Designation: B 456 – 95

Standard Specification for Electrodeposited Coatings of Copper Plus Nickel Plus Chromium and Nickel Plus Chromium[1]

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers requirements for several types and grades of electrodeposited copper plus nickel plus chromium or nickel plus chromium coatings on steel, nickel plus chromium coatings on copper and copper alloys, and copper plus nickel plus chromium coatings on zinc alloys for applications where both appearance and protection of the basis metal against corrosion are important. Five grades of coatings are provided to correspond with the service conditions under which each is expected to provide satisfactory performance: namely, extended very severe, very severe, severe, moderate, and mild. Definitions and typical examples of these service conditions are provided in Appendix X1.

1.2 The following hazards caveat pertains only to the test methods portions, Appendix X2, Appendix X3, and Appendix X4, of this specification: *This standard does not purport to address all of 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.*

NOTE 1—The ISO standards 1456 and 1457 are not requirements but can be referenced for additional information.

2. Referenced Documents

2.1 *ASTM Standards:*

B 117 Practice for Operating Salt Spray (Fog) Testing 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 252 Guide for Preparation of Zinc Alloy Die Castings for Electroplating and Conversion Coatings[3]

B 253 Guide for Preparation of Aluminum Alloys for Electroplating[3]

B 254 Practice for Preparation of and Electroplating on Stainless Steel[3]

B 281 Practice for Preparation of Copper and Copper Base Alloys for Electroplating and Conversion Coatings[3]

B 287 Method of Acetic Acid-Salt Spray (Fog) Testing[4]

B 320 Practice for Preparation of Iron Castings for Electroplating[3]

B 368 Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)[3]

B 380 Method of Corrosion Testing of Decorative Electrodeposited Coatings by the Corrodkote Procedure[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 Thickness by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals[3]

B 504 Test Method for Measurement of Thickness of Metallic Coatings by the Coulometric Method[3]

B 530 Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Electrodeposited Nickel Coatings on Magnetic and Nonmagnetic Substrates[3]

B 537 Practice for Rating of Electroplated Panels Subjected to Atmospheric Exposure[3]

B 554 Guide for Measurement of Thickness of Metallic Coatings on Nonmetallic Substrates[5]

B 568 Test Method for Measurement of Coating Thickness by X-Ray Spectrometry[3]

B 571 Test Methods for Adhesion of Metallic Coatings[3]

B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings[3]

B 659 Guide for Measuring Thickness of Metallic and Inorganic Coatings[3]

B 697 Guide for Selection of Sampling Plans for Inspection of Electrodeposited Metallic and Inorganic Coatings[3]

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

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

[4] Discontinued. See *1986 Annual Book of ASTM Standards*, Vol 03.02.

[5] Discontinued. See *1985 Annual Book of ASTM Standards*, Vol 02.05.

B 762 Method of Variables Sampling of Metallic and Inorganic Coatings[3]
B 764 Test Method for Simultaneous Thickness and Electrochemical Potential Determination of Individual Layers in Multilayer Nickel Deposit (STEP Test)[3]
D 1193 Specification for Reagent Water[6]
D 3951 Practice for Commercial Packaging[7]
E 50 Practices for Apparatus, Reagents, and Safety Precautions for Chemical Analysis of Metals[8]

2.2 *ISO Standards:*

ISO 1456 Metallic coatings—Electrodeposited coatings of nickel plus chromium and of copper plus nickel plus chromium[9]
ISO 1457 Metallic coatings—Electroplated coatings of copper plus nickel plus chromium on iron or steel[9]

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. When necessary, the significant surfaces shall be specified by the purchaser and shall be indicated on the drawings of the parts, or by the provision of suitably marked samples.

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:

SC 5 extended severe service
SC 4 very severe service,
SC 3 severe service,
SC 2 moderate service, and
SC 1 mild service.

4.2.2 Typical service conditions for which the various service condition numbers are appropriate are given in Appendix X1.

