

This document is not an ASTM standard and is intended only to provide the user of an ASTM standard an indication of what changes have been made to the previous version. Because it may not be technically possible to adequately depict all changes accurately, ASTM recommends that users consult prior editions as appropriate. In all cases only the current version of the standard as published by ASTM is to be considered the official document.



Designation: B 635 – 91 (Reapproved 1997)



Designation: B 635 – 00

Standard Specification for Coatings of Cadmium-Tin Mechanically Deposited ¹

This standard is issued under the fixed designation B 635; 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.

¹ This specification is under the jurisdiction of ASTM Committee B-8 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.08.04 on Soft Light Metals.

Current edition approved ~~Feb. 22, 1991~~, March 10, 2000. Published May ~~1991~~, 2000. Originally published as B 635 – 78. Last previous edition B 635 – 901 (1997).

1. Scope

1.1 This specification covers the requirements for a coating that is a mixture of cadmium and tin mechanically deposited on metal products. The coating is provided in various thicknesses up to and including 12 μm.

1.2 Mechanical deposition greatly reduces the risk of hydrogen embrittlement and is suitable for coating bores and recesses in many parts that cannot be conveniently plated electrolytically. (See Appendix X1.)

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific hazards statements, see Section 7.

2. Referenced Documents

2.1 ASTM Standards:

B 117 Practice for Operating Salt Spray (Fog) Apparatus²

B 183 Practice for Preparation of Low-Carbon Steel for Electroplating³

B 201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces³

B 242 Practice for Preparation of High-Carbon Steel for Electroplating³

B 322 Practice for Cleaning Metals Prior to Electroplating³

B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section³

B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals³

B 567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method³

B 571 Test Methods for Adhesion of Metallic Coatings³

B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings³

B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings³

E 87 Methods for Chemical Analysis of Lead, Tin, Antimony, and Their Alloys (Photometric Methods)⁴

E 396 Test Methods for Chemical Analysis of Cadmium⁵

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection⁶

2.2 U.S. Federal Standard:

FED-STD-141 Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling and Testing⁷

2.3 U.S. Military Standard:

MIL-L-7808J Lubricating Oil, Aircraft Turbine Engine, Synthetic Base⁷

3. Classification

3.1 *Classes*—Cadmium-tin coatings are classified on the basis of thickness, as follows:

² Annual Book of ASTM Standards, Vol 03.02.

³ Annual Book of ASTM Standards, Vol 02.05.

⁴ Discontinued—See 1984 Annual Book of ASTM Standards, Vol 03.05.

⁵ Annual Book of ASTM Standards, Vol 03.05.

⁶ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁷ Annual Book of ASTM Standards, Vol 01.08.

⁷ Diestek and Weber, *Electrolytic and Chemical Conversion Coatings*, Portcullis Press, Redhill, Surrey, U.K., 1976.

⁷ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

Class	Minimum Thickness, μm
12	12
8	8
5	5

3.2 *Types*—Cadmium-tin coatings are identified by types on the basis of supplementary treatment required, as follows:

3.2.1 *Type I*—As coated, without supplementary chromate treatment (see X1.1).

3.2.2 *Type II*—With supplementary chromate treatment (see X1.2).

4. Ordering Information

4.1 To make the application of this specification complete, the purchaser needs to supply the following information to the supplier in the purchase order or other governing document:

4.1.1 Class, including a maximum thickness, if appropriate, type, and need for supplemental lubricant (3.1, 3.2, and 5.2.4.2).

4.1.2 Nature of substrate, for example, high-strength steel, need for stress-relief, and cleaning precautions to be followed (5.2.2).

4.1.3 Significant surfaces (5.3).

4.1.4 Requirements and methods of testing for one or more of the following requirements: need for and type of test specimens (8.1), composition (8.2), thickness (8.4), adhesion (8.6), and absence of hydrogen embrittlement and the waiting period prior to testing and testing loads (8.8) and lubricating resistance (S2).

4.1.5 Sampling plan for each inspection criterion and responsibility for inspection, if necessary (Section 6 and Supplementary Requirement S1).

4.1.6 Requirements for certified report of test results (Section 10).

5. Requirements

5.1 *Nature of Finish*—The coating shall be 45 to 75 mass % cadmium, the remainder tin.

