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Standard Specification for Electrodeposited Coatings of Cadmium[1]

This standard is issued under the fixed designation B 766; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers the requirements for electrodeposited cadmium coatings on products of iron, steel, and other metals.

NOTE 1—Cadmium is deposited as a coating principally on iron and steel products. It can also be electrodeposited on aluminum, brass, beryllium copper, copper, nickel, and powder metallurgy parts.

1.2 The coating is provided in various thicknesses up to and including 25 µm either as electrodeposited or with supplementary finishes.

1.3 Cadmium coatings are used for corrosion resistance and for corrosion prevention of the basis metal part. The as-deposited coating (Type I) is useful for the lowest cost protection in a mild or noncorrosive environment where early formation of white corrosion products is not detrimental or harmful to the function of a component. The prime purpose of the supplementary chromate finishes (Types II and III) on the electroplated cadmium is to increase corrosion resistance. Chromating will retard or prevent the formation of white corrosion products on surfaces exposed to various environmental conditions as well as delay the appearance of corrosion from the basis metal.

1.4 Cadmium plating is used to minimize bi-metallic corrosion between high-strength steel fasteners and aluminum in the aerospace industry. Undercutting of threads on fastener parts is not necessary as the cadmium coating has a low coefficient of friction that reduces the tightening torque required and allows repetitive dismantling.

1.5 Cadmium-coated parts can easily be soldered without the use of corrosive fluxes. Cadmium-coated steel parts have a lower electrical contact resistance than zinc-coated steel. The lubricity of cadmium plating is used on springs for doors and latches and for weaving machinery operating in high humidity. Corrosion products formed on cadmium are tightly adherent. Unlike zinc, cadmium does not build up voluminous corrosion products on the surface. This allows for proper functioning during corrosive exposure of moving parts, threaded assemblies, valves, and delicate mechanisms without jamming with debris.

2. Referenced Documents

2.1 The following standards form a part of this document to the extent referenced herein.

2.2 *ASTM Standards:*

A 165 Specification for Electrodeposited Coatings of Cadmium on Steel[2]

B 117 Practice for Operating Salt Spray (Fog) Apparatus[3]

B 183 Practice for Preparation of Low-Carbon Steel for Electroplating[4]

B 201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces[4]

B 242 Practice for Preparation of High-Carbon Steel for Electroplating[4]

B 253 Guide for Preparation of Aluminum Alloys for Electroplating[4]

B 254 Practice for Preparation of and Electroplating on Stainless Steel[4]

B 281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings[4]

B 320 Practice for Preparation of Iron Castings for Electroplating[4]

B 322 Practice for Cleaning Metals Prior to Electroplating[4]

B 343 Practice for Preparation of Nickel for Electroplating with Nickel[4]

B 374 Terminology Relating to Electroplating[4]

B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section[4]

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[4]

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[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.08.04on Soft Metals.

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[2] Discontinued; see 1987 *Annual Book of ASTM Standards*, Vol 02.05. Replaced by Specification B 766.

[3] *Annual Book of ASTM Standards*, Vol 03.02.

[4] *Annual Book of ASTM Standards*, Vol 02.05.

B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method[4]
B 507 Practice for Design of Articles to Be Electroplated on Racks[4]
B 558 Practice for Preparation of Nickel Alloys for Electroplating[4]
B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method[4]
B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry[4]
B 571 Practice for Qualitative Adhesion Testing of Metallic Coatings[4]
B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings[4]
B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[4]
E 8 Test Methods for Tension Testing of Metallic Materials[5]
F 519 Method for Mechanical Hydrogen Embrittlement Evaluation of Plating Processes and Service Environments[6]

2.3 *Federal Standard:*

QQ-P-416 Plating, Cadmium (Electrodeposited)[7]

2.4 *International Standard:*

ISO 2082 Metallic Coatings—Electroplated Coatings of Cadmium on Iron or Steel[8]

2.5 *Military Standard:*

MIL-STD-1312 Fasteners, Test Methods[9]

3. Terminology

3.1 *Definitions*—Definitions of terms used in this specification are in accordance with Terminology B 374.

