Designation: B605 – 22

Standard Specification for Electrodeposited Coatings of Tin-Nickel Alloy[1]

This standard is issued under the fixed designation B605; 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. Scope*

1.1 This specification covers the requirements for electrodeposited tin-nickel alloy coatings from aqueous solutions intended for the corrosion protection of fabricated articles of iron, steel, zinc-base alloys, copper, and copper alloys. The composition of the alloy remains constant at 65/35 tin-nickel in spite of wide fluctuations in both composition and operating conditions. The composition corresponds quite closely to an equiatomic ratio, and the process favors the co-deposition of tin and nickel atoms at identical rates.

1.2 This specification does not apply to sheet, strip, or wire in the fabricated form. It also may not be applicable to threaded articles having basic major diameters up to and including 19 mm because of the nonuniformity of thickness that can be expected on fine threads. However, a decision to use the coating on such components may be made by the purchaser.

1.3 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.*

1.5 *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:*[2]

B183 Practice for Preparation of Low-Carbon Steel for Electroplating
B242 Guide for Preparation of High-Carbon Steel for Electroplating
B246 Specification for Tinned Hard-Drawn and Medium-Hard-Drawn Copper Wire for Electrical Purposes
B252 Guide for Preparation of Zinc Alloy Die Castings for Electroplating and Conversion Coatings
B281 Practice for Preparation of Copper and Copper-Base Alloys for Electroplating and Conversion Coatings
B322 Guide for Cleaning Metals Prior to Electroplating
B374 Terminology Relating to Electroplating
B487 Test Method for Measurement of Metal and Oxide Coating Thickness by Microscopical Examination of 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
B507 Practice for Design of Articles to Be Electroplated on Racks
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
B602 Guide for Attribute Sampling of Metallic and Inorganic Coatings
B634 Specification for Electrodeposited Coatings of Rhodium for Engineering Use
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
B765 Guide for Selection of Porosity and Gross Defect Tests for Electrodeposits and Related Metallic Coatings
B809 Test Method for Porosity in Metallic Coatings by Humid Sulfur Vapor ("Flowers-of-Sulfur")
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

[1] This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.06 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* 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**

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3. Terminology

3.1 *Definitions:*

3.1.1 Many terms used in this standard are defined in Terminology B374.

3.1.2 *significant surface, n*—that portion of a coated article's surface where the coating is required to meet all the requirements of the coating specification for that article. Significant surfaces are those that are essential to the serviceability or function of the article, or which can be a source of corrosion products or tarnish films that interfere with the function or desirable appearance of the article. Significant surfaces are those surfaces that are identified by the purchaser by, for example, indicating them on an engineering drawing of the product or marking a sample item of the product.

3.1.3 *undercoating, n*—a metallic coating layer between the basis metal or substrate and the topmost metallic coating. The thickness of an undercoating is usually greater than 0.8 µm. This is in contrast to strikes or flashes, whose thicknesses are generally lower.

4. Classifications

4.1 *Coating Grades*—Six grades of coatings, designated by service condition numbers, are covered by this specification. For each coating grade a coating thickness grade is specified (see Tables 1-3).

4.2 *Service Condition Number*—The service condition number indicates the severity of exposure for which the grade of coating is intended.

SC5—extended severe service
SC4—very severe service
SC3—severe service
SC2—moderate service
SC1—mild service
SC0—mild service (copper and copper alloys only)

NOTE 1—Typical service conditions for which the service condition numbers are appropriate are given in Appendix X1.

4.3 *Coating Thickness Notation*—The coating thickness is specified for each service condition in the following manner: Basis metal/Undercoating (thickness)/Sn-Ni (thickness). For example, Fe/Cu4/Sn-Ni25 would indicate a 25 µm tin-nickel coating over an iron or steel article with a 4 µm thick copper undercoating. All thickness notations are minimum thicknesses.

TABLE 1 Tin-Nickel Coatings on Steel

Service Condition Number		Thickness Notation	Minimum Thickness, µm
5	Fe/Cu[A] /Sn-Ni	as specified[B] (above 45)	as specified[B] (above 45)
4	Fe/Cu[A] /Sn-Ni	45	45
3	Fe/Cu[A] /Sn-Ni	25	25
2	Fe/Sn-Ni	15	15
1	Fe/Sn-Ni	8	8

[A] Copper undercoat shall be at least 4.0 µm.
[B] Thickness of Sn-Ni shall be stated in a Thickness Notation. A statement of Service Condition 5 is not sufficient.