5.2 *Process*:

5.2.1 *Stress Relief Treatment*—All steel parts that have ultimate tensile strength of 1000 MPa and above and that contain tensile stresses caused by machining, grinding, straightening, or cold forming operation shall be given a stress relief heat treatment prior to cleaning and metal deposition. The temperature and time at temperature shall be $190 \pm 15^\circ\text{C}$ for a minimum of 3 h so that maximum stress relief is obtained without reducing the hardness below the specified minimum.

5.2.2 High-strength steels that have heavy oxide or scale shall be cleaned before application of the coating in accordance with Practice B 242. In general, non-electrolytic alkaline, anodic-alkaline, and some inhibited acid cleaners are preferred to avoid the risk of producing hydrogen embrittlement from the cleaning procedure.

5.2.3 For preparation of low-carbon steels, see Practice B 183. For cleaning, useful guidelines are also given in Practice B 322.

5.2.4 *Supplementary Treatments*:

5.2.4.1 Chromate treatment for Type II shall be done in a solution containing hexavalent chromium. This solution shall produce a bright or semi-bright continuous, smooth, protective film. This film may have a slight yellowish or iridescent color. The absence of color shall not be considered evidence of the absence of a Type II film or as a basis for rejection of the parts. Only post treatments that contain salts that yield films containing hexavalent chromium are permitted as treatments for producing Type II coatings.

5.2.4.2 Waxes, lacquers, or other organic coatings may be used to improve lubricity, and the need for them should be supplied in the purchase order or other governing document (4.1.1). Such supplemental lubrication treatments shall not be used to ensure conformance to the salt spray corrosion resistant requirements or to enhance the test results of the lead acetate spot test (8.5.2).

5.3 *Thickness*:

5.3.1 The thickness of the coating everywhere on the significant surfaces shall be at least that of the specified class as defined in 3.1.

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

NOTE 1—The thickness of mechanically-deposited coatings varies from point-to-point on the surface of a product, characteristically tending to be thicker on flat surfaces and thinner at exposed edges, sharp projections, shielded or recessed areas, interior corners and holes, with such thinner areas often being exempted from thickness requirement.

5.3.3 When significant surfaces are involved on which the specified thickness of deposit cannot readily be controlled, the purchaser and manufacturer should recognize the necessity for either thicker or thinner deposits. For example, to reduce buildup in thread roots, holes, deep recesses, bases of angles, and similar areas, the deposit thickness on the more accessible surfaces will have to be reduced proportionately.

NOTE 2—The coating thickness requirement of this specification is a minimum requirement; that is, the coating thickness is required to equal or exceed the specified thickness everywhere on the significant surfaces. Variation in the coating thickness from point to point on a coated article is an inherent characteristic of mechanical deposition processes. Therefore, the coating thickness will have to exceed the specified value at some points on the significant surfaces to ensure that the thickness equals or exceeds the specified value at all points. Thus, in most cases, the average coating thickness on an article will be greater than the specified value; how much greater is largely determined by the shape of the article and the characteristics of the deposition 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 ensure that a single article meets the requirement.

5.4 *Adhesion*—The cadmium-tin coating shall be sufficiently adherent to the basis metal to pass the tests specified in 8.6.

5.5 *Corrosion Resistance*:

5.5.1 The presence of corrosion products visible to the unaided eye at normal reading distance at the end of the specified test period as stated in Table 1 shall constitute failure, except that corrosion products at the edges of specimens shall not constitute failure. Slight “wisps” of white corrosion, as opposed to obvious accumulations, shall be acceptable.

NOTE 3—The hours given in Table 1 are the minimums required to guarantee satisfactory performance. Longer periods before the appearance of white corrosion products and rust are possible, but salt spray resistance does not vary in exact proportion with increased plating thickness. The hours given for Type II reflect the added protection of chromate treatments without requiring impractical testing periods.