4. Classification

4.1 *Classes*—Electrodeposited cadmium coatings shall be classified on the basis of thickness as follows:

Class	Minimum Thickness, µm
25	25
12	12
8	8
5	5

NOTE 2—Cadmium coatings thicker than 12 µm are normally not economical.

4.2 *Types*—Electrodeposited cadmium coatings shall be identified by types on the basis of supplementary treatment required as follows:

4.2.1 *Type I*—As electrodeposited without supplementary treatment.

4.2.2 *Type II*—With supplementary colored chromate treatment.

4.2.3 *Type III*—With supplementary colorless chromate treatment.

NOTE 3—It is strongly recommended that production items be processed as either Type II or Type III.

5. Ordering Information

5.1 In order to make the application of this specification complete, the purchaser needs to supply the following information to the seller in the purchase order or other governing document:

5.1.1 The name, designation, and date of issue of this specification.

5.1.2 Deposit by class and type (4.1 and 4.2).

5.1.3 Composition and metallurgical condition of the substrate to be coated. Application to high-strength steel parts (6.2).

5.1.4 Heat treatment for stress relief, whether it has been performed or is required (6.3).

5.1.5 Additional undercoat, if required (6.5).

5.1.6 Plating process variation, if required (6.6).

5.1.7 Hydrogen embrittlement relief, if required (6.7).

5.1.8 Desired color of the Type II film (6.8.2).

5.1.9 Location of significant surfaces (7.1.2).

5.1.10 Coating luster (7.5).

5.1.11 Whether non-destructive or destructive tests are to be used in cases of choice (Note 14).

5.1.12 Configuration, procedures, and tensile load for hydrogen embrittlement relief test (9.4, 10.6, Supplementary Requirements S2, and S3).

5.1.13 Whether certification is required (Section 12).

5.1.14 Whether supplementary requirements are applicable.

6. Materials and Manufacture

6.1 *Nature of Coating*—The coating shall be essentially pure cadmium produced by electrodeposition usually from an alkaline cyanide solution.

6.2 *High Tensile Strength Steel Parts*— Steel parts having an ultimate tensile strength greater than 1650 MPa (approximately 50 HRC) shall not be plated by electrodeposition unless authorized by the purchaser.

6.3 *Stress Relief*—Steel parts having an ultimate tensile strength of 1050 MPa (approximately 35 HRC) and above, and that have been machined, ground, cold-formed, or cold-straightened shall be heat-treated at 190 ± 15°C for 5 h or more for stress relief before cleaning and coating.

6.4 *Preparatory Procedures*—The basis metal shall be subjected to such cleaning procedures as necessary to ensure a surface satisfactory for subsequent electroplating. Materials used for cleaning shall have no damaging effects on the basis metal resulting in pits, intergranular attack, stress corrosion cracking, or hydrogen embrittlement. If necessary, cleaning materials for steel parts should be evaluated in accordance with Method F 519.

NOTE 4—For basis metal preparation, the following standards should be employed depending upon the metallurgical composition: Practices B 183, B 242, B 253, B 254, B 281, B 320, B 322, B 343 and B 558.

6.5 *Substrate*—Cadmium shall be deposited directly on the basis metal part without an undercoat of another metal except when the part is either stainless steel or aluminum and its alloys. An undercoat of nickel is permissible on stainless steel. With aluminum and aluminum alloys, the oxide layer shall be

[5] *Annual Book of ASTM Standards*, Vol 03.01.
[6] *Annual Book of ASTM Standards*, Vol 15.03.
[7] Available from U.S. Government Printing Office, Washington DC 20402.
[8] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.
[9] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

removed and replaced by a metallic zinc layer in accordance with Guide B 253. For better adherence, a copper strike or a nickel coating may be applied to the zinc layer before electroplating with the cadmium.

