



Designation: B604 – 91 (Reapproved 2019)

Standard Specification for Decorative Electroplated Coatings of Copper Plus Nickel Plus Chromium on Plastics¹

This standard is issued under the fixed designation B604; 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 several grades and types of electrodeposited copper plus nickel plus chromium coatings on plateable plastic substrates where appearance, durability and resistance to thermal cycling are important to service performance. Five grades of coatings are provided to correlate with the service conditions under which each is expected to provide satisfactory performance.

1.2 This specification covers the requirements for coatings applied subsequent to the application of metal film by autocatalytic deposition or subsequent to the application of any strike coatings after autocatalytic deposition.

1.3 The following caveat pertains only to the test method portions of Section 6, Annex A1, and Appendix X2, Appendix X3, and Appendix X4 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.*

1.4 *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

- B368 Test Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)
- B487 Test Method for Measurement of Metal and Oxide

¹ This specification is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.05 on Decorative Coatings.

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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.

Coating Thickness by Microscopical Examination of Cross Section

- B489 Practice for Bend Test for Ductility of Electrodeposited and Autocatalytically Deposited Metal Coatings on Metals
- B504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method
- B530 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates
- B532 Specification for Appearance of Electroplated Plastic Surfaces
- B533 Test Method for Peel Strength of Metal Electroplated Plastics
- B556 Guide for Measurement of Thin Chromium Coatings by Spot Test
- 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
- B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings
- B659 Guide for Measuring Thickness of Metallic and Inorganic Coatings
- B727 Practice for Preparation of Plastics Materials for Electroplating
- B764 Test Method for Simultaneous Thickness and Electrode Potential Determination of Individual Layers in Multilayer Nickel Deposit (STEP Test)
- D1193 Specification for Reagent Water
- E50 Practices for Apparatus, Reagents, and Safety Considerations for Chemical Analysis of Metals, Ores, and Related Materials

3. Terminology

3.1 Definitions:

3.1.1 *significant surfaces*—those surfaces normally visible (directly or by reflection) that are essential to the appearance or 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.

4. Classification

4.1 Five grades of coatings designated by service condition numbers and several types of coatings defined by classification numbers are covered by this specification.

4.2 Service Condition Number:

4.2.1 The service condition number indicates the severity of exposure for which the grade of coating is intended, in accordance with the following scale:

- SC5—extended very severe
- SC4—very severe
- SC3—severe
- SC2—moderate
- SC1—mild

4.2.2 Service condition numbers are further defined in **Appendix X1** where they are related to the severity of exposure encountered by electroplated articles.

4.3 *Coating Classification Number*—The coating classification number is a means of specifying the types and thicknesses of coatings appropriate for each grade and is comprised of the following:

4.3.1 The symbol for the substrate (PL) indicating it is plateable plastic, followed by a slash mark,

4.3.2 The chemical symbol for copper (Cu),

4.3.3 A number giving the minimum thickness of the copper coating in micrometres,

4.3.4 A lower-case letter designating the type of copper electrodeposit (see 4.4 and 6.3.1),

4.3.5 The chemical symbol for nickel (Ni),

4.3.6 A number giving the minimum thickness of the nickel in micrometres,

4.3.7 A lower-case letter designating the type of nickel electrodeposit (see 4.4 and 6.3.2),

4.3.8 The chemical symbol for chromium (Cr), and

4.3.9 A lower-case letter or letters designating the type of chromium (see 4.4 and 6.3.3).

4.4 *Symbols for Expressing Classification*—The following lower-case letters shall be used in coating classification numbers to describe the types of coatings:

- a — ductile copper deposited from acid-type baths
- b — single-layer nickel deposited in the fully-bright condition
- d — double- or triple-layer nickel coatings
- r — regular (that is, conventional) chromium
- mc — microcracked chromium
- mp — microporous chromium

4.5 *Example of Complete Classification Number*—A coating on plastic comprising 15 µm minimum ductile acid copper plus 15 µm minimum double-layer nickel plus 0.25 µm minimum microporous chromium has the classification number: PL/Cu15a Ni15d Cr mp.

