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Electroplating of Nickel and Chromium on Metal Parts - Automotive Ornamentation and Hardware

RATIONALE

The Technical Committee which originally created this document no longer exists.

This was reviewed by two experts in the field and it has been determined to contain basic and stable technology which is not dynamic in nature. The contents of the document were deemed accurate and do not require an update prior to stabilization.

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Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

1. Scope—This standard covers requirements for several types and grades of electrodeposited nickel/chromium coatings on ferrous or copper alloy basis metals and copper/nickel/chromium on zinc or aluminum alloys for the finishing and corrosion protection of decorative ornamentation and hardware of motor vehicles and marine controls and fittings. Four grades of coatings are provided to correlate with the service conditions under which each is expected to provide satisfactory performance, namely: very severe, severe, moderate, and mild. Definitions and typical examples of these service conditions are provided in Appendix A.[1] Information contained in this document generally conforms to the information contained in ASTM B 456, Specification for Electrodeposited Coatings of Nickel plus Chromium.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein.

2.1.1 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959

ASTM A 219—Methods of Test for Local Thickness of Electrodeposited Coatings
ASTM B 183—Preparation of Low Carbon Steel for Electroplating
ASTM B 242—Preparation of High Carbon Steel for Electroplating
ASTM B 252—Preparation of Zinc Die Castings for Electroplating
ASTM B 253–68—Preparation of and Electroplating on Aluminum Alloys by the Zincate Process
ASTM B 281—Preparation of Copper and Copper Alloys for Electroplating
ASTM B 287
ASTM B 320—Preparation of Iron Castings for Electroplating
ASTM B 368—Method for Copper-Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)

1. It is recognized that uses exist in which either thicker or thinner coatings than those covered by these specifications may be required. In such cases, the particular thickness desired by the purchaser (minimum, maximum, or range of thickness permissible) should be the subject of agreement between the purchaser and the plater.

ASTM B 380—Methods for Corrosion Testing of Decorative Chromium Electoplating by the Corrodkote Procedure
ASTM B 456—Specification for Electrodeposited Coatings of Nickel Plus Chromium
ASTM E 105—Practice for Probability Sampling of Materials
ASTM E 122—Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process

2.2 Other Publications

50th Technical Proceedings of the American Electroplaters' Society (1963)

3. Manufacture

3.1 Only those parts shall be plated that are free from visible surface defects, such as scratches, porosity, nonconducting inclusions, roll and die marks, cold shuts, cracks, etc., which may adversely affect the appearance and the performance of coatings. In order to minimize problems of this sort, the specifications covering the basis material or the item to be plated should be appropriately specified.

3.2 When required, the basis metal shall be subjected to such polishing, buffing, or finishing operations as are necessary to yield deposits with the desired final appearance. (See Section 5)

3.3 Proper preparatory procedures and thorough cleaning of the basis metal surface are essential in order to assure satisfactory adhesion and corrosion performance of the coating. Accordingly, it is suggested that the following ASTM documents on the preparation of various basis metals for electroplating be followed where appropriate:

ASTM B 183—Preparation of Low Carbon Steel for Electroplating
ASTM B 242—Preparation of High Carbon Steel for Electroplating
ASTM B 253–68—Preparation of and Electroplating on Aluminum Alloys by the Zincate Process
ASTM B 252—Preparation of Zinc Die Castings for Electroplating
ASTM B 281—Preparation of Copper and Copper Alloys for Electroplating
ASTM B 320—Preparation of Iron Castings for Electroplating

4. ***Significant Surfaces***—Significant surfaces are 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, or which can be the source of corrosion products that deface visible surfaces on the assembled article. When necessary, the significant surface shall be the subject of agreement between purchaser and manufacturer and shall be indicated on the drawings of the parts, or by the provision of suitably marked samples. [2]

5. Appearance

5.1 The significant surface of the plated article shall be free from clearly visible plating defects, such as blisters, pits, roughness, cracks, or unplated areas, and shall not be stained or discolored. On articles where a visible contact mark is unavoidable, its position shall be the subject of agreement between the manufacturer and the purchaser.