6.6 *Plating Process*—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.

6.7 *Hydrogen Embrittlement Relief*— Steel parts having a tensile strength of 1200 MPa (approximately 38 HRC) and higher shall be baked at 190 ± 15°C for 8 h or more within 4 h after electroplating to provide hydrogen embrittlement relief. Electroplated springs and other parts subject to flexure shall not be flexed, loaded, or used before the hydrogen embrittlement relief treatment. The baking treatment for hydrogen embrittlement relief shall be done before the application of any supplementary chromate treatment. When specified, freedom from embrittlement shall be determined.

NOTE 5—For high-strength steels, greater than 1300 MPa or approximately 40 HRC, it is strongly recommended that the baking time be extended to 23 h or more to ensure hydrogen embrittlement relief.

NOTE 6—Electroplated steel parts, passivated by the baking operation for hydrogen embrittlement relief, require reactivation before the chromate treatment. This application, immersion in a dilute acid solution, should be done as soon as practical. If the chromating solution contains sulfuric acid, then the reactivating solution should be 1 part of sulfuric acid (sp gr 1.83) by volume added to 99 parts of water. If the chromating solution contains hydrochloric acid, then the reactivating solution should be 1 part of hydrochloric acid (sp gr 1.16) by volume added to 99 parts of water. Duration of immersion should be as brief as is consistent with the nature of the work. Separately racked items can be reactivated in approximately 5 s, whereas a perforated container of barrel-plated parts requires approximately 15 s.

6.8 *Chromate Treatment*:

6.8.1 Chromate treatments for Types II and III shall be done in or with special aqueous acidic solutions composed of hexavalent chromium along with certain anions that act as catalyst or film-forming compounds to produce a continuous smooth protective film. Chromic acid and nitric acid bright dips shall not be used for treatment to produce chromate coatings. When proprietary materials are used for this treatment, the instructions of the supplier should be followed.

6.8.2 The Type II film color shall range from an iridescent yellow or a thicker, more protective iridescent bronze or brown to the heavier olive drab. It may also be dyed to a desired color. When necessary, the color of the film shall be indicated by the purchaser and specified by the provision of a suitably colored sample or indicated on the drawing for the part.

6.8.3 The absence of color shall not be considered as evidence of lack of Type III film or as a basis for rejection. Presence of clear Type III film shall be determined by a spot test as specified in 10.4.

6.8.4 Waxes, lacquers, or other organic coatings shall not be used as a substitute for, nor may they be used in conjunction with, supplementary treatments when the purpose is to ensure conformance to the salt spray requirements. Waxes and the like, may be used to improve lubricity.

7. Coating Requirements

7.1 *Thickness*:

7.1.1 The thickness of the coating everywhere on the significant surfaces shall conform to the requirements of the specified class, as defined in 4.1.

7.1.2 Significant surfaces are those normally visible (directly or by reflection) that are essential to the appearance or serviceability of the article when assembled in normal position; or that can be the source of corrosion products that will deface visible surfaces on the assembled article. When necessary, the significant surfaces shall be indicated by the purchaser on applicable drawing of the article, or by the provision of suitably marked samples.

NOTE 7—As heavier coatings are required for satisfactory corrosion resistance than Class 5, allowance should be made in the fabrication of most threaded articles, such as nuts, bolts, and similar fasteners with complementary threads for dimensional tolerances to obtain necessary coating build-up. Flat surfaces and certain shielded or recessed areas, such as root-diameter of threads, have a tendency to exhibit lack of build-up and to be heavier at exposed edges and sharp projections with electrodeposited coatings. This trend is also found with vacuum-deposited cadmium coatings and is in direct contrast with mechanically deposited coatings.