4.3 *Coating Classification Number*—The coating classification number comprises:

4.3.1 The chemical symbol for the basis metal (or for the principal metal if an alloy) followed by a slash mark, except in the case of stainless steel. In this case, the designation shall be SS followed by the designated AISI number followed by a slash, that is, SS463/,

4.3.2 The chemical symbol for copper (Cu) (if copper is used),

4.3.3 A number indicating the minimum thickness of the copper coating in micrometres (if copper is used),

4.3.4 A lower-case letter designating the type of copper deposit (if copper is used) (see 4.4 and 6.2.3),

4.3.5 The chemical symbol for nickel (Ni),

4.3.6 A number indicating the minimum thickness of the nickel coating, in micrometres,

4.3.7 A lower-case letter designating the type of nickel deposit (see 4.4 and 6.2.4),

4.3.8 The chemical symbol for chromium (Cr), and

4.3.9 A letter (or letters) designating the type of chromium deposit and its minimum thickness in micrometres (see 4.4 and 6.2.5).

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
p —dull or semi-bright nickel requiring polishing to give full brightness
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 Numbers*—A coating on steel comprising 15 µm minimum (ductile acid) copper plus 25 µm minimum (duplex) nickel plus 0.25µ m minimum (micro-cracked) chromium has the classification number: Fe/Cu15a Ni25d Cr mc (see 4.3 and 6.2 for explanation of symbols).

5. Ordering Information

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

5.1.1 The ASTM designation number of this standard.

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 is quoted and not the classification number, the manufacturer is free to supply any of the types of coatings designated by the classification numbers corresponding to the specified service condition number, as given in Table 1, Table 2, Table 3, or Table 4. 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).

[6] *Annual Book of ASTM Standards*, Vol 11.01.
[7] *Annual Book of ASTM Standards*, Vol 15.09.
[8] *Annual Book of ASTM Standards*, Vol 03.05.
[9] Available from International Standards Organization, 1 Rue de Varembe, Geneva 20, Switzerland.

TABLE 1 Nickel Plus Chromium Coatings on Steel

NOTE 1—Results of a test program indicate there is some doubt whether the coating systems described by the classification numbers involving regular chromium are satisfactory for SC 4 and SC 3.

NOTE 2—When permitted by the purchaser, copper may be used as an undercoat for nickel but is not substitutable for any part of the nickel thickness specified. If the use of copper is permitted, Table 3 may be used to obtain the same service conditions.

Service Condition No.	Classification No.[A]	Nickel Thickness, µm
SC 5	Fe/Ni35d Cr mc	35
	Fe/Ni35d Cr mp	35
SC 4	Fe/Ni40d Cr r	40
	Fe/Ni30d Cr mc	30
	Fe/Ni30d Cr mp	30
SC 3	Fe/Ni30d Cr r	30
	Fe/Ni25d Cr mc	25
	Fe/Ni25d Cr mp	25
	Fe/Ni40p Cr r	40
	Fe/Ni30p Cr mc	30
	Fe/Ni30p Cr mp	30
SC 2[B]	Fe/Ni20b Cr r	20
	Fe/Ni15b Cr mc	15
	Fe/Ni15b Cr mp	15
SC 1[B]	Fe/Ni10b Cr r	10

[A] When a dull or satin finish is required, unbuffed p nickel may be substituted for a b nickel or for the bright layer of d nickel.

[B] p or d nickel may be substituted for b nickel in Service Condition Nos. 2 and 1, and mc or mp chromium may be substituted for r chromium in Service Condition No. 1.

TABLE 2 Copper Plus Nickel Plus Chromium Coatings on Steel

Service Condition No.	Classification No.[A]	Nickel Thickness, µm
SC 5	Fe/Cu15a Ni30d Cr mc	30
	Fe/Cu15a Ni30d Cr mp	30
SC 4	Fe/Cu15a Ni25d Cr mc	25
	Fe/Cu15a Ni25d Cr mp	25
SC 3	Fe/Cu12a Ni20d Cr mc	20
	Fe/Cu12a Ni20d Cr mp	20

[A] When a dull or satin finish is required, unbuffed p nickel may be substituted for the bright layer of d nickel.

5.1.10 The minimum values of the electrochemical potential differences between individual nickel layers as measured in accordance with Test Method B 764 within the limits given in 6.7.