5.5.2 There are no requirements for corrosion of base metals other than steels.

NOTE 4—Mechanical deposition is exclusively a barrel-finishing process. It is recognized that mechanical deposition on parts may therefore produce surfaces which have a different characteristic from those on parts which are finished exclusively by racking. Similarly, corrosion testing of actual parts may produce different results from those on test panels. Salt spray requirements that are appropriate to indicate the technical quality with which a process is carried out may be impractical for acceptance of actual parts. In such cases the purchaser should indicate his requirements on the purchase order (see 4.1.4).

NOTE 5—In many instances, there is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other media, because several factors that influence the progress of corrosion, such as the formation of protective films, vary greatly with the conditions encountered. The results obtained in the test should not, therefore, 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 resistance of these materials in service.

5.6 *Absence of Hydrogen Embrittlement*—Steel springs and other high-strength steel parts subject to flexure shall be held for a minimum of 48 h at room temperature after coating, before being loaded, flexed, or used. Such parts shall be free from hydrogen embrittlement. When specified in the purchase order, freedom from embrittlement shall be determined by the test specified herein (see 4.1.4 and 8.8).

5.7 *Workmanship*—The coating shall be uniform in appearance and substantially free of blisters, pits, nodules, flaking and other defects that can adversely affect the function of the coating. The coating shall cover all surfaces as stated in 5.3, including thread roots, thread peaks, corners, recesses, and edges. The coating shall not be stained or discolored throughout to an extent that would adversely affect appearance as a functional requirement. However, superficial staining that results from rinsing or drying, and variations in color or luster shall not be cause for rejection.

NOTE 6—The nature of the mechanical plating process is such that coatings characteristically will not be as smooth or as bright as some electroplated coatings.

5.8 *Surface Defects*—Defects and variations in appearance in the coating that arise from surface conditions of the substrate (scratches, pores, roll marks, inclusions, etc.) and that persist in the finish despite the observance of good metal finishing practices shall not be cause for rejection.

NOTE 7—Applied finishes generally perform better in service when the substrate over which they are applied is smooth and free of torn metal, inclusions, pores, and other defects. It is recommended that the specifications covering the unfinished product provide limits for these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical treatments, and electropolishing. However, these are not normal in the treatment steps preceding the application of the finish. When desired, they must be specified on the purchase order (see 4.1.2).

6. Sampling Requirements

6.1 A random sample Sampling

6.1 The purchaser and producer are urged to employ statistical process control in the coating process. Properly performed, statistical process control will assure coated products of satisfactory quality and will reduce the size required by Test Method B 602 shall be selected from amount of acceptance inspection. The sampling plan used for the inspection lot (see 6.2). The articles in of the sample quality coated article shall be agreed upon between the purchaser and producer.

6.1.1 When a collection of coated articles (inspection lot, see 6.2) is examined for conformance to compliance with the requirements placed on the articles, a relatively small number of this specification and the articles (sample) is selected at random and is inspected. The inspection lot shall be is then classified as conforming or nonconforming to each requirement in accordance

TABLE 1 Minimum Hours to Failure (White Corrosion and Red Rust for Cadmium-Tin Coatings on Iron and Steel)^A

Type	Class 12		Class 8		Class 5	
	White Corrosion	Rust	White Corrosion	Rust	White Corrosion	Rust
I	not applicable	144	not applicable	120	not applicable	60
II	96	168	96	168	96	168

^A Corrosion products are those visible to the unaided eye at normal reading distances after gentle washing to remove salt deposits.

complying with the criteria requirements based on the results of the inspection of the sample. The size of the sample and the criteria for compliance are determined by the application of statistics. The procedure is known as sampling plans in inspection. Test Method B 602.

NOTE 8—Test B 602, Guide B 697, and Method B 602 contains three B 762 contain sampling plans that are to be used with non-destructive test methods and a fourth to be used with destructive test methods. The three methods designed for non-destructive tests differ in the quality level they require sampling inspection of the product. Test coatings.

6.1.2 Test Method B 602 ~~requires~~ contains four sampling plans, three for use of the plan with the intermediate quality level unless the purchaser specifies otherwise. The purchaser should compare the plans with his needs tests that are nondestructive and state which plan is to be used. If the plans in one when they are destructive. Test Method B 602 provides a default plan if one is not serve the needs, additional ones are given in Guide B 697.

NOTE 9—When both destructive specified.