TABLE 2 Tin-Nickel Coatings on Copper or Copper Alloys

Service Condition Number		Thickness Notation	Minimum Thickness, µm
5	Cu/Sn-Ni[A]	as specified[B] (above 45)	as specified[B] (above 45)
4	Cu/Sn-Ni[A]	45	45
3	Cu/Sn-Ni[A]	25	25
2	Cu/Sn-Ni[A]	15	15
0	Cu/Sn-Ni[A]	4	4

[A] An undercoating of copper 4.0 µm thick shall be applied on copper-zinc alloys to serve as a zinc diffusion barrier.
[B] Thickness of Sn-Ni shall be stated in a Thickness Notation. A statement of Service Condition 5 is not sufficient.

TABLE 3 Tin-Nickel Coatings on Zinc Alloys

Service Condition Number		Thickness Notation	Minimum Thickness, µm
4	Zn/Cu[A] /Sn-Ni	45	45
3	Zn/Cu[A] /Sn-Ni	25	25
2	Zn/Cu[A] /Sn-Ni	15	15
1	Zn/Cu[A] /Sn-Ni	8	8

[A] An undercoating of copper 4.0 µm thick shall be applied to prevent zinc from contaminating the Sn-Ni plating bath and to serve as a diffusion barrier.

5. Ordering Information

5.1 To make the application of this standard complete, the purchaser needs to supply the following information to the seller in the purchase order or other government documents.

5.1.1 The name, designation, and date of issue of this standard,

5.1.2 Location of significant surface(s) (see section 3.1.2),

5.1.3 The service number or coating thickness notation (see 4.2 and 4.3),

5.1.4 Undercoating, if required (see 6.2 and Tables 1-3),

5.1.5 Any requirement for submission of sample coated articles (see 7.2.1),

5.1.6 Whether or not location of rack marks is to be defined (see 7.2.1),

5.1.7 Any requirement for porosity testing and the criteria for acceptance (see 7.5.2),

5.1.8 Basis metal alloy designation and ultimate tensile strength of the steel,

5.1.9 Whether the part underwent cold forming or cold straightening subsequent to heat treatment (see Note 2),

5.1.10 Exception to heat treatment for stress relief prior to plating (see 7.6),

5.1.11 Baking requirements after electroplating, if required (see 7.7),

5.1.12 Any packaging requirement (see section 7.8),

5.1.13 Inspection procedure to be used (see Section 9),

5.1.14 Any requirement for certification (see Section 11), and

5.1.15 Any requirement for test specimens (see 8.1.1).

NOTE 2—Information in 5.1.8 and 5.1.9 is necessary for proper pretreatment (7.6) and post coating treatment (7.7) if applicable.

6. Material and Process

6.1 *Composition of Coating*—Electrolytes that have been investigated for producing Sn-Ni alloy deposits include cyanide, fluoborate, pyrophosphate, and acetate, but the only one in general commercial use is the fluoride-chloride formulation.[3] The deposit contains 35 ± 5 % nickel with the remainder tin (see Note 3).

NOTE 3—The electrodeposited tin-nickel coating is a single-phase, metastable compound, corresponding approximately to the formula SnNi. It is stable at ordinary temperatures but starts to recrystallize at elevated temperatures. The safe working temperature of the coating is 300 °C, although actual melting does not commence below 800 °C. The coating is hard (700HV100). Like many such compounds, it is inherently somewhat brittle, but if it is free of internal stresses, the brittleness is not sufficient to impair its serviceability or to cause the coating to flake under impact. Because of the brittleness of the tin-nickel, however, it is not possible to fabricate parts by bending coated sheet material, because the compressive stresses in the coating on the inside of the bend usually cause some of the coating to flake off. To provide serviceability, the coating must be deposited in a stress-free condition. In addition, it is generally inadvisable to specify tin-nickel finish for parts subject to deformation in service.

6.2 *Basis Metal*—Tin-nickel can be deposited directly on steel, copper, and copper-base alloys. However, an undercoating of copper can improve performance in some systems and shall be used under the following conditions:

6.2.1 On steel, a copper undercoating with a minimum thickness of 4 µm, shall be used for Service Conditions 3, 4, and 5.