5.1.11 *Adhesion Test*—The adhesion test to be used (see 6.3).

6. Product Requirements

6.1 *Visual Defects*:

6.1.1 The significant surfaces of the electroplated article shall be free of clearly visible plating 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 clean and free of damage.

6.1.2 Defects in the surface of the basis metal, such as scratches, porosity, nonconducting inclusions, roll and die marks, cold shuts, and cracks, may adversely affect the appearance and the performance of coatings applied thereto despite the observance of the best electroplating practices. Accordingly, the plater's responsibility for defects in the coating resulting from such conditions shall be waived.

TABLE 3 Copper Plus Nickel Plus Chromium Coatings on Zinc Alloy

NOTE 1—Results of a test program indicate there is some doubt whether the coating systems described by the classification numbers involving regular chromium are satisfactory for SC 4 and SC 3.

Service Condition No.	Classification No.[A]	Nickel Thickness, µm
SC 5	Zn/Cu5 Ni35d Cr mc	35
	Zn/Cu5 Ni35d Cr mp	35
SC 4	Zn/Cu5 Ni35d Cr r	35
	Zn/Cu5 Ni30d Cr mc	30
	Zn/Cu5 Ni30d Cr mp	30
SC 3	Zn/Cu5 Ni25d Cr r	25
	Zn/Cu5 Ni20d Cr mc	20
	Zn/Cu5 Ni20d Cr mp	20
	Zn/Cu5 Ni35p Cr r	35
	Zn/Cu5 Ni25p Cr mc	25
	Zn/Cu5 Ni25p Cr mp	25
SC 2[B]	Zn/Cu5 Ni20b Cr r	20
	Zn/Cu5 Ni15b Cr mc	15
	Zn/Cu5 Ni15b Cr mp	15
SC 1[B]	Zn/Cu5 Ni10b Cr r	10

[A] When a dull or satin finish is required, unbuffed p nickel may be substituted for b nickel or for the bright layer of d nickel.

[B] p or d nickel may be substituted for b nickel in Service Condition Nos. 2 and 1, and mc or mp chromium may be substituted for r chromium in Service Condition No. 1.

TABLE 4 Nickel Plus Chromium Coatings on Copper or Copper Alloy

NOTE 1—Although the classification numbers are satisfactory for each of the indicated service condition numbers, systems using microdiscontinuous chromium are generally superior in corrosion resistance to those using regular chromium.

Service Condition No.	Classification No.[A]	Nickel Thickness, µm
SC 4	Cu/Ni30d Cr r	30
	Cu/Ni25d Cr mc	25
	Cu/Ni25d Cr mp	25
SC 3	Cu/Ni25d Cr r	25
	Cu/Ni20d Cr mc	20
	Cu/Ni20d Cr mp	20
	Cu/Ni25p Cr r	25
	Cu/Ni20p Cr mc	20
	Cu/Ni20p Cr mp	20
	Cu/Ni30b Cr r	30
	Cu/Ni25b Cr mc	25
	Cu/Ni25b Cr mp	25
SC 2[B]	Cu/Ni15b Cr r	15
	Cu/Ni10b Cr mc	10
	Cu/Ni10b Cr mp	10
SC 1[B]	Cu/Ni5b Cr r	5

[A] When a dull or satin finish is required, unbuffed p nickel may be substituted for b nickel or for the bright layer of d nickel.

[B] p or d nickel may be substituted for b nickel in Service Condition Nos. 2 and 1 and mc or mp chromium may be substituted for r chromium in Service Condition No. 1.

NOTE 2—To minimize problems of this type, the specifications covering the basis material or the item to be electroplated should contain appropriate limitations on such basis metal conditions.

6.2 *Process and Coating Requirements*:

6.2.1 Proper preparatory procedures and thorough cleaning of the basis metal surface are essential for satisfactory adhesion and corrosion performance of the coating. Accordingly, the applicable practices for the preparation of various basis metals for electroplating shall be followed. Various ASTM practices for the preparation of basis metal are available. See Section 2.