6.1.3 Guide B 697 provides a large number of plans and non-destructive tests exist for also gives guidance in the measurement selection of a characteristic, the purchaser needs to state which plan. Guide B 697 provides a default plan if one is not specified.

6.1.4 Test Method B 762 can be used so only for coating requirements that the proper sampling plan is selected. Also, have a test may destroy the numerical limit, such as coating but in thickness. The test must yield a noncritical area. Or, although it destroys the coating, it may numeric value and certain statistical requirements must be th met. Test Method B 762 contains several plans and also gives instructions for calculating plans to meet special needs. Test Method B 762 provides a default plan if one is not specified.

6.1.5 Guide F 1470 can be reclaimed by stripping used for fasteners such as internally threaded, externally threaded and nonthreaded fasteners and washers. This guide provides for two plans: one designated the “detection process” and one designated the “prevention process.” The purchaser needs and producer shall agree on the plan to state whether such a test is to be considered destructive or non-destructive. used.

6.2 An inspection lot shall be defined as 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. In no case shall the lot exceed production for one week.

6.3 If separate test specimens are used to represent the coated articles in a test, the specimens shall be of the nature, size, and number, and be processed as required in 8.1. group.

7. Hazards

7.1 **Warning**—Cadmium is toxic and must not be used in a coating for articles that can come into contact with food or beverages, or for dental or other equipment that can be inserted into the mouth. Consult appropriate agencies for regulations in this connection.

7.2 **Precaution**—Because of the toxicity of cadmium vapors and cadmium oxide fumes, cadmium-tin coated articles must not be used at temperatures of 165°C and above. They must not be welded, spot-welded, soldered, or otherwise strongly heated, without adequate ventilation that will efficiently remove all toxic fumes. (See X4.2.)

8. Test Methods

8.1 Test Specimens:

8.1.1 Test specimens may be used to represent the coated articles in a test if the articles are of a size, shape, or material that is not suitable for the test, or if it is preferred not to submit articles to a destructive test because, for example, the articles are expensive or few. 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.

8.1.2 The test specimen shall duplicate those characteristics of the article that influence the property being tested, and it shall be processed with the article through those process steps that influence the property.

8.1.2.1 The test specimen used to represent an article in an adhesion, corrosion resistance, or appearance test shall be made of the same material, shall be in the same metallurgical condition, and shall have the same surface condition as the article it represents. It shall be placed in the production lot of and be processed along with the article it represents.

8.1.2.2 A test specimen used to represent an article in a coating thickness test shall be introduced into the process at the point where the coating or coatings are applied and it shall be carried through all steps that have a bearing on the coating thickness.

8.1.2.3 When a test specimen is used to represent a coated article in a thickness test, the specimen will not necessarily have the same thickness and thickness distribution as the article unless the specimen and the article are of the same general size and shape. Therefore, before coated articles may be accepted on the basis of a thickness test performed on test specimens, the relationship between the thickness on the specimen and the thickness on the part shall be established. The criterion of acceptance shall be that thickness on the specimen that corresponds to the required thickness on the article.

8.2 **Composition**—Chemical composition of the cadmium-tin coating shall be determined when required on the purchase order by procedures given in Methods E 87 or Test Methods E 396, or by other methods specified on the purchase order (see 4.1.4) as long as they can determine composition to within the desired limits.

8.3 *Workmanship*—The quality of workmanship shall be determined by the unaided eye at normal reading distance.

8.4 *Thickness*:

8.4.1 The thickness of the coating shall be determined by the microscopical method (Test Method B 487), the magnetic method (Test Method B 499), or the beta backscatter method (Test Method B 567), as applicable. Other methods may be used if it can be demonstrated that the uncertainty of the measurements with these methods is less than 10 %.

8.4.1.1 The composition of the deposit shall be considered when selecting standards for calibrating beta backscatter instruments.

8.4.2 The thickness of the coating shall be measured at the location or locations on the significant surfaces of the product where the coating would be expected to be the thinnest or at such locations as specified on the purchase order (see 4.1.3 and 5.3.2).

8.4.3 Thickness measurements of Type II deposits shall be made after application of the supplementary treatment.

~~NOTE 10—The 8—~~The process by which Type II coatings are produced dissolves a small amount of the cadmium-tin. For this reason the thickness requirement to be checked refers to the thickness of the deposit after the application of the Type II coating.