2. 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 electrodes, or nonconducting shields.

5.2 The plated article shall be clean and free from damage. The purchaser shall specify 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.

6. Manner of Specifying Requirements

6.1 Coating Classification Number or Service Condition Number—When ordering articles to be plated in accordance with this standard, the purchaser shall state, in addition to SAE J207, either the classification number of the particular coating required (see 6.4) or the basis metal and the service condition number denoting the severity of the conditions it is required to withstand (see paragraph 6.2). If the service condition number is quoted but not the classification number, the manufacturer is free to supply any of the classes of coating corresponding to the service condition number; but when requested to do so, the manufacturer shall inform the purchaser of the classification number of the coating supplied.

6.2 Service Condition Number—The service condition number indicates the severity of the service conditions in accordance with the following scale:

SC 4—very severe service
SC 3—severe service
SC 2—moderate service
SC 1—mild service

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

6.3 Coating Classification Number—The coating classification number comprises:

a. The chemical designation for the basis metal (or for the principle metal if an alloy). The following chemical symbols are used:

   FE—for steel (or iron)
   ZN—for zinc alloy
   CU—for copper or copper alloy
   AL—for aluminum

b. The chemical designation for nickel (NI).
c. A number indicating the minimum thickness of the nickel coating, in micrometers.[3]
d. A letter designating the type of nickel deposit.
e. The chemical designation for chromium (CR).
f. A letter (or letters) designating the type of chromium deposit.

6.3.1 Type Of Nickel And Deposit Thickness

6.3.1.1 Type of Nickel—The type of nickel[4] is designated by the following symbols:

B—For nickel deposited in the fully bright condition.

P—For dull or semi-bright nickel requiring polishing to give full brightness, containing less than 0.005% sulfur[5], and having an elongation not less than 8% when tested by the method given in Appendix C.

3. The approximately equivalent coating thickness in mils are given in Tables 1–4. (1 μm = approximately 0.04 mil; 1 mil = 0.001 in = 25 μm.)
4. ASTM A 219, section on microscopic examination of polished and etched.
5. The sulfur contents are specified in order to indicate the type of nickel plating solution that is to be used. Although no simple method exists for determining the sulfur content of a nickel deposit on a coated article, the x-ray fluorescence technique can be used. A chemical determination is possible on a specially prepared test specimen.

D—For a double-layer or triple-layer nickel coating, of which the bottom layer contains less than 0.005% sulfur[6], and which has an elongation not less than 8% when tested by the method given in Appendix C, and the top layer contains more than 0.04% sulfur[6]. The thickness of the bottom layer in double-layer coatings shall be not less than 75% of the total nickel thickness, and in triple-layer coatings shall be not less than 50% of the total nickel thickness; the thickness of the top layer in either case being not less than 10% of the total nickel thickness. If there are three layers, the intermediate layer shall contain more sulfur than the top layer and shall not exceed 10% of the total nickel thickness.

6.3.1.2 *Thickness of Nickel Deposits*—The number following the chemical designation NI indicates, in micrometers[7], the minimum thickness of the nickel deposit, measured in accordance with ASTM A 219, Methods of Test for Local Thickness of Electrodeposited Coatings, at points on the significant surface.

6.3.2 TYPE OF CHROMIUM AND DEPOSIT THICKNESS—The thickness of the chromium deposit shall be measured by the method given in ASTM A 219, at points on the significant surface.

The type of chromium and thickness of deposit is designated by the following symbols placed after the chemical designation CR (numerals are not used in this case to specify thickness as in the case of nickel):

R—For regular (that is, conventional) chromium, having a minimum thickness of 0.25 μm (0.01 mil), except in the case of SC 1 where the minimum thickness is 0.12 μm (0.005 mil).

MC—For microcracked chromium, having