6.2.2 Following the preparatory operations, the parts (articles) to be electroplated are introduced in such plating baths as required to produce the types of deposits described by the specific coating classification numbers or one of the coating classification numbers listed in Table 1, Table 2, Table 3, or Table 4 appropriate for the specified service condition number.

6.2.3 *Type of Copper and Deposit Thickness*:

6.2.3.1 *Type of Copper*—The type of copper is designated by the following symbols that are placed after the thickness value:

a for ductile copper deposited from acid-type baths containing additives that promote leveling by the copper deposit and that have an elongation not less than 8 %.

No symbol is placed after the thickness value if a minimum elongation is not required or if a deposit from a non-leveling bath is permitted.

6.2.3.2 *Thickness of Copper Deposits*—The number following the chemical symbol for copper (Cu) indicates in micrometres the minimum thickness of the copper deposit at points on significant surfaces (see 3.1).

6.2.4 *Type of Nickel and Deposit Thickness*:

6.2.4.1 *Type of Nickel*—The type of nickel is designated by the following symbols, which are placed after the thickness value (Note 5):

b for nickel deposited in the fully bright condition.

p for dull or semi-bright nickel requiring polishing to give full brightness. This nickel shall contain less than 0.005 mass % sulfur (Note 3 and Note 4), and have an elongation of not less than 8 %.

d for a double-layer or triple-layer nickel coating. The bottom layer of this coating system shall contain less than 0.005 mass % sulfur (Note 4), and shall have an elongation of not less than 8 %. The top layer of this system shall contain more than 0.04 mass % sulfur (Note 3 and Note 4), and its thickness shall be not less than 10 % of the total nickel thickness; the thickness of the bottom layer in double-layer coatings shall not be less than 60 % of the total nickel thickness, except for steel, where it shall be at least 75 %. 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 5.

NOTE 3—The sulfur contents are specified in order to indicate which type of nickel electroplating solution must be used. Although at present, no simple method is 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 X3).

NOTE 4—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 B 487. The thickness of the individual nickel layers in double-layer and triple-layer coatings, as well as the electrochemical relationships between the individual layers, can also be measured by the STEP test,[10] in accordance with Test Method B 764.

6.2.4.2 Thickness of Nickel Deposit—The number following the chemical symbol Ni indicates, in micrometres, the minimum thickness of the nickel electrodeposit at points on the significant surface (see 3.1).

6.2.5 *Type of Chromium and Deposit Thickness*:

6.2.5.1 *Type of Chromium*—The type of chromium deposit is designated by the following symbols placed after the chemical symbol Cr:

r for "regular" (that is, conventional) chromium.

mc for microcracked chromium, having more than 30 cracks/mm in any direction over the whole of the significant surface. The cracks shall be invisible to the unaided eye (see 6.9).

mp for microporous chromium containing a minimum of 10 000 pores/10 mm by 10 mm square (10 000 cm^2). The pores shall be invisible to the unaided eye (see 6.9).

6.2.5.2 *Thickness of Chromium Deposit*—The minimum thickness of the chromium deposit shall be 0.25 µm on significant surfaces (see 3.1), except that for service condition SC 1 (see 4.2.1) the minimum thickness may be reduced to 0.13 µm. 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.

6.2.5.3 When plating chromium over microdiscontinuous nickel, excessive thickness will bridge the nonconductive particles within the nickel layer. A maximum of 0.5 µm is recommended.

6.3 *Adhesion*—The coating shall be sufficiently adherent to the basis metal, and the separate layers of multilayer coatings shall be sufficiently adherent to each other, to pass the appropriate tests detailed in Test Methods B 571. The particular test or tests to be used shall be specified by the purchaser.

6.4 *Ductility*—The ductility shall be such that the elongation will not be less than stated in 6.2.3.1 for copper and 6.2.4.1 for nickel when tested by the method given in Appendix X2. Greater elongation 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 3.1 and Note 5).

NOTE 5—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

[10] Harbulak, E. P., "Simultaneous Thickness and Electrochemical Potential Determination of Individual Layers in Multilayer Nickel Deposits," *Plating and Surface Finishing*, Vol 67, No. 49, February 1980.

