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Standard Specification for Coatings of Cadmium-Zinc Mechanically Deposited[1]

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[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.

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1. Scope

1.1 *General*—This specification covers the requirements for a coating that is a mixture of cadmium and zinc deposited on metallic products by mechanical deposition. The coating is provided in four thickness classes (see Table 1) and several finish types (see Table 2).

1.2 *Toxicity*—**Warning:** Cadmium is toxic; therefore these coatings should not be used on articles that will contact food or beverages, or for dental and other equipment that may be inserted into the mouth. Also, the coatings should not be used on articles that will be heated to high temperatures, because cadmium will form toxic fumes. Similarly, if coated articles are welded, soldered, or otherwise heated during fabrication, adequate ventilation should be provided to exhaust toxic fumes.

1.3 *Similar Documents*—Other kinds of mechanically deposited coatings are covered by Specifications B 635, B 695, and B 696.

1.4 The following precautionary caveat pertains only to the test method portion, Section 9, of this specification. *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.*

2. Referenced Documents

2.1 *ASTM Standards:*

B 117 Practice for Operating Salt Spray (Fog) Apparatus[2]
B 183 Practice for Preparation of Low-Carbon Steel for Electroplating[3]
B 242 Practice for Preparation of High-Carbon Steel for Electroplating[3]
B 320 Practice for Preparation of Iron Castings for Electroplating[3]
B 322 Practice for Cleaning Metals Prior to Electroplating[3]
B 374 Terminology Relating to Electroplating[3]
B 487 Test Method for Measurement of Metal and Oxide Coating Thicknesses by Microscopical Examination of a Cross Section[3]
B 499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[3]
B 571 Test Methods for Adhesion of Metallic Coatings[3]
B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings[3]

[2] *Annual Book of ASTM Standards*, Vol 03.02.
[3] *Annual Book of ASTM Standards*, Vol 02.05.

TABLE 1 Thickness Classes

Class	Coating Thickness Minimum, µm	Typical Applications
7	7	Automotive fasteners
12	12	Increased corrosion resistance (for example, bellville washers)
25	25	Exterior hardware
50	50	Pole line hardware in severe environments

TABLE 2 Coating Types

Type	Description	Typical Applications
I	As-coated, without supplementary treatments.	Lowest cost where white corrosion products are acceptable. For elevated temperature application that will degrade Type II coatings (see 1.2).
IIa	With yellow to bronze color supplementary chromate coating.	Delay the appearance of white corrosion products. Increase total corrosion protection.
IIb	With brown to olive drab color supplementary chromate coating.	Greater corrosion resistances than IIa. To provide a match to military equipment.
IIc	Type IIa, dyed.	Color coding Decorative purposes
IId	Type IIa with an added lubricant or organic finish (oil, wax, lacquer, etc.)	Lubricity Maximum corrosion resistance

B 635 Specification for Coatings of Cadmium-Tin Mechanically Deposited on Iron and Steel[3]
B 695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel[3]
B 696 Specification for Coatings of Cadmium Mechanically Deposited[3]
B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[3]
B 762 Method of Variables Sampling of Metallic and Inorganic Coatings[3]
E 27 Method for Spectrographic Analysis of Zinc and Zinc Alloys by the Solution-Residue Technique[4]
E 396 Test Methods for Chemical Analysis of Cadmium[5]
E 536 Test Method for Chemical Analysis of Zinc and Zinc Alloys[6]
F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection[7]

3. Terminology

3.1 *Definitions*—Some of the terms used in this are defined in Terminology B 374.

4. Classification

4.1 *Thickness Classes*—The coating is classified in four thickness classes, as defined in Table 1.
4.2 *Coating Types*—The coating is classified by type, as defined in Table 2.

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 on the purchase order or other governing documents:
5.1.1 The name, designation, and year of issue of this specification,
5.1.2 Thickness class (see 4.1), including a maximum thickness if appropriate,
5.1.3 Coating type (see 4.2), including required color if Type IIc is used, and required lubricant or organic finish if Type IId is used,
5.1.4 Nature of the substrate, for example: high-carbon steel, mild steel, copper, brass:
5.1.4.1 State if precoating stress relief heat treatment is required and the time and temperature to be used if different from the standard values (see section 12.1),
5.1.4.2 State if special pretreatments are required to modify the surface of the article (see Note 1),
5.1.4.3 If special cleaning precautions are to be followed (see A1.1), and
5.1.5 Identification of significant surfaces (see 7.4.2).
5.1.6 Requirements and methods of testing one or more of the following:
5.1.6.1 Need for and type of special test specimens (see 9.1),
5.1.6.2 Appearance (see 7.3),
5.1.6.3 Deposit composition (see 9.2),
5.1.6.4 Thickness (see 9.5),
5.1.6.5 Adhesion (see 9.6),

[4] Discontinued; see *1986 Annual Book of ASTM Standards*, Vol 03.06.
[5] *Annual Book of ASTM Standards*, Vol 03.05.
[6] *Annual Book of ASTM Standards*, Vol 03.06.
[7] ~~Holford, Raymond N., Jr., "Five Year Outdoor Exposure Corrosion Comparison," Mechanical Finishing, July 1988.~~ *Annual Book of ASTM Standards*, Vol 01.08.