5. Ordering Information

5.1 When ordering articles to be electroplated in accordance with this standard, the purchaser shall state the following:

5.1.1 ASTM designation number.

5.1.2 *Either* the classification number of the specific coating required (see 4.3) *or* the substrate material and the service condition number denoting the severity of the conditions it is required to withstand (see 4.2). If the service condition number

TABLE 1 Copper Plus Nickel Plus Chromium Coatings on Plastic^A

Service Condition Number	Classification Number	Equivalent Nickel Thickness	
		µm	mils (approx.)
SC 5	PL/Cu15a Ni30d Cr mc	30	1.2
	PL/Cu15a Ni30d Cr mp	30	1.2
SC 4	PL/Cu15a Ni30d Cr r	30	1.2
	PL/Cu15a Ni25d Cr mc	25	1.0
	PL/Cu15a Ni25d Cr mp	25	1.0
SC 3	PL/Cu15a Ni25d Cr r	25	1.0
	PL/Cu15a Ni20d Cr mc	20	0.8
	PL/Cu15a Ni20d Cr mp	20	0.8
SC 2	PL/Cu15a Ni15b Cr r	15	0.6
	PL/Cu15a Ni10b Cr mc	10	0.4
	PL/Cu15a Ni10b Cr mp	10	0.4
SC 1	PL/Cu15a Ni7b Cr r	7	0.3

^A The minimum copper thickness may be greater in some applications to meet thermal cycling and other requirements.

is quoted and not the classification number, the manufacturer is free to supply any of the types of coatings designated by the classification number corresponding to the service condition number, as given in **Table 1**.³ On request, the manufacturer shall inform the purchaser of the classification number of the coating applied.

5.1.3 The appearance required, for example, bright, dull, or satin. Alternatively, samples showing the required finish or range of finish shall be supplied or approved by the purchaser.

5.1.4 The significant surfaces, to be indicated on drawings of the parts, or by the provision of suitably marked specimens (see 3.1).

5.1.5 The positions on significant surfaces for rack or contact marks, where such marks are unavoidable (see 6.1.1).

5.1.6 The extent to which defects shall be tolerated on nonsignificant surfaces.

5.1.7 The ductility if other than the standard value (see 6.4).

5.1.8 The extent of tolerable surface deterioration after corrosion testing (see 6.6.3).

5.1.9 Sampling methods and acceptance levels (See Section 7).

5.1.10 Whether thermal cycle and corrosion testing shall be conducted individually on separate specimens as described in 6.6 and 6.7, or sequentially using the same specimens as described in 6.8, and whether the specimens shall be unmounted or mounted in a manner simulating assembly when these tests are conducted.

5.2 The minimum values of the electrochemical potential differences between individual nickel layers as measured in accordance with Test Method **B764** within the limits given in 6.10.

6. Product Requirements

6.1 Visual Defects:

³ "Performance of Decorative Electrodeposited Copper-Nickel-Chromium Coatings on Plastics" is a final report on programs conducted by ASTM and ASEP to evaluate the coating classification numbers. A copy of the report has been filed at ASTM Headquarters as RR:B08-1003.

6.1.1 The significant surfaces of the electroplated articles shall be free of visible defects, such as blisters, pits, roughness, cracks, and uncoated areas, and shall not be stained or discolored. On articles where a visible contact mark is unavoidable, its position shall be specified by the purchaser. The electroplated article shall be free of damage and clean.

6.1.2 Defects in the surface of the molded plastic, such as cold shots, ejection marks, flash, gate marks, parting lines, splay and others, may adversely affect the appearance and performance of coatings applied thereto despite the observance of the best electroplating practice. Accordingly, the electroplater's responsibility for defects in the coating resulting from the plastic-molding operation shall be waived (Note 1).

NOTE 1—To minimize problems of this type, the specifications covering the items to be electroplated should contain appropriate limitations on the extent of surface defects. Specification B532 distinguishes between defects that arise primarily in molding and those that arise in electroplating operations.

6.2 *Pretreatments*—Proper preparatory procedures are essential for satisfactory performance of electrodeposited coatings on plastics. Procedures described in Practice B727 may be followed. In the case of patented processes, the instructions provided by the suppliers of those processes shall be followed.

6.3 *Process and Coating Requirements*—Following preparatory operations, plastic articles are placed in electroplating solutions as required to produce the composite coating described by the specific coating classification number or by coating one of the specified classification numbers listed in Table 1 appropriate for the specified service condition number.