NOTE 8—The coating thickness requirements of this specification is a minimum requirement. Variation in thickness from point to point on an article is inherent in electroplating. Therefore, the thickness will have to exceed the specified value at some points on the significant surfaces to ensure that it equals or exceeds the specified value at all points. Hence, in most cases, the average coating thickness of an article will be greater than the specified value; how much greater is largely determined by the shape of the article (see Practice B 507) and the characteristics of the electroplating process. In addition, the average coating thickness on articles will vary from article to article within a production lot. Therefore, if all of the articles in a production lot are to meet the thickness requirement, the average coating thickness for the production lot as a whole will be greater than the average necessary to assure that a single article meets the requirement.

7.1.3 For nonsignificant visible surfaces, the minimum thickness for Classes 25 and 12 shall be Class 8 (8 µm); for Class 8 it shall be Class 5 (5 µm); and for Class 5 it shall be 4 µm.

7.2 *Adhesion*—The cadmium coating shall be sufficiently adherent to the basis metal to pass the tests detailed in 10.2.

7.3 *Abrasion Resistant*—The supplementary Type II chromate film shall be adherent, nonpowdery, and abrasion resistant (10.3).

7.4 *Corrosion Resistance*—Cadmium coatings with supplementary chromate films on iron and steel basis metals shall show neither white corrosion products of cadmium nor basis metal corrosion products at the end of 96 h for Type II film or 12 h for Type III film when tested by continuous exposure to salt spray. The appearance of corrosion products visible to the unaided eye at normal reading distance shall be cause for rejection, except white corrosion products at the edges of specimens shall not constitute failure.

NOTE 9—The hours given are the minimum required to guarantee satisfactory performance. Longer periods before the appearance of white corrosion and basis metal corrosion (rust from iron and steel products) are possible. Salt spray resistance does not vary in exact proportion with increased plating thicknesses of Types II and III coatings. Although specified hours to failure (red rust for iron and steel articles) for Type I coating is not stated, the hours given for Types II and III reflect the added protection of the chromate treatment without requiring impractical testing.

NOTE 10—In many instances, there is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other media. Factors such as the formation of protective films, basis materials, and temperature can influence the progress of corrosion greatly, depending upon the conditions encountered in service. The results obtained in the test should, therefore, not be regarded as a direct guide to the corrosion resistance of the tested materials in all environments where these materials may be used. Also, performance of different materials in the test cannot always be taken as a direct guide to the relative corrosion of these materials in service.

7.5 *Luster*—Either a bright or dull luster shall be acceptable; however, for steel parts that are heat treated to 40 HRC (approximately 1300 MPa) and harder, they shall have a dull luster or finish.

NOTE 11—High-strength steel parts that are cadmium plated from baths without brighteners are much more permeable to hydrogen than those bright cadmium plated. Bright cadmium is a very good hydrogen barrier that "seals in" the hydrogen. As embrittlement is a surface or subsurface phenomenon, even a 24 h baking is not sufficient to provide embrittlement relief of high-strength steels plated with a Class 12 deposit from a bright cyanide plating bath.

7.6 *Workmanship and Finish*—The coating shall be smooth, adherent, uniform in appearance, and free from blisters, pits, nodules, flaking, and other defects that may affect the function of the coating. The coating shall cover all surfaces as stated in 7.1, including thread roots, thread peaks, corners, holes, recesses, and edges. There shall be no indication of contamination or improper operation of equipment used to produce the deposit, such as excessively powdery or darkened coatings. Superficial staining and variations in color or luster shall not be cause for rejection. Defects and variations in appearance of the coating that arise from surface conditions of the substrate (pores, scratches, roll marks, inclusions, and the like) and that persist in the finish despite the observance of good application techniques shall not be cause for rejection.