TABLE 5 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
			Steel	Other[A]	Steel and Other[A]
Bottom	≥8 %	<0.005 mass %	≥75 %	≥60 %	50–70 %
Middle (high-sulfur)	...	>0.15 mass %	...	...	≤10 %
Top (b)	...	>0.04 mass %	10–25 %	10–40 %	≥30 %
Test Method	See Appendix X2	Note 3[B]	...	...	Note 4[B]

[A] Copper, zinc, and aluminum substrates and their alloys.
[B] For Notes 3 and 4, see Section 6.

TABLE 6 Nickel Plus Chromium[A] on Stainless Steels, AISI Designated Type 300 and 400 Series,[B] and Aluminum Alloys

NOTE 1—Before nickel-chromium plating, the stainless steel surface and the aluminum substrate shall be prepared by a pretreatment from Practice B 254,[C] Guide B 253,[D] or equivalent, which is agreed upon between the supplier and the user.

Service Condition No.	Classification No.	Nickel Thickness, µm
SC 4	SS-3XX[E]/Ni20b/Cr mp	20
SC 4	SS-4xx[E]/Ni25b/Cr mp	25
SC 5	Al/Cu15a/Ni40d/Cr mp	40

[A] Data in Table 6 were obtained using only microporous chromium systems. No data are available for the use of standard or microcracked systems.
[B] The stainless steel alloy numbers used in this specification are based on the AISI system. They may not be interchangeable with other numbering systems such as the United Numbering System (UNS) or foreign designations.
[C] Preplate for stainless steel substrates.
[D] Preplate for aluminum substrates.
[E] Insert number for specific 300 or 400 alloy.

involve the use of conforming, auxiliary, or bipolar electrodes or nonconducting shields.

6.5.3.1 The coulometric method described in Test Method B 504 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 B 764, which is similar to the coulometric method, may be used to closely estimate the thicknesses of individual layers of nickel in a multilayer coating.

6.5.3.2 The microscopial method described in Test Method B 487 may be used to measure the thickness of each nickel layer and of the copper layer.

6.5.3.3 The X-ray method described in Test Method B 568 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 6.5.3. Other methods are outlined in Guide B 659.

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 condition number (or for the service condition number corresponding to a specified classification number) as shown in Table 7. The test is described in detail in the referenced ASTM designation.

NOTE 6—There is no direct relation between the results of an accelerated corrosion test and the resistance to corrosion in other media, because several factors, such as the formation of protective films, influence the progress of corrosion and vary greatly with the conditions encountered. The results obtained in the test should, therefore, not 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 resistance of these materials in service.

6.6.2 After the article has been subjected to the treatment described in the relevant corrosion test method, it shall be examined for corrosion of the basis metal or blistering of the coating. Any basis metal corrosion or blistering of the coating shall be cause for rejection. It is to be understood that occasional widely scattered, small corrosion defects may be observed after the testing period. In general, "acceptable resistance" shall mean that such defects are not, when viewed critically, significantly defacing or otherwise deleterious to the

TABLE 7 Corrosion Tests Appropriate for Each Service Condition Number

NOTE 1—The so-called "neutral" salt spray test, Practice B 117 has been generally discredited as an accelerated corrosion test for decorative nickel-chromium coatings largely because of lack of reproducibility of results.[A] It is recognized, however, that the test is still used in some segments of the electroplating industry to check the quality of coatings intended for use under relatively mild service conditions. Accordingly, it is suggested that any use of this test and the requirements to be met be the subject of agreement between the purchaser and the manufacturer and, further, that its use be confined to the coatings indicated as appropriate for Service Conditions Nos. 2 and 1.
NOTE 2—The Acetic-salt Method B 287 has been discontinued.

Basis Metals	Service Condition No.	Corrosion Test and Duration h		
		CASS Method B 368	Corrodkote Method B 380	Acetic-salt Method B 287
Steel, zinc alloy,	SC 5	44	...	...
or copper and	SC 4	22	Two 16-h cycles	144
copper alloy,	SC 3	16	16	96
stainless steel and	SC 2	4	4	24
aluminum alloys	SC 1	...	...	8

[A] Mendizza, A., "Standard Salt Spray Test—Is It a Valid Acceptance Test?" Properties, Tests and Performance of Electrodeposited Metallic Coatings, *ASTM STP 197*, ASTM 1956, p. 107.

function of the electroplated part. A method of rating corrosion is given in Practice B 537.