6.2.2 On copper-zinc alloys, a copper undercoating with a minimum thickness of 4 µm shall be used for all service conditions to prevent diffusion of the zinc.

6.2.3 Zinc-base alloys shall have an undercoating of a minimum of 4 µm of copper to prevent diffusion of the zinc into the deposit and to prevent contamination of the electrolyte with zinc.

NOTE 4—Tin-nickel-coated zinc-alloy diecastings shall never be returned for remelting to prevent contamination of the zinc alloy with tin.

7. Coating Requirements

7.1 *Composition of Coating*—The deposit shall contain 65 ± 5 % tin, the balance nickel.

7.2 *Appearance:*

7.2.1 The coating on all readily visible surfaces shall be smooth, fine grained, continuous, adherent, free of visible blisters, pits, nodules, indications of burning, excessive buildup, staining, and other defects. All tin-nickel coated articles shall be clean and undamaged. When necessary, preliminary samples showing the finish shall be supplied for approval. Where a rack contact mark is unavoidable, its location shall be indicated on the article or its drawing.

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

NOTE 5—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 product 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.

NOTE 6—Proper preparatory procedures and thorough cleaning are essential to ensure satisfactory adhesion and corrosion resistance performance of the coating. Materials used for cleaning should not damage the basis metal, for example, by causing defects such as pits, intergranular attack, stress corrosion cracking, and unwarranted hydrogen embrittlement. It is recommended that the following Practices, where appropriate for cleaning, be used: B183, B242, B252, B281, and B322.

7.3 *Thickness:*

7.3.1 The thickness of the coating everywhere on the significant surfaces shall conform to the requirements in Tables 1-3 as to minimum thickness.

NOTE 7—The thickness of electrodeposited coatings varies from point to point on the surface of the product. (See Practice B507.) The thickness is less in interior corners and holes. Such surfaces are often exempt from thickness requirements. If the full thickness is required in those locations, the electroplater will have to use special techniques that will probably raise the cost of the process.

NOTE 8—The coating thickness requirement of this specification is a minimum. Variation in the thickness from point to point on an article and from article to article in a production lot is inherent in electroplating. Therefore, if all of the articles in a production are to meet the thickness requirement, the average coating thickness for the production lot as a whole will be greater than the specified minimum.

7.4 *Adhesion*—The coatings shall be adherent to the basis metal when subject to either test, in accordance with 8.5.2 and 8.5.3. There shall be no separation of the coating from the substrate.

7.5 *Integrity of the Coating:*

7.5.1 *Gross Defects/Mechanical Damage*—The coatings shall be free of mechanical damage, large pores, and similar gross defects. For some applications, this requirement may be relaxed to allow for a small number of such defects (per unit area), especially if they are outside the significant surfaces.

7.5.2 *Porosity*—Almost all as-plated electrodeposits contain some porosity. The amount of porosity that may be tolerable depends on the severity of the environment that the article is likely to encounter during service or storage. If the pores are few in number or away from significant surfaces, their presence can often be tolerated. Such acceptance (or pass-fail) criteria shall be part of the product specification for the particular article or coating requiring the porosity test (see 8.6 for porosity test methods).

7.6 *Pre-Treatments of Iron and Steel for Reducing the Risk of Hydrogen Embrittlement*—Steel parts having an ultimate tensile strength greater than 1000 MPa (31H RC) that contain tensile stresses caused by cold forming or cold straightening which have not been heat treated after the cold forming process, 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. If the purchaser does not specify an exception to heat treatment, then the plater shall use Table 1 in Specification

[3] Lowenheim, F. A., *Electroplating*, McGraw-Hill Inc., 1978.

B849 to determine the appropriate heat treatment for the steel based on its tensile strength.

7.7 *Post-Coating Treatments of Iron and Steel for Reducing the Risk of Hydrogen Embrittlement*—Electroplated steel parts having a tensile strength greater than 1200 MPa (39 HRC), as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. Baking of electroplated steel parts with tensile strength 1200 MPa (39 HRC), or less, is not mandatory.

7.7.1 Steel parts having a tensile strength greater than 1200 MPa (39 HRC), as well as surface hardened parts, shall be baked to reduce the risk of hydrogen embrittlement. For such parts, purchasers shall specify the baking requirements in the ordering information. Purchasers are directed to the appropriate ER Class in Guide B850 Table 1.