5.1.6.6 Corrosion resistance (see 9.7),
5.1.6.7 Absence of hydrogen embrittlement, waiting time prior to testing and testing loads (see 9.8), and
5.1.7 The sampling plan to be used (see 8.1) and responsibility for inspection (see section 13.1).

6. Significance and Use

6.1 *Corrosion Resistance, General*—This functional coating is used to provide corrosion resistance. The performance of this coating depends largely on its thickness and the kind of environment to which it is exposed. Published results of enviromental corrosion studies have demonstrated that the coating provides corrosion resistance greater than equivalent thicknesses of zinc coatings in industrial environments and greater corrosion resistance than equivalent thicknesses of cadmium coatings in marine environments.[8]

6.2 *Galvanic Corrosion Resistance*—The galvanic couple that results in the corrosion of steel and aluminum parts in contact with each other in corrosive environments can also be minimized by plating the steel parts with this mechanically deposited coating.

6.3 *Hydrogen Embrittlement, Absence of*—The mechanical coating process does not produce any permanent hydrogen embrittlement in products made from high-strength steels, for example, fasteners or lock washers.

7. Coating Requirements

7.1 *Nature of Coating*—The coating shall be a mechanically deposited mixture of cadmium and zinc with the composition 45 to 75 mass % zinc, remainder cadmium.

7.2 *Coating Process*:

7.2.1 *Coating*—The cadmium-zinc coating shall be produced by mechanical deposition in accordance with the process description given in Annex A1.

7.2.2 *Supplementary Treatments*—Type II coatings shall be produced by treatment with acidic solutions that contain hexavalent chromium compounds and anions that act as catalysts or film-forming compounds.

7.3 *Appearance*:

7.3.1 *General*—The coating on all readily visible surfaces shall be uniform in appearance, well compacted, and complete in coverage. Superficial staining from rinsing and drying and mild variations in color and luster are acceptable.

7.3.2 *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 coating despite the observance of good metal finishing practices shall not be cause for rejection.

NOTE 1—Coatings 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. The specifications covering the unfinished products should provide limits for these defects. A metal finisher can often remove defects through special treatments, such as grinding, polishing, abrasive blasting, chemical etches, and electropolishing. However, these are not normal in the treatment steps preceding the application of the coating. When they are desired, they are the subject of special agreement between the purchaser and the seller.

7.4 *Thickness*:

7.4.1 *Conformance to Specified Class*—The thickness of the coating everywhere on the significant surfaces shall conform to the requirements of the specified class as defined in 4.1.

7.4.2 *Significant Surfaces*—Significant surfaces are usually defined as those normally visible (directly or by reflection) that are essential to the appearance and serviceability of the article when assembled in normal position; or that can be the source of corrosion products that deface visible surfaces on the assembled article. Significant surfaces are further defined at those surfaces that are identified as such by the purchaser, for example, by indicating them on an engineering drawing of the product or by marking a sample item of product.

7.4.3 *Minimum Thickness Requirement*—The coating 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 thickness from point to point on an article and from article to article in a production lot is inherent in mechanically deposited coatings. 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 specified minimum.

NOTE 2—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, and interior corners and holes, depending on the dimensions, with such thinner areas often being exempted from thickness requirements.

NOTE 3—Processes used to produce Type II finishes remove some of the coating. Because thickness requirements apply to the finished article, additional thicknesses may have to be applied to compensate for the metal removed in the Type II process.

7.5 *Adhesion*—The coating shall be adherent, as defined or tested in accordance with 9.6.

7.6 *Corrosion Resistance*:

[8] Polleys, R. W., "The Adhesion Testing of Electroplated Coatings," *Proceedings*, American Electroplaters' Society, Vol 50, 1963, p. 54.
[8] Holford, Raymond N., Jr., "Five Year Outdoor Exposure Corrosion Comparison," Mechanical Finishing, July 1988.

7.6.1 *Type I Coatings on Ferrous Articles*—Type I coated ferrous articles shall not develop red corrosion products (“rust”) when submitted to the 5 % salt spray test for the following times:

Class 7	36 h
Class 12	72 h
Class 25	192 h
Class 50	300 h

7.6.2 *Type II Coatings, White Corrosion*—Type II coatings shall not develop white corrosion products when submitted to the salt spray test for 72 h. The organic coating or lubricant shall be removed from Type IId coatings before the test or the test can be run on articles that are withdrawn from processing before the organic coating is applied.

