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~~Designation:B 633–98~~ Designation: B633 – 11

Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel[1]

This standard is issued under the fixed designation B633; 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 requirements for electrodeposited zinc coatings applied to iron or steel articles to protect them from corrosion. It does not cover electrodeposited zinc-coated steel wire or sheets (see Specification ~~A 591~~A591/A591M~~/A 591M~~ for sheets).

1.2 The coatings are provided in four standard thickness classes (4.1), in the as-plated condition or with one of three types of supplementary finish (4.2).

~~1.3~~

1.3 High strength metals, unless otherwise specified, including high strength steels having a tensile strength greater than 1700 MPa (247 ksi R_c 46) shall not be electroplated.

1.4 The values stated in SI units shall be regarded as standard.

1.5 *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.*

1.6 *This standard has been revised to address RoHS requirements that seek to limit the exposure of workers and the public from exposure to toxic metals. Additional types have been added to permit non-chromate passivate treatments to be used in replacement of hexavalent chromium.*

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

A591/A591M Specification for Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Weight [Mass] Applications

B117 Practice for Operating Salt Spray (Fog) Apparatus

B183 Practice for Preparation of Low-Carbon Steel for Electroplating

B201 Practice for Testing Chromate Coatings on Zinc and Cadmium Surfaces

B242 ~~Practice~~Guide for Preparation of High-Carbon Steel for Electroplating

B254 Practice for Preparation of and Electroplating on Stainless Steel

B320 Practice for Preparation of Iron Castings for Electroplating

B322 ~~Practice~~Guide for Cleaning Metals Prior to Electroplating

B374 Terminology Relating to Electroplating

B487 Test Method for Measurement of Metal and Oxide Coating ~~Thicknesses~~Thickness by Microscopical Examination of ~~a~~ Cross Section

B499 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals

B504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method

B567 Test Method for Measurement of Coating Thickness by the Beta Backscatter Method

B568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry

B571 ~~Test Methods for Adhesion of Metallic Coatings[4]~~ Practice for Qualitative Adhesion Testing of Metallic Coatings

B602 ~~Test Method for Attribute Sampling of Metallic and Inorganic Coatings~~[4]

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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 B08.04 on Soft Metals.~~

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* ~~, Vol 01.06.~~volume information, refer to the standard's Document Summary page on the ASTM website.

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B697Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[4]
B762Method of Variables Sampling of Metallic and Inorganic Coatings[4] Test Method for Attribute Sampling of Metallic and Inorganic Coatings
B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
B762 Test Method of Variables Sampling of Metallic and Inorganic Coatings
B849 Specification for Pre-Treatments of Iron or Steel for Reducing Risk of Hydrogen Embrittlement
B850 Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement
D2092 Guide for Treatment of Zinc-Coated (Galvanized) Steel Surfaces for Painting
F1740Guide for Inspection of Nylon, Polyester, or Nylon/Polyester Blend, or Both Kernmantle Rope Guide for Preparation of Zinc-Coated (Galvanized) Steel Surfaces for Painting
F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

2.2 *Military Standard:*[3]
MIL-STD-1312 Fastener Tests, Methods (Test 12)

3. Terminology

3.1 *Definitions:* —
3.1.1 Definitions of the terms used in this specification are in accordance with Terminology B 374B374.
3.1.2 *passivite*—for the purpose of this specification, a conversion coating on zinc shall not contain hexavalent chromium.

4. Classification

4.1 *Thickness*—The coating shall be provided in one of the four thickness classes defined in Table 1.
4.2 *Finish*—The coating shall have one of the finish types defined as follows:

Type	Description
I	As-plated without supplementary treatment
II	With colored chromate conversion coatings
III	With colorless chromate conversion coatings
IV	With phosphate conversion coatings

—The coating shall have one of the finish types defined in Table 2.

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5. Ordering Information

5.1 When ordering the electroplating of articles, the purchaser shall state the designation number, ASTM B633, the date of issue, the class or service condition number, and the type. (SeeType (see 4.1, 4.2, and 7.1).
5.2 If necessary, the purchaser shall include on his part drawings or purchase order the following:
5.2.1Electroplating application to high strength steel, if specified (6.4),
5.2.1 Basis metal alloy designation and ultimate tensile strength of the steel,
5.2.2 Thickness, if other than specified (4.1, 7.1),
5.2.3 Location of significant surface (7.1.1, 7.1.2),
5.2.4 Luster (7.3),
5.2.5Corrosion resistance test, if specified (
5.2.5 Exceptions to stress relief heat treatment prior to plating, ((6.4),
5.2.6 Exception to Hydrogen Embrittlement Relief after plating, (6.5).
5.2.7 Corrosion resistance test, if specified (9.3, 10.3),

[3] Annual Book of ASTM Standards, Vol 03.02.
[3] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://www.dodssp.daps.mil.