7.7.2 A purchaser wishing to specify baking requirements, irrespective of tensile strength, shall specify such requirements in the ordering information. Purchasers are directed to Guide B850 Table 1.

7.7.3 Any baking treatment done under this section (7.7) shall begin within 4 h of removal from the electroplating process.

7.7.4 Electroplated springs and other parts subject to flexure shall not be flexed before the hydrogen embrittlement relief treatment.

7.8 *Supplementary Requirements*—Packaging—If packaging requirements are to be met under this specification, they shall be in accordance with Practice D3951.

8. Test Methods

8.1 *Special Test Specimens:*

8.1.1 The permission or the requirement to use special test specimens, the number to be used, the material from which they are to be made, and their shape and size shall be stated by the purchaser.

NOTE 9—Test specimens often are 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 in number. The specimen should duplicate the characteristics of the article that influence the property being tested.

8.1.2 Special test specimens used to represent articles in an adhesion, solderability, porosity, 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 articles they represent, and they shall be placed in the production lot of and be processed along with the articles they represent.

8.1.3 Special test specimens used to represent articles in a coating thickness test may be made of a material that is suitable for the test method even if the represented article is not of the same material. For example, a low-carbon steel specimen may represent a brass article when the magnetic thickness test is used (see Test Method B499). The thickness specimen need not be carried through the complete process with the represented article. If not, it shall be introduced into the process at the point where the coating is applied and it shall be carried through all steps that have a bearing on the coating thickness. In rack plating, the specimen shall be racked in the same way with the same distance from and orientation with the anodes and other items in the process as the article it represents.

NOTE 10—When special test specimens are used to represent coated articles in a thickness test, the specimens will not necessarily have the same thickness and thickness distribution as the articles unless the specimens and the articles are of the same general size and shape. Therefore, before finished articles can be accepted on the basis of a thickness test performed on special test specimens, the relationship between the thickness on the specimen and the thickness on the part needs to be established. The criterion of acceptance is that thickness on the specimen that corresponds to the required thickness on the article.

8.2 *Composition of the Coating*—The deposit continues to have a content of 35 ± 5 % nickel (with the balance tin) over a wide range of solution compositions and operating conditions (see 1.1). For this reason, an analysis of the deposit is required infrequently, if at all. A sample of the deposit can be obtained by plating on a passivated stainless steel panel from which the deposit can be peeled. The composition of the deposit can be determined by such methods as volumetric or gravimetric analysis, density measurements, atomic adsorption, X-ray and spectrometry.

8.3 *Appearance*—The coating shall be examined at up to 4× magnification for conformance to the requirements for appearance.

8.4 *Thickness*—The coating thickness shall be measured at locations on the significant surface(s) where the thickness would appear to be a minimum. Several methods of determining the thickness are available, depending upon the thickness of coating, the shape of the article, and the basis metal. They are known as microscopical, magnetic, coulometric, and beta backscatter. X-ray spectrometry may be used, but if the basis metal is a tin-containing alloy, such as bronze, or if a nickel undercoating is present, the measurement instruments must be calibrated on the same substrate material. The following methods are acceptable for measuring local thickness of the coating: Test Methods B487, B499, B504, B567, and B568.

8.5 *Adhesion:*

8.5.1 Adhesion shall be determined by either the burnishing test or the heat-quench test.

8.5.2 *Burnishing Test*—The adhesion of thinner deposits can be determined by the burnishing test described in Section 4 of Practice B571.

8.5.3 *Heat-Quench Test*—The heat-quench test is described in Section 9 of Practice B571. For tin-nickel alloy coatings the temperatures of test for various substrates shall be the same as those shown in Table 1 of the test method for chromium, nickel plus chromium, and copper coatings (see Note 12).

NOTE 11—This test may have an adverse effect on the mechanical properties of the article tested.

8.6 *Porosity and Gross Defects Testing:*

8.6.1 Coatings on articles of steel (or iron) having a local thickness of 10 µm or greater should be subjected to the test given in Appendix X2, and the results evaluated according to the procedure described.

8.6.2 For coatings on articles made from copper or copper alloy as the substrate metal, the following tests can be used.