NOTE 12—Coatings generally perform better in service when the substrate over which they are applied is smooth and free from torn metal, inclusions, pores, and other defects. The specifications covering the unfinished product should provide limits for these defects. A metal finisher can often remove defects through special treatments such as grinding, polishing, electropolishing, and chemical treatments. However these are not normal in the treatment steps preceding the application of the coating. When desired, they are subject of a special agreement between the purchaser and supplier.

8. Sampling

8.1 *Inspection Lot*—An inspection lot shall be a collection of coated articles that are of the same kind, that have been produced to the same specifications, that have been coated by a single supplier at one time or at approximately the same time under essentially identical conditions, and that are submitted for acceptance or rejection as a group.

8.2 *Selection*—A random sample of the size required by Test Method B 602 shall be selected from the inspection lot. The articles in the lot shall be inspected for conformance to the requirements of this specification and the lot shall be classified as conforming to or nonconforming to each requirement in accordance with the criteria of the sampling plan in Test Method B 602.

NOTE 13—Test Method B 602 contains four sampling plans, three of which are to be used with nondestructive test methods, the fourth is to be used with destructive test methods. The three methods for nondestructive tests differ in the quality level they require of the product. Test Method B 602 requires use of the plan with the intermediate quality level unless the purchaser specifies otherwise. It is recommended that the purchaser compare the plans with his needs and state which plan is to be used. If the plans in Test Method B 602 do not serve the needs, additional plans are given in Guide B 697. Both Method B 602 and Guide B 697 list references where additional information on sampling inspection and additional plans are given.

NOTE 14—When both destructive and nondestructive tests exist for the measurement of a characteristic, the purchaser needs to state which is to be used so that the proper sampling plan is selected. Whether or not a test is destructive may not always be clear. A test may destroy the coating, but in a noncritical area; or, although it may destroy the coating, a tested piece can be reclaimed by stripping and recoating. The purchaser needs to state whether the test is to be considered destructive or nondestructive. The decision is important because the plans for destructive tests are significantly less able to discriminate between acceptable and unacceptable lots. This is because fewer parts are tested using this plan.

8.3 *Specimens*—If separate test specimens are to be used to represent the coated articles in a test, the specimens shall be of the nature, size, and number and shall be processed as required in 9.1, 9.2, 9.3, 9.4, Supplementary Requirement S2, or in the purchase order.

9. Specimen Preparation

9.1 *Electroplated Parts or Separate Specimens*—When the electroplated parts are of such form, shape, size, and value as to prohibit use, or are not readily adaptable to a test, or when destructive tests of small lot size are required, the test shall be made by the use of separate specimens electroplated concurrently with the articles represented. The permission or the requirement to use test specimens, their number, the material from which they shall be made, and their shape and size shall be stated in the purchase order or other governing document. The separate specimens shall be of a basis metal equivalent to that of article represented, of the same metallurgical condition, and shall have the same surface condition. These separate specimens shall be introduced into the lot at regular intervals before the cleaning operation, preliminary to electroplating, and shall not be separated therefrom until after completion of the electroplating. Conditions affecting the electroplating of specimens, including the spacing, plating media, bath agitation, temperature, etc., in respect to the other objects being electroplated, shall correspond as nearly as possible to those affecting the significant surfaces of the articles represented. Unless a need can be demonstrated, separately prepared specimens shall not be used in place of production items for nondestructive and visual examinations.

9.2 *Thickness, Adhesion, Abrasion Resistance and Presence of Clear (Type III) Coating Specimens*—If separate specimens for thickness, adhesion, abrasion resistance, and the presence of clear (Type III) coating tests are required, they shall be strips approximately 100 mm long, 25 mm wide, and 1 mm thick, or cylindrical pieces with the cross-section area approximately equal to that of the production item.

9.3 *Corrosion Resistance Specimens*—If separate specimens for the corrosion resistance test are required, they shall be panels, approximately 150 mm long, 100 mm wide, and 1 mm thick.