6.6.3 Surface deterioration of the coating itself is expected to occur during the testing of some types of coatings. The extent to which such surface deterioration will be tolerated shall be specified by the purchaser.

6.7 *STEP Test Requirements:*

6.7.1 The electrochemical potential differences between individual nickel layers shall be measured for multilayer coatings corresponding to SC5, SC4, and SC3 in accordance with Test Method B 764 (STEP Test).

NOTE 7—Universally accepted STEP values have not been established but some agreement in the value of ranges has been obtained. The STEP values depend upon which two nickel layers are being measured.

The STEP potential difference between the semi-bright nickel layer and the bright nickel layer has a range of 100 to 200 mV. For all combinations of nickel layers, the semi-bright nickel layer is more noble (cathodic) than the bright nickel layer.

The STEP potential difference between the high-activity nickel layer and the bright nickel layer in triple-layer coatings has a potential range of 15 to 35 mV. The high-activity nickel layer is more active (anodic) than the bright nickel layer.

The STEP potential difference between the bright nickel layer and a nickel layer between the bright nickel layer and the chromium layer has a potential range of 0 to 30 mV. The bright nickel layer is more active (anodic) than the nickel layer prior to chromium.

6.8 *Sulfur Content*:

6.8.1 The sulfur content of the nickel deposit shall meet the maximum or minimum values as stated in 6.2.4.1 and Table 5.

6.8.2 Methods for sulfur determinations are given in Appendix X3.

6.9 *Density and Measurement of the Discontinuities in Chromium*:

6.9.1 The density of cracks or pores in microcracked or microporous chromium deposits shall meet minimum values. Microcracked chromium shall have more than 30 cracks/mm (300 cracks/cm) in any direction over the whole of the significant surface. Microporous chromium shall contain a minimum of 10 000 pores/10 by 10 mm square (10 000 pores/cm^2) in any direction over the whole of the significant surface. The cracks and pores shall be invisible to the unaided eye.

6.9.2 Methods for measuring the discontinuities are given in Appendix X4. See X4.4 in Appendix X4 for a means of determining *active* corrosion sites by corrosion testing.

7. Sampling Requirements

7.1 The sampling plan used for the inspection of a quantity of coated articles shall be as agreed upon by the purchaser and supplier.

NOTE 8—Usually, when a collection of coated articles, the inspection lot (8.2), is examined for compliance with the requirements placed on the coating, a relatively small number of the articles, the 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 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 coatings.

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

Guide B 697 provides a large number of plans and also gives guidance on the selection of a plan. When Guide B 697 is specified, the buyer and seller need to agree on the plan to be used.

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. Method B 762 contains several plans and also gives instructions for calculating plans to meet special needs. The buyer and the seller may agree on the plan or plans to be used. If they do not, B762 identifies the plan to be used.

NOTE 9—When both destructive and nondestructive tests exist for the measurement of a characteristic, the purchaser needs to state which is to be used so the proper sampling plan is selected. A test may destroy the coating but in a noncritical area; or, although it may destroy the coating, a tested part may be reclaimed by stripping and recoating. The purchaser needs to state whether the test is to be considered destructive or nondestructive.

7.2 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 approximately the same time under essentially identical conditions, and that are submitted for acceptance or rejection as a group.

7.3 If separate 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 Appendix X2, Appendix X3, and Appendix X4. Unless a need can be demonstrated, separately prepared specimens shall not be used in place of production items for nondestructive tests and visual examination. For destructive tests including determination of adhesion, ductility, sulfur contents, the number of discontinuities, and corrosion testing, separately prepared specimens may be used.

8. Packaging

8.1 Parts plated for the U.S. Government and military, including subcontracts, shall be packaged in accordance with Practice D 3951.

9. Keywords

9.1 corrosion; decorative; electrodeposited chromium; electrodeposited copper; electrodeposited nickel