Designation: B733 – 22

Standard Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal[1]

This standard is issued under the fixed designation B733; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification covers requirements for autocatalytic (electroless) nickel-phosphorus coatings applied from aqueous solutions to metallic products for engineering (functional) uses.

1.2 The coatings are alloys of nickel and phosphorus produced by autocatalytic chemical reduction with hypophosphite. Because the deposited nickel alloy is a catalyst for the reaction, the process is self-sustaining. The chemical and physical properties of the deposit vary primarily with its phosphorus content and subsequent heat treatment. The chemical makeup of the plating solution and the use of the solution can affect the porosity and corrosion resistance of the deposit. For more details, see ASTM STP 265 (**1**)[2] and Refs (**2**), (**3**), (**4**), and (**5**).

1.3 The coatings are generally deposited from acidic solutions operating at elevated temperatures.

1.4 The process produces coatings of uniform thickness on irregularly shaped parts, provided the plating solution circulates freely over their surfaces.

1.5 The coatings have multifunctional properties, such as hardness, heat hardenability, abrasion, wear and corrosion resistance, magnetics, electrical conductivity provide diffusion barrier, and solderability. They are also used for the salvage of worn or mismachined parts.

1.6 The low phosphorus (2 to 4 % P) coatings are microcrystalline and possess high as-plated hardness (620 to 750 HK 100). These coatings are used in applications requiring abrasion and wear resistance.

1.7 Lower phosphorus deposits in the range between 1 % and 3 % phosphorus are also microcrystalline. These coatings are used in electronic applications providing solderability, bondability, increased electrical conductivity, and resistance to strong alkali solutions.

1.8 The medium phosphorous coatings (5 to 9 % P) are most widely used to meet the general purpose requirements of wear and corrosion resistance.

1.9 The high phosphorous (more than 10 % P) coatings have superior salt-spray and acid resistance in a wide range of applications. They are used on beryllium and titanium parts for low stress properties. Coatings with phosphorus contents greater than 11.2 % P are not considered to be ferromagnetic.

1.10 *Units*—The values stated in SI units are to be regarded as standard.

1.11 The following precautionary statement 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.12 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

B368 Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

B374 Terminology Relating to Electroplating

B380 Test Method for Corrosion Testing of Decorative Electrodeposited Coatings by the Corrodkote Procedure

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

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.03 on Engineering Coatings.

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[2] The boldface numbers given in parentheses refer to a list of references at the end of the text.

[3] 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* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

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
B537 Practice for Rating of Electroplated Panels Subjected to Atmospheric Exposure
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 Practice for Qualitative Adhesion Testing of Metallic Coatings
B578 Test Method for Microindentation Hardness of Electroplated Coatings
B602 Guide for Attribute Sampling of Metallic and Inorganic Coatings
B667 Practice for Construction and Use of a Probe for Measuring Electrical Contact Resistance
B678 Test Method for Solderability of Metallic-Coated Products
B697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings
B762 Guide 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
B851 Specification for Automated Controlled Shot Peening of Metallic Articles Prior to Nickel, Autocatalytic Nickel, or Chromium Plating, or as Final Finish
D1193 Specification for Reagent Water
D2670 Test Method for Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)
D2714 Test Method for Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine
D3951 Practice for Commercial Packaging
D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
E60 Practice for Analysis of Metals, Ores, and Related Materials by Spectrophotometry
E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness
E156 Test Method for Determination of Phosphorus in High-Phosphorus Brazing Alloys (Photometric Method) (Withdrawn 1993)[4]
E352 Test Methods for Chemical Analysis of Tool Steels and Other Similar Medium- and High-Alloy Steels
F519 Test Method for Mechanical Hydrogen Embrittlement Evaluation of Plating/Coating Processes and Service Environments
G5 Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements
G31 Guide for Laboratory Immersion Corrosion Testing of Metals
G59 Test Method for Conducting Potentiodynamic Polarization Resistance Measurements
G85 Practice for Modified Salt Spray (Fog) Testing

2.2 *SAE Documents:*[5]
AMS 2430 Shot Peening[6]
AMS 2590 Rotary Flap Peening of Metal Parts[7]

2.3 *ANSI Standard:*[8]
ANSI/ASQ Z1.4 Sampling Procedures and Tables for Inspection by Attributes[9]

2.4 *Military Standard:*[10]
MIL-STD-1916 DOD Preferred Methods of Acceptance of Product

2.5 *ISO Standard:*[11]
ISO 4527 Metallic Coatings-Autocatalytic (Electroless) Nickel-Phosphorus Alloy Coatings—Specification and Test Methods

3. Terminology

3.1 *Definitions:*

3.1.1 *significant surfaces, n*—those substrate surfaces which the coating must protect from corrosion or wear, or both, and that are essential to the performance.

3.2 *Other Definitions*—Terminology B374 defines most of the technical terms used in this specification.

4. Coating Classification

4.1 The coating classification system provides for a scheme to select an electroless nickel coating to meet specific performance requirements based on alloy composition, thickness and hardness.

4.1.1 TYPE describes the general composition of the deposit with respect to the phosphorus content and is divided into five categories which establish deposit properties (see Table 1).

NOTE 1—Due to the precision of some phosphorus analysis methods, a deviation of 0.5 % has been designed into this classification scheme. Rounding of the test results due to the precision of the limits provides for an effective limit of 4.5 % and 9.5 %, respectively. For example, coating with a test result for phosphorus of 9.7 % would have a classification of TYPE V, see Appendix X5, Alloy TYPEs.

4.2 *Service Condition Based on Thickness:*

[4] The last approved version of this historical standard is referenced on www.astm.org.

[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[6] The original reference MIL-S-13165 Shot Peening of Metal Parts was cancelled in February 1998 and referred to SAE AMS-S-13165, which was also cancelled and superseded by AMS 2430.

[7] The original reference MIL-R-81841 Rotary Flap Peening of Metal Parts was cancelled in April 2012 and referred to SAE AMS 2590.

[8] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[9] The original reference MIL-STD-105 Sampling Procedures and Tables for Inspection by Attributes was cancelled in February 2008 and referred to MIL-STD-1916 or ANSI/ASQ Z1.4.

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

[11] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.