9.4 *Hydrogen Embrittlement Relief Specimens*—If separate specimens are required for the hydrogen embrittlement relief test, the configuration shall be specified by the purchaser.

NOTE 15—When required for testing, the manufacturer of the basis metal parts should provide the coating facility with the stated test specimens, loading bolts, loading rings, and the like.

10. Test Methods

10.1 *Thickness*:

10.1.1 The thickness of electrodeposited cadmium coatings shall be determined by Test Methods B 487, B 499, B 504, B 567, or B 568, as applicable. Other methods may be used, if it can be demonstrated that the uncertainty of measurements with these methods is less than 10%.

10.1.2 The thickness measurements of Types II and III deposits shall be made after application of the supplementary treatments. Whenever Test Method B 504 or B 567 is used, remove the supplementary treatment from the test area before measuring the thickness. Remove by using a mild abrasive (a paste of levigated alumina or magnesium oxide) and rubbing gently with the finger.

10.2 *Adhesion*—The electrodeposited cadmium coating shall be tested for adhesion to the basis metal or substrate layer in a manner that is consistent with the service requirements of the coated article. When examined at a magnification of approximately 4× diameters, the coating shall not show separation at the interface. The formation of cracks in the coating caused by rupture of the basis metal that does not result in flaking, peeling, or blistering of the coating shall not be considered as nonconformance. Use one of the following methods for determining adhesion.

10.2.1 The surface of the coated article shall be scrapped or sheared with a sharp edge, knife, or razor blade through the coating down to the basis metal and examined at 4× magnification for evidence of nonadhesion.

10.2.2 The part shall be plastically deformed, if possible, by clamping in a vise and bending the projecting portion back and forth until rupture occurs.

10.2.3 Any suitable test procedure, such as the burnishing test, the draw test, the peel test, or the scribe test in accordance with Test Methods B 571 shall be used.

NOTE 16—There is no single satisfactory test for evaluating the adhesion of electrodeposited coatings. Those given (10.2.1, 10.2.2, and 10.2.3) are widely used; however, other tests may prove more applicable in special cases.

10.3 *Abrasion Resistance*—The abrasion resistance of the supplementary chromate films (Types II and III) shall be determined in accordance with Practice B 201.

10.4 *Clear (Colorless) Type III Coatings*—The presence of a clear Type III coating shall be determined in accordance with Practice B 201.

10.5 *Salt Spray Corrosion Resistance*—The 5% neutral salt spray (fog) test as defined in Test Method B 117 shall be used when there is a steel or iron substrate. Parts with supplementary chromate film shall be aged at room temperature for at least 24 h before subjection to the test.

10.6 *Hydrogen Embrittlement*—The test to indicate freedom from hydrogen embrittlement failure of coated parts or specimens need not be conducted unless the method is specified in the purchase order. The method description shall include specimen configuration, means of applying a load to the part, stress or load level, and duration of test. Parts shall not crack or fail by fracture when tested.

10.7 *Visual Examination*—The coating shall be examined for compliance with the requirements of luster, workmanship, and finish.

11. Rejection and Rehearing

11.1 Coatings that fail to conform to the requirements of this specification or authorized modifications may be rejected. They may be reconsidered for acceptance by rectifying inspection in accordance with Methods B 602 and B 697 when allowed by the purchaser. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claims for a rehearing. Coatings that show imperfection during subsequent manufacturing operations may be rejected.

12. Certification

12.1 When specified in the purchase order or contract, the producer's or supplier's certification shall be furnished to the purchaser stating that samples representing each lot have been processed, tested, and inspected in accordance with this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

13. Packaging and Packing

13.1 Preservation, packaging and packing methods for electrodeposited cadmium parts or articles employed by a supplier shall be such as to preclude damaging during shipment and handling.

14. Keywords

14.1 cadmium; electrodeposited coatings; electrodeposited coatings; cadmium

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the contract or order and for all agencies of the United States Government.