6.3.1 *Type of Copper*—Ductile copper shall be deposited from acid-type baths containing organic additives that promote leveling by the copper deposit.

6.3.2 *Type of Nickel*—For double- or triple-layer nickel coatings, the bottom layer shall contain less than 0.005 mass % sulfur (Note 2). The top layer shall contain greater than 0.04 mass % sulfur (Note 3), and its thickness shall be not less than 10 % of the total nickel thickness. In double-layer coatings, the thickness of the bottom layer shall be not less than 60 % of the total nickel thickness. In triple-layer coatings, the bottom layer shall be not less than 50 % nor more than 70 %. If there are three layers, the intermediate layer shall contain not less than 0.15 mass % sulfur and shall not exceed 10 % of the total nickel thickness. These requirements for multilayer nickel coatings are summarized in Table 2.

6.3.3 *Thickness of Chromium Deposit*—The minimum permissible thickness of the chromium deposit shall be 0.25 μm on significant surfaces. The thickness of chromium is designated by the same symbol as the type instead of by numerals as in the case of copper and nickel (see 4.4).

NOTE 2—The sulfur content is specified in order to indicate which type of nickel electroplating solution must be used. Although no simple method is yet available for determining the sulfur content of a nickel deposit on a coated article, chemical determinations are possible using specially prepared test specimens. See Appendix X2 for the determination of sulfur in electrodeposited nickel.

NOTE 3—It will usually be possible to identify the type of nickel by microscopical examination of the polished and etched section of an article prepared in accordance with Test Method B487. The thickness of the individual nickel layers in double-layer and triple-layer coatings, as well

TABLE 2 Summary of the Requirements for Double- and Triple-Layer Nickel Coatings

Layer Type of Nickel	Specific Elongation	Sulfur Content	Thickness Relative to Total Nickel Thickness	
			Double-Layer	Triple-Layer
Bottom(s)	8 %	less than 0.005 %	equal to or greater than 50 %	equal to or greater than 50 %
Middle (high-sulfur ...)	...	greater than 0.15 mass %	...	10 % max
Top (b)	...	greater than 0.04 %	equal to or greater than 40 %	equal to or greater than 40 %
Test Method	Appendix X3 ^A		...	^B

^A See Note 2 in the text of this specification.

^B See Note 3 in the text of this specification.

as the electrochemical relationships between the individual layers can be measured by the STEP test in accordance with Test Method B764.

6.4 *Ductility*—The minimum value of the ductility shall be 8 % for copper and for nickel when tested by the method given in Appendix X3. Greater ductility may be requested but shall be subject to agreement between the purchaser and the manufacturer.

6.5 *Coating Thickness:*

6.5.1 The minimum coating thickness shall be as designated by the coating classification number.

6.5.2 It is recognized that requirements may exist for thicker coatings than are covered by this specification.

6.5.3 The thickness of a coating and its various layers shall be measured at points on the significant surfaces (see 4.2 and Note 4.)

NOTE 4—When significant surfaces are involved on which the specified thickness of deposit cannot readily be controlled, such as threads, holes, deep recesses, bases of angles, and similar areas, the purchaser and the manufacturer should recognize the necessity for either thicker deposits on the more accessible surfaces or for special racking. Special racks may involve the use of conforming, auxiliary, or bipolar electrodes, or nonconducting shields.

6.5.3.1 The coulometric method described in Test Method B504 may be used to measure thickness of the chromium, the total thickness of the nickel, and the thickness of the copper. The STEP test, Test Method B764, which is similar to the coulometric method, may be used to determine the thicknesses of individual layers of nickel in a multilayer coating.

6.5.3.2 The microscopical method described in Test Method B487 may be used to measure the thickness of each nickel layer and of the copper layer.

6.5.3.3 The beta backscatter method described in Test Method B567 may be used when the total thickness of a copper/nickel/chromium composite coating is to be measured, without any indication of the thickness of each individual layer.

6.5.3.4 Other methods may be used if it can be demonstrated that the uncertainty of the measurement is less than 10 %, or less than that of any applicable method mentioned in 6.4.3. Other methods are outlined in Test Methods B530 and B568 and Guides B556 and B659.

6.6 *Corrosion Testing:*

6.6.1 Coated articles shall be subjected to the corrosion test for a period of time that is appropriate for the particular service