TABLE 1 Thickness Classes for Coatings

ClassificationA Number and Conversion Coating Suffix	Service ConditionB,C	Thickness, min µm
Fe/Zn 25	SC 4 (very severe)	25
Fe/Zn 12	SC 3 (severe)	12
Fe/Zn 8	SC 2 (moderate)	8
Fe/Zn 8	SC 2 (moderate)	8
Fe/Zn 5	SC 1 (mild)	5
Fe/Zn 5	SC 1 (mild)	5

A Iron or steel with zinc electroplate. Numeral indicates thickness in micrometres.
B See Appendix X2.
C Where service conditions are valid only for coatings with chromate conversion coating. Type II for SC 4 and SC 3 and Type III for SC 2 and SC 1.

TABLE 2 Finish Type and Corrosion Resistance Requirements

Type	Description	Minimum Salt Spray h
I	As-plated without supplementary treatments	
II	With colored chromate coatings	96
III	With colorless chromate conversion coatings	12
IV	With phosphate conversion coatings	
V	With colorless passivate	72
VI	With colored passivate	120

5.2.~~6~~8 Hydrogen embrittlement test, if required (9.4, 10.4~~),~~

~~5.2.7Sample size for inspection, if other than specified, and~~

~~5.2.8Supplementary requirements, if applicable (Supplementary Requirement).~~), including the tensile strength of the items,

5.2.9 Sample size for inspection, if other than specified, and

5.2.10 Supplementary requirements, if applicable (see Supplementary Requirement).

6. Materials and Manufacture

6.1 The coatings shall be ~~essentially pure~~non-alloyed zinc produced by electrodeposition.

6.2 Defects in the surface of the basis metal, such as scratches, porosity, pits, inclusions, cracks, roll marks, and die marks, may adversely affect the appearance and performance of coatings applied thereto despite the observance of the best electroplating practices. Accordingly, the electroplater's responsibility for defects in the coating resulting from such conditions shall be waived, except when he is the prime contractor supplying electroplated parts. In this event, the basis metal shall be subjected to such polishing or buffing operations as are necessary to yield deposits with the desired final luster and appearance. To minimize problems of this sort, the specifications covering the basis material on the item to be electroplated shall contain appropriate limitations to such basis metal conditions.

6.3 *Cleaning of Basis Metal*—Proper preparatory procedures and thorough cleaning of the basis metal are essential to ensure satisfactory adhesion and corrosion resistance performance of the coating. It is recommended that the following appropriate recommended practices and guides be used: ~~B 183, B 242, B 254, B 320, and B 322~~B183, B242, B254, B320, and B322.

~~6.4*High-Tensile Strength Metals*—Unless otherwise specified, high strength steels having a tensile strength greater than 1700 MPa shall not be electroplated.~~

~~6.5*Stress Relief*—All steel parts having an ultimate tensile strength of 1000 MPa and above, and that have been machined, ground, cold formed or cold straightened, shall be heat treated at a minimum of 190°C for 3 h or more for stress relief before cleaning and electroplating.~~

~~6.6*Hydrogen Embrittlement Relief*— All electroplated parts having a tensile strength of 1200 MPa or higher shall be baked at a minimum of 190°C for 3 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 before the hydrogen embrittlement relief treatment. The baking treatment shall be done before the application of the supplementary treatments. Baked parts shall not crack or fail by fracture when tested in accordance with~~

6.4 *Pretreatment of Iron or Steel for the Purpose of Reducing the Risk of Hydrogen Embrittlement*—All steel parts having an ultimate tensile strength greater than 1000 MPa (31 HRC) and that have been machined, ground, cold formed, or cold straightened, shall be heat treated for stress relief to reduce the risk of hydrogen embrittlement in the part before clean and electroplate processes. If these heat treatments are not required, the purchaser shall specify in the ordering information their exception, (5.2.5). If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in B849 to determine the appropriate heat treatment for the steel based on its tensile strength.

6.5 *Post Coating Treatments of Iron and Steel for the Purpose of Reducing the Risk of Hydrogen Embrittlement*—All electroplated steel parts having a tensile strength greater than 1000 MPa (31 HRC) as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. If these heat treatments are not required, the purchaser shall specify in the ordering information their exception (5.2.5). If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in B850 to determine the appropriate heat treatment for the steel based on its tensile strength. The baking treatment shall be done before the application of the supplementary treatments and within 4 h of removal from the last process. Electroplated springs and other parts subject to flexure shall not be flexed before the hydrogen embrittlement relief treatment. Baked parts shall not crack or fail by fracture when tested in accordance with 10.4.

~~6.7~~

6.6 *Reactivation Treatment*—~~Electroplated surfaces passivated as a result of the baking operation shall be reactivated before receiving a supplementary treatment. Surfaces intended for supplementary treatments (Types II and III) may be reactivated by immersion in a dilute acid solution. Surfaces should be activated as soon as possible following baking and should be handled carefully to avoid contamination.~~

~~6.8~~*—Electroplated surfaces passivated as a result of the baking operation shall be reactivated before receiving a supplementary treatment.*

NOTE 1—Surfaces should be activated as soon as possible following baking and handled carefully to avoid contamination and maintain an active surface for post processing. Proprietary methods are available to prepare the surface or a 2% v/v sulfuric acid in deionized water or a 7-10 g/l solution of sulfamic acid in deionized water can be used.