S1. Responsibility for Inspection

S1.1 The producer or supplier shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier 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 retains the right to perform any of the inspections and tests set forth in this specification where such inspections and tests are deemed necessary to ensure that the supplies and services conform to the prescribed requirements.

S2. Specimens for Hydrogen Embrittlement Relief

S2.1 Four specimens shall be used to represent the lot. The specimens for the test shall be round notched specimens with the axis of the specimen (load direction) perpendicular to the short transverse grain flow direction. The configuration shall be in accordance with the figure pertaining to 12.7 ± 0.025 mm (0.5 ± 0.001 in.) round tension test specimens with 50.8 ± 0.13 mm (2.0 ± 0.05 in.) gage length and examples of small-size specimens proportional to the standard specimen in Method E 8. Specimens shall have a 60 ± 1° V-notch located approximately at the center of the gagelength. The cross section area at the root of the "V" shall be approximately equal to half the area of the full cross-section area of the specimen's reduced section. The "V" shall have a 0.254 ± 0.013 mm radius of curvature at the base of the notch.

S3. Embrittlement Relief Test

S3.1 The notched specimens shall be subjected to a sustained tensile load equal to 75 ± 2 % of the ultimate notch tensile strength of the material. The articles, parts, or specimens shall be held under load for at least 200 h and then examined for cracks or fracture.

S3.2 Parts such as spring pins, lock rings, and the like, that are installed in holes or rods shall be similarly assembledusing the applicable parts specifications or drawing toler-ances which impose the maximum sustained tensile load on the plated part. The selected samples shall be subjected to a sustained tensile load equal to 115 % of the maximum design yield load for which the part was designed. Fastener hardware, where the maximum yield load is not known or given, shall be tested in accordance with MIL-STD 1312, Test 5. Parts that require special fixtures, extreme loads to comply with the above requirements, or where the maximum design yield load is not known, may be represented by separate notched specimens.

NOTE S00017—The manufacturer of the basis metal parts should provide the coating facility with notched tensile specimens when required for testing.

APPENDIXES

(Nonmandatory Information)

X1. Electrodeposited Cadmium Coating

X1.1 *Use*—Electrodeposited cadmium coatings, mainly on iron and steel products, are widely used in many industries. Electrodeposition of the cadmium on other metal products being used to a greater extent in both the aerospace and communication industries. The corrosion rate of cadmium plated parts is much lower than that of unplated parts in most atmospheres as well as in water. In addition, the electrochemical relationship between cadmium and a basis metal, for example, steel, is such that the corrosion or rusting is suppressed by galvanic action even where the cadmium coating may be damaged or worn through. The Type I, as-deposited coating, may be used to improve solderability, to lower electrical contact resistance, to provide surface conductivity on electronic equipment, and to prevent seizing of moving parts, bolts, nuts, and latches.

X1.2 *Limitations*—The Type I electrodeposited coatings should not be used on production items that in service will reach a temperature of 225°C or higher or will come in contact with other parts that reach these temperatures. Cadmium coated parts that may be subjected to heat from soldering, brazing, or welding operations should be so labeled and tagged to indicate being so coated because of the danger from poisonous cadmium oxide vapors during these operations.

X2. Supplementary Treatments

X2.1 *Purpose*—The clear chromate film (Type III) is generally used to prevent fingermarkings and corrosion of parts that may occur at room temperature during assembly and storage or will be exposed to a mild environmental condition. The purpose of the colored chromate supplementary finish (Type II) on cadmium coatings is to retard the weathering to form white corrosion products on the surfaces exposed to stagnant water, sea water, marine atmospheres, high humidity, or cyclic condensation and drying. Most of the iridescent yellow to live drab Type II chromate films will be satisfactory as an undercoat if production items are to receive an organic paint system application, as generally required by the aerospace industry.