~~NOTE 11—The 9—~~The thickest chromate film (olive drab) is approximately 1.5 μm thick.⁸ If this significantly affects the accuracy of the thickness measuring method used (for example, Test Method B 567) the Type II coating should be removed from the test area. Removal should be done by using a very mild abrasive (a paste of levigated alumina or magnesium oxide rubbed on gently with the finger).

8.5 *Presence of Chromate*:

8.5.1 Chromate conversion coatings of cadmium-tin both have an essentially silvery-white appearance. In the absence of a definitive method for distinguishing a Type II coating from a lacquer or other non-chromate film, the salt spray test shall be used to verify the presence of a Type II coating, in terms of hours to white corrosion product.

8.5.2 Frequently, the presence of a chromate coating on a product is tested for by a diphenyl carbazide test, and the quality of the coating is assessed by a lead acetate test. The reliability of these tests has been questioned because the diphenyl carbazide test merely tests for the presence of chromate ions, which may or may not be in the form of a coating, and because the lead acetate test will not distinguish between chromate and other kinds of coatings. Therefore, these tests have value as controls of an in-house process but are of less value in the evaluation of a purchased product whose processing is neither under the control nor the cognizance of the purchaser. The lead acetate test is described in Practice B 201. The diphenyl carbazide test is described in Annex A1 of this specification.

8.6 *Adhesion*—Adhesion of the cadmium-tin deposit to the basis metal shall be tested in a manner that is consistent with the service requirements of the coated article. The ability to separate the coating from the substrate by peeling, as distinct from flaking caused by rupture of the deposit or of the base metal, shall be evidence of failure. One of the following methods for determining adhesion shall be used:

8.6.1 The part shall be plastically deformed, if possible, to rupture as specified on the purchase order (see 4.1.4).

8.6.2 The surface of the coated article shall be scraped or sheared with a sharp edge, knife, or razor blade through the coating down to the basis metal and examined under 4 \times magnification.

~~NOTE 12—~~There is no single satisfactory test for evaluating the adhesion of mechanically deposited coatings. Those given in 8.6 are widely used; however, other tests may prove more applicable in specific cases. Various qualitative methods are discussed in Test Methods B 571. A review of methods of measuring adhesion is given in Polleys, R. W., "The Adhesion Testing of Electroplated Coatings," *Proceedings*, American Electroplaters' Society, APAEA, Vol 50, 1963, p. 54. Application of pressure-sensitive tape to the coating is a method which may be misleading. Metal particles adhering to the tape may only reflect rinsing technique. Distinctions must be made between superficial surface effects which will not adversely affect other requirements, and internal coating consolidation (cohesion), or adhesion to the basis metal or undercoating.

8.7 *Salt Spray Corrosion Resistance* :

8.7.1 The 5 % neutral salt spray (fog) test as defined in Practice B 117 shall be used.

8.7.2 If samples with Type II coatings are to be examined both for white corrosion products and for rust, separate sets of samples shall be used to determine the 96-h end point for white corrosion and the 168-h end point for rust; this is to permit exposure for the longer period without having to wash specimens for examination of white corrosion in accordance with Practice B 117.

8.7.3 Parts with Type II supplementary chromate film shall be aged at room temperature for 24 h before subjection to the salt spray test.

8.7.4 Parts with coatings of wax, etc. shall not be used as samples for corrosion testing for conformance to the requirements of 5.5.

8.8 *Absence of Hydrogen Embrittlement* :

8.8.1 Coated parts to be tested for the absence of embrittlement from cleaning shall be tested for brittle failure in accordance with a suitable method to be specified on the purchase order (see 4.1.4). The description of the method shall include the means of applying a load to the part, the stress or load level to be applied, the duration of the test, and the waiting time that must elapse between deposition of the cadmium-tin and testing or use of the part and the criterion of failure.

8.8.2 Parts that must conform to U.S. Government requirements shall be subjected to loading conditions described above for at least 200 h.