7.6.3 *Type II Coatings on Ferrous Articles*—Type II coated ferrous articles shall not develop red corrosion products (“rust”) when submitted to the 5 % salt spray test for the following times:

Class 7	72 h
Class 12	96 h
Class 25	192 h
Class 50	300 h

The organic coating or lubricant shall be removed from Type IId coatings before the salt spray test or the test can be run on articles that are withdrawn from processing before the organic coating is applied.

NOTE 4—In many instances, there is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other tests or actual environments, because several factors that influence the progress of corrosion, such as the formation of protective film, 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.

8. Sampling

8.1 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 amount of acceptance inspection. The sampling plan used for the inspection of a quantity of the quality coated articles shall be agreed upon between the purchaser and the supplier.

NOTE 5—Usually, when producer.

8.1.1 When a collection of coated articles—the (inspection lot (, see 8.2) is examined for compliance with the requirements placed on the articles, a relatively small number of the articles, the sample, articles (sample) is selected at random and is inspected. The inspection lot is then classified as complying or not complying with the requirements based on the results of the inspection of the sample. The size of the sample and the criteria of for compliance are determined by the application of statistics. The procedure is known as sampling inspection. Three standards Test Method B 602, Guide B 697, and Method B 762 contain sampling plans that are designed for the sampling inspection of the coating: Test coatings.

8.1.2 Test Method B 602, Guide B 697, and Method B 762.

Test Method B 602 contains three four sampling plans, three for use with tests that are non-destructive and a fourth to be used with destructive test methods. The buyer and seller may agree on the plan or plans to be used. If one when they do not, are destructive. Test Method B 602 identifies the provides a default plan to be used.

Guide if one is not specified.

8.1.3 Guide B 697 provides a large number of plans and also gives guidance in the selection of a plan. When Guide B 697 is specified, the buyer and the seller need to agree on the provides a default plan t if o bne u is not specified.

8.1.4 Test Method B 762 can be used only for coating requirements that have a numerical limit, such as coating thickness. The test must yield a numerical value and certain statistical requirements must be 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.

8.1.5 Guide F 1470 can be 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 seller may “prevention process.” The purchaser and producer shall agree on the plan or plans to be used. If they do not, Method B 762 identifies the plan to be used. used.

8.2 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. NOTE 6—When both destructive and non-destructive 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. A test may destroy the coating but in a non-critical area; or, although it may destroy the coating, a tested part can be reclaimed by stripping and recoating. The purchaser needs to state whether the test is to be considered destructive or non-destructive.

8.3 If special 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 9.1.

9. Test Methods

9.1 *Special Test Specimens*:

9.1.1 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. State the permission or the requirement to use the test specimens, their number, the material from which they shall be made, and their size and shape in the purchase order or other governing document.

9.1.2 Duplicate in the test specimen those characteristics of the article that influence the property being tested, and process it with the article through those process steps that influence the property.

9.1.3 Make the test specimen used to represent an article in an adhesion, corrosion resistance, or appearance test of the same material, in the same metallurgical condition, and have the same surface condition as the article it represents. Place it in the production lot of and process along with the article it represents.

9.1.4 Introduce a test specimen used to represent an article in a coating thickness test into the process at the point where the coating or coatings are applied and carry it through all steps that have a bearing on the coating thickness.

NOTE ~~7~~5—When a test specimen is used to represent a coated article in a thickness test, the specimen will not necessarily have the same coating thickness and coating 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 as thickness test performed on test specimens, the relationship between the thickness on the specimen and the thickness of the part needs to be established. The criterion of thickness acceptance is that coating thickness on the specimen that corresponds to the required thickness on the article.

9.2 *Composition of Coating*—Determine chemical composition of the coating by procedures in Method E 27, Test Methods E 396, Test Method E 536, or by other methods that can determine composition to within 0.1 mass % unit.

9.3 *Process*—The supplier shall certify that the cadmium-zinc coating was produced from the mechanical deposition process as required by this specification.

9.4 *Appearance*—Examine the coating by the unaided eye at a normal reading distance for conformance to the requirements of appearance.

9.5 *Thickness*:

9.5.1 Determine the thickness of the coating by Test Methods B 487 or B 499, 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 %.

9.5.2 Measure the thickness of the coating at the location or locations on the significant surfaces of the article where the coating would be expected to be the thinnest, or at such locations as specified on the purchase order.

