cadmium and in direct contrast with mechanically deposited cadmium coatings.

6.7 Type II temperature limitations. Chromate treatments (Type II) should not be used on coated parts that will not be painted and which will be continuously exposed to temperatures in excess of 66°C (150°F) or intermittently exposed for short periods to temperatures of approximately 131°C (300°F) or more. These treatments may be used to prevent finger marking and corrosion which may occur at room temperature during assembly and storage.

6.8 Type II handling precautions. Chromate treatments (Type II), which involve only dipping in chemical solutions, normally require a sufficient period of drying, approximately 24 hours at 21°C to 32°C (70°F to 90°F), to render the parts

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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.

6.9 Toxicity. Cadmium, because of its toxicity, shall not be employed as a coating for any object intended for use as a food container, cooking utensil or for any object likely to come in contact with food. Cadmium-coated 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.

6.10 Packaging limitations. Cadmium coated 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 coating 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 paints 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 coated 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.

6.11 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.

Custodians:

Army - MR
Navy - AS
Air Force - 20

Preparing activity:

Navy - AS

(Project MFFP-0248)

Review activities:

Army - AL, AR, EL, MI
Navy - OS
Air Force - 99
DLA - IS(E)

User activities:

Army - AT
Navy - SH

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TABLE I. Thickness.

Class	Thickness	
	Inch, minimum	Approximate equivalent thickness, micrometers <u>1/</u>
1	0.0005	13
2	0.0003	8
3	0.0002	5

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

TABLE II. Sampling for visual examination and nondestructive tests.

Number of items in lot inspections	Number of items in samples (randomly selected)	Acceptance number (maximum number of sample items nonconforming to any test)
15 or less	7 <u>1/</u>	0
16 to 40	10	0
41 to 110	15	0
111 to 300	25	1
301 to 500	35	1
501 and over	50	2

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