~~NOTE 13—~~It is recommended that tests for embrittlement involve subjecting parts to the specified operating conditions for at least 100 h except as noted in 8.8.2. The stress level induced by the test and the waiting period prior to test depend upon many factors, such as shape of the part, carbon content

⁸ Biestek and Weber, *Electrolytic and Chemical Conversion Coatings*, Portcullis Press, Redhill, Surrey, U.K., 1976.

of the steel, hardness of the part, and stress level in use. Parts with a tensile strength of over 1000 MPa for example, may require a 48-h waiting period; parts with lower tensile strength may require less than a 24-h waiting period. High-carbon steel parts or those cold-worked or heat-treated to tensile strengths of 1450 MPa minimum, where these parts will be subjected to a sustained load in use, may require testing at loads specified by the purchaser.

9. Rejection and Rehearing

9.1 Materials that fail to conform to the requirements of this specification may be rejected. Rejection shall be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of a test, the producer or supplier may make a claim for rehearing. Finishes that show imperfections during subsequent manufacturing operations may be rejected.

10. Certification

10.1 The purchaser may require in the purchase order or contract that the producer or supplier give to the purchaser certification that the finish was produced and tested in accordance with this specification and found to meet the requirements. The purchaser may similarly require that a report of the test results be furnished (see 4.1.6).

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser as part of the purchaser's order or contract, 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 and test requirements specified herein (see 4.1.5). Except as otherwise specified in the contract or order, the producer or supplier may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

S2. Lubricating Oil Resistance

S2.1 *Procedure*—The coating shall withstand immersion in diester lubricating oil conforming to MIL-L-7808 at a temperature of $121 \pm 3^\circ\text{C}$ for 24 h. Upon cooling to room temperature, parts or specimens shall be examined and compared with unexposed parts or specimens. The part or specimen shall then be tested in accordance with FED-STD 141, Method 6223 using a mandrel whose diameter is 14 times the basis metal thickness. The time of test shall be 2 s.

S2.2 *Evaluation* —After holding at 121°C and cooling to room temperature, the test pieces shall show no wrinkling, blistering, pitting, or other surface defects. Discoloration shall not be cause for rejection. After performance of the deformation test (Method 6223), if the edge of the ruptured coating can be peeled back, or if separation of the coating from the basis metal can be seen at the point of rupture when examined at 4X magnification, adhesion is not satisfactory due to poor resistance to lubricating oil.

S2.3 *Separate Specimens* —If separate specimens for lubricating oil resistance tests are required, they shall be ferrous alloy panels not less than 152 mm in length and 76 mm in width and they shall be approximately 1 mm thick. The ferrous alloy shall be of such composition and hardness that the specimen will withstand deformation without cracking or fracture.

ANNEX

(Mandatory Information)

A1. DIPHENYL CARBAZIDE TEST

A1.1 Hexavalent Chromium Test

A1.1.1 Dissolve 0.5 g of 1,5-diphenyl carbazide in a solvent mixture consisting of 20 mL of acetone and 20 mL of 95 % ethanol by using, if necessary, a warm (50°C) water bath. Add to this a dilute phosphoric acid solution consisting of 20 mL of water and 20 mL of phosphoric acid.

A1.1.2 Place a drop on the surface to be tested. A pink to purple color will indicate the presence of chromate anions.

NOTE A1.1—The test solution is heat- and light-sensitive and must be discarded when it discolors.

A1.2 Hexavalent and Trivalent Chromium Test

A1.2.1 An alternative test solution for either tri- or hexavalent chromium is the following:

	Formula A	
Distilled or deionized water, mL		40
Sodium hypochlorite, 5 %, mL		10
Glacial acetic acid, mL		60
Diphenyl carbazide, g		1
Hydrochloric acid, concentrated, mL		15
Hydrogen peroxide, 30 %, mL		5

A1.2.2 Add each component to the distilled water in the order given above. The solution may turn pink in the beginning but the color will fade later. This solution may be stable for 2 weeks.

A1.2.3 Place a small piece of filter paper (3 mm²) on the part to be tested, with the part at room temperature. Put two drops of Formula A solution upon the filter paper and wait for 1 to 3 min for color to develop. It will change to pink if chemical chromium film exists.

A1.2.4 The test part may be warmed to about 65°C by a hot-air blower. Then drop Formula A solution immediately on the part to observe any change of color.