9.5.3 Make thickness measurements of Type II coatings after the application of the supplementary treatment. Chromate treatments can significantly affect the accuracy of the thickness measuring methods used. For this reason, remove Type II supplementary coatings from the test areas prior to thickness measurement. Remove the supplementary coatings by using a very mild abrasive (a paste of levigated alumina or magnesium oxide rubbed on gently with the finger). The process by which Type II supplementary coatings are produced dissolves a small amount of cadmium-zinc. For this reason the thickness requirement refers to the thickness of the coating after the application of the Type II supplementary coating.

9.6 *Adhesion*—Test adhesion of the cadmium-zinc deposit to the basis metal 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, is evidence of failure. Use either one of the following methods for determining adhesion, or any more applicable test method as defined in Note ~~8:~~ 6:

9.6.1 Deform the part, if possible, to its rupture and examine the coating to determine evidence of failure as defined in 9.6.

9.6.2 Scrape or shear the surface of the coated article with a sharp edge, knife, or razor blade through the coating down to the basis metal and examine under 4 × magnification.

NOTE ~~8~~6—There is no single satisfactory test for evaluating the adhesion of mechanically deposited coatings. Those given in 9.6 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 other methods of measuring adhesion has been presented by Polleys.[9] Application of pressure-sensitive tape to the coating 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.

9.7 *Corrosion Resistance*:

9.7.1 Test the corrosion resistance of the coating by the 5 % neutral salt spray (fog) test as defined in Practice B 117.

9.7.2 If samples with Type II coatings are being examined both for white corrosion products and for rust, separate sets of samples may be used to determine the 72-h end point for white corrosion and the 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.

9.7.3 Age parts with a Type II supplementary chromate film at room temperature for 24 h before subjection to the salt spray test.

9.7.4 The presence of corrosion products, either white from the coating itself or red from an iron or steel basis metal, and visible to the unaided eye at a normal reading distance at the end to the specified test period constitute failure, except that corrosion

[9] Polleys, R. W., "The Adhesion Testing of Electroplated Coatings," *Proceedings*, American Electroplaters' Society, Vol 50, 1963, p. 54.

products at the edges of specimens, or within 5 mm from edges or sharp corners, do not constitute failure. Slight "whisps" of white corrosion products, as opposed to obvious accumulations, are acceptable.

9.8 *Absence of Hydrogen Embrittlement*—Test coated parts being tested for the absence of embrittlement from cleaning for brittle failure in accordance with a suitable method to be specified on the purchase order (see 5.1.6.7). 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 coating and testing or use of the part and the criterion of failure (see Annex A2).

NOTE 97—It is recommended that tests for embrittlement involve subjecting parts to the specified test conditions for at least 100 h. The stress level induced by the test and the waiting period prior to test depend on many factors, such as shape of the part, carbon content of the steel, hardness of the part, and the stress level in use. Parts with a tensile strength of over 1000 MPa, for example, may require a 48-h waiting period; parts with a 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.

10. Rejection and Rehearing

10.1 Coated articles 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 the test, the producer or supplier may make a claim for rehearing. Coatings that show imperfections during subsequent manufacturing operations may be rejected.

11. Certification

11.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and that the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement applies only when specified by the purchaser in the contract of order.

S1. *Stress Relief*—Parts that are made from steels with ultimate tensile strengths greater than 1050 MPa and that have been machined, ground, cold-formed, or cold-straightened shall be stress-relieved before processing by heat treating for 5 h at 190 ± 15°C.

SPECIAL GOVERNMENT REQUIREMENTS

The following special requirements shall apply when the purchaser is the United States Government or an agent of the United States Government.

S2. The producer or supplier shall be responsible for the performance of all inspection and test requirements specified herein (see section 6.7). Except as otherwise specified in the contract or order, the producer or supplier may use his own or any other suitable facility 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.

ANNEXES

(Mandatory Information)

A1. COATING PROCESS

A1.1 The coating process is described in this annex in general terms. The producer of the coating will establish the specific operating details.

A1.1.1 Preclean as necessary to remove gross contamination (oil, scale, corrosion, preservatives, etc.). Useful cleaning guidelines are given in Practices B 183, B 242, B 320, and B 322.

A1.1.2 Prepare the surface, generally within the mechanical deposition container, by a chemical (generally a mild, inhibited acidic) procedure.

A1.1.3 Deposit, as appropriate to the basis metal, a thin metal coating by immersion, without the use of electric current, in an appropriate chemical solution. For ferrous metals, this coating is generally copper.

A1.1.4 Tumble the parts in a container with the following: cadmium and zinc powders, impact media, generally glass beads, a promoter or accelerator, and a liquid, generally water.

A1.1.5 Separate the articles from the other ingredients.

A1.1.6 Rinse,

A1.1.7 Apply any required supplementary treatment, and

A1.1.8 Dry.

A2. HYDROGEN EMBRITTLEMENT

A2.1 A major advantage of mechanical plating is that it does not produce any permanent 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.