X2.2 *Limitations*—Supplementary chromate treatments should not be applied to production items that will not be painted and will be continuously exposed to temperatures in excess of 65°C or intermittently exposed for short periods to a temperature of about 150°C. The protective value of the supplementary coating decreases under these conditions. Temperatures above 65°C will accelerate the deterioration of the chromate film especially in drier environments, such that the chromate coating can become so powdery that no protection is provided.

X2.3 *Handling Precautions*—Chromate treated articles that involve only dipping in chemical solutions normally require 24 h at 20 to 30°C to render them suitable for handling without damage to the finish coating while the latter is in the gelatinous form. It is important with such coatings that the supplement film is not damaged while wet in order to comply with the workmanship requirements.

X3. Service Conditions

X3.1 The service life of a cadmium coating, based upon atmospheric exposure tests, has supported the generalization that the protective value of the deposit is proportional to its thickness and to the environment to which it is exposed. Conditions of exposure and basis metals are so varied that it is not possible to predict the exact service life of a coating of a given thickness, with or without a supplementary finish. Table X3.1 provides recommended thicknesses with a supplementary finish on typical applications (mainly iron and steel articles) that are suitable under certain service conditions.

TABLE X3.1 Service Life and Conditions

Service Condition	Class	Treatment	Exposure	Typical Applications
Severe	25[A] or 12	Type II	To condensation, perspiration, infrequent wetting by rain, cleaners	Military hardware, electronic parts for tropical service, washing machinery
Moderate	8	Type II	Mostly to dry indoor atmospheres but subjected to occasional condensation, wear, or abrasion	Threaded parts, screws, bolts, radio parts instruments, TV, and radio chassis
Mild	5	Type II or Type III	Indoor atmospheres and with rare condensation and subject to minimum wear or abrasion	Springs, locks, washers, tools, fasteners, electronic and electrical parts

[A] Cadmium coatings thicker than 12 µm are normally not economical.

X4. Toxicity

X4.1 Cadmium, because of its toxicity, should not be used on articles intended for use as food containers, cooking utensils, or for other objects likely to come in contact with food.

X5. Packaging Limitations

X5.1 Electrodeposited cadmium coated articles without supplementary protective films should not be packaged or packed in nonventilated containers either together or in contact with electrical and electronic equipment, because of the danger of deleterious effects on the cadmium coating from unstable electrical insulation. In addition to organic electrical insulation, phenolic resinous substances and other containing unsaturated carbon-to-carbon linkages, such as oil paints and impregnated papers, cause an abnormal attack on the cadmium by setting free in the presence of moisture, formic acid, butyric acid, and the like. Corrosion of cadmium coated articles have been noted when they 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.

X6. Cross Reference

X6.1 The correlation between the classes and types used in this specification, Specification A 165, Federal Specification QQ-P-416, and International Standard ISO 2082 are indicated in Table X6.1

TABLE X6.1 Correlation of Specifications

Specification B 766		Specification A 165	
Class	Thickness, µm	Type	Thickness, µm
25	25[A]	NS	12
12	12	OS	8
8	8	TS	5
5	5		
Supplementary Finish:		Supplementary Finish:	
Type:		Not Specified	
I	None, as deposited		
II	With a colored chromate treatment		
III	With a colorless chromate treatment		

Specification QQ-P-416		Specification ISO 2082		
Class	Thickness, in. (µm):	Service Condition	Class	Thickness, µm:
1	0.0005(13)	3	Fe/Cd25c	25
2	0.0003 (8)	2	Fe/Cd12c	12[A]
3	0.0002 (5)	1	Fe/Cd5c	5
Supplementary Finish:		Supplementary Finish:		
Type:		Not as a requirement, but stated a colored or colorless coating shall be applied unless otherwise specified. Phosphating may be used as alternate treatment for articles to be painted.		
I	None, as deposited			
II	With chromate treatment (colored)			
III	With phosphate treatment			

[A] Cadmium coatings thicker than 12 µm are normally not economical.

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