A1.3 Hexavalent or Trivalent Chromium Test

A1.3.1 Solutions to distinguish between tri- and hexavalent chromium films are the following:

	Formula B	
Part 1—	Glacial acetic acid, mL	60
	Diphenyl carbazide, mg	1
	Hydrochloric acid, concentrated, mL	15
	Distilled or deionized water, mL	40
Part 2—	Sodium hypochlorite, 5 %, mL	10
	Hydrogen peroxide, 30 %, mL	5
	Distilled water, mL	40

A1.3.2 When Part 1 is applied to the part with hexavalent chromium in accordance with the procedure mentioned in A1.1.2, a change of color will be seen. On the other hand, Part 1 will give no pink color when applied to a trivalent chromium film. To confirm the presence of a trivalent film, Part 1 solution is combined with one or two drops of Part 2 solution. When a trivalent film is present, a pink color will show.

APPENDIXES

(Nonmandatory Information)

X1. CHARACTERISTICS

X1.1 Cadmium-tin coatings excel in minimizing dissimilar metals corrosion between coated articles and certain metals with which they are in contact. Such metals, particularly the aluminum alloys, can produce a high electrical potential with the coated part. Cadmium-tin deposits are widely used to minimize corrosion in automotive lamp contacts. These deposits, when treated with Type II coatings, give improved corrosion resistance over Type I, yet maintain the silvery metallic appearance of the article that is desired by many consumers.

X1.2 In addition, in some environments and in salt spray tests, corrosion protection equivalent to cadmium coatings of a given thickness may be obtained with less thickness by use of a cadmium-tin coating. The use of less cadmium by the substitution of cadmium-tin reduces pollution problems associated with cadmium.

X2. PROCESS

X2.1 Mechanical deposition of cadmium-tin coatings should consist in general, of all of the steps listed below, and in the sequence as shown:

X2.2 Preparation of the surface of the parts to be coated, by chemical (generally acidic) procedure, to an extent that permits uniformly satisfactory results from subsequent steps.

X2.3 Deposition of a thin metal coating, where applicable, by immersion in appropriate chemical solutions, without the use of electric current for ferrous basis metals this thin coating is generally copper. There are no thickness requirements for this coating.

X2.4 Tumbling of the parts that have been treated in accordance with X2.2 and X2.3 in a container with the following:

X2.4.1 The metals to be deposited, in powder form, and mixed in the desired proportions.

X2.4.2 Impact media, which may be glass or other substances that are essentially inert to the chemicals of the deposition process. The function of this media is to aid in providing mechanical forces to drive the metal powders onto the substrate parts.

X2.4.3 A “promoter” or “accelerator” that aids in the uniform deposition of the metal powders.

X2.4.4 A liquid medium, generally water.

X2.5 Separation of the parts from the solid and liquid media.

X2.6 Rinsing.

X2.7 Drying.

X3. SPECIFIC TYPES

X3.1 *Type I (Plain Cadmium-Tin)* is useful for lowest cost protection where early formation of white corrosion products is not detrimental. It is also used for higher temperature applications up to approximately 120°C, where the effectiveness of chromates is greatly reduced.

X3.2 *Type II (Unleached Chromates)*—The unleached chromates that on pure cadmium or pure zinc are colored (yellow iridescent, olive drab, bronze, etc.) are used to delay the appearance of white or red corrosion products on the cadmium-tin plated article. Mechanically deposited cadmium-tin coatings typically do not show the characteristic yellow color of pure zinc or pure cadmium treated with a colored chromate. Leached coatings are therefore unnecessary with this plating.

X4. HYDROGEN EMBRITTLEMENT

X4.1 A major advantage of mechanical plating is that it does not produce hydrogen embrittlement in hardened steel during the coating process. However, pronounced embrittlement can be produced in certain cleaning processes. The mild degree of embrittlement that might result from following proper procedures with cleaning methods permitted in this specification normally is self-relieving within a day’s time at room temperature.

X4.2 Because the mechanical cadmium-tin coatings of the compositions covered by this specification have their minimum melting point at 177°C, they may be heated to 165°C without danger of cadmium vapor, when this is desired for additional embrittlement relief. (See Section 7.)

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).