6.7 *Supplementary Treatments*—The supplementary film treatment for Types II, III, V, and ~~III~~VI shall be in accordance with Practice ~~B 201~~B201 (see Notes 2 and 3). The treatment required for conversion to Type IV shall be in accordance with Guide ~~D 2092~~D2092.

~~NOTE1—The zinc surface is attacked by supplementary treatments, thereby diminishing the amount of metallic zinc present. With Classes Fe/Zn25 and Fe/Zn13, this reduction is insignificant; but it is significant with Fe/Zn8 and Fe/Zn5. Therefore, it is recommended that supplementary treatments not be applied to zinc coatings having a nominal thickness less than 5 µm.~~

~~7.*Coating Requirements* Coating Requirements~~ 2—The zinc surface is attacked by supplementary treatments, thereby diminishing the amount of metallic zinc present. With Classes Fe/Zn25 and Fe/Zn13, this reduction is insignificant; but it is significant with Fe/Zn8 and Fe/Zn5. Therefore, it is recommended that supplementary treatments not be applied to zinc coatings having a nominal thickness less than 5 µm.

NOTE 3—Although Types V and VI are technically not "chromate" films and they do not contain leachable hexavalent chromium ions, they are supplemental coatings that render the active zinc surface passive and provide added protection to the steel part.

7. Coating Requirements

7.1 *Thickness*—The thickness shall be specified in accordance with 4.1 and 5.1~~—~~. (see Note 2)

7.1.1 *Significant Surfaces*—Significant surfaces are areas where minimum thicknesses to be met shall be designated on the applicable drawing or by the provision of a suitably marked sample. Significant surfaces may be defined as those normally visible, directly or by reflection, which are essential to the appearance or serviceability of the article when assembled in normal ~~position;~~position or which ~~can be~~are the source of corrosion products that deface visible surfaces on the assembled article.

7.1.2 Surfaces on which the specified thickness of deposit cannot readily be controlled, such as threads, holes, deep recesses, bases of angles, and similar areas, are normally exempt from minimum thickness requirements, unless they are specially designated as not exempt. When such areas are designated, and thus made subject to minimum thickness requirements, the purchaser and the manufacturer shall recognize the necessity for either thicker deposits on other areas or for special racking.

NOTE~~2—The~~ 4—The dimensional tolerance of most threaded articles, such as nuts, bolts, screws, and similar fasteners with complementary threads, normally does not permit the application of a coating thickness much greater than 8.0 µm. If heavier coatings are required, allowance for the deposit ~~build-up~~buildup must be made during the manufacture of the threaded articles.

7.2 *Adhesion*—The adhesion of the coating shall be such that when examined in accordance with 10.2, the coating shall not show separation from the basis metal at the interface.

7.3 *Luster*—Unless otherwise specified by the purchaser, a bright, semi-bright, or dull ~~luster~~finish shall be acceptable.

7.4 *Corrosion Resistance*— Zinc coatings with Types II, III, V, and ~~III~~VI treatments shall show neither corrosion products of zinc nor basis metal corrosion products at the end of the test ~~period, as shown below,~~periods describe in Table 2 when tested by continuous exposure to salt spray in accordance with 10.3~~. The appearance of corrosion products visible to the unaided eye at normal reading distance shall be cause for rejection except that white corrosion products at the edges of specimens shall not constitute failure.~~

~~Corrosion Resistance Requirements~~

~~Types~~	~~Test Period, h~~
~~II~~	~~96~~
~~III~~	~~12~~

. The appearance of corrosion products when examined with 20/20 eyesight at normal reading distance shall be cause for rejection, except that white corrosion products 6 mm or less from the edges of specimens shall not constitute failure. For corrosion resistance requirements, see Table 2.

7.5 *Workmanship*—The surface of the electroplated article shall be uniform in appearance, free of visible coating defects, such as blisters, pits, roughness, nodules, burning, cracks, or unplated areas, and other defects that will affect the function of the coating. The coating shall not be stained or discolored. However, superficial staining that results from rinsing or slight discoloration resulting from any drying or baking operation to relieve hydrogen embrittlement, shall not be cause for rejection. On articles ~~where~~in which a visible contact mark is unavoidable, its position shall be that chosen by the purchaser. The electroplated article shall be clean and free of damage.

8. Sampling

8.1 The purchaser and producer are urged to employ statistical process control in the coating process. Properly performed, statisitical process control will assure coated products of satisfactory quality and will ~~reduce~~assure the amount of acceptance inspection. The sampling plan used for the inspection of the quality coated article shall be agreed upon between the purchaser and producer.

8.1.1 When a collection of coated articles (inspection lot, see 8.2) is examined for compliance with the requirements placed on the articles, a relatively small number of the articles (sample) is selected at random and is inspected. The inspection lot is then classified as complying with the requirements based on the results of the inspection of the sample. The size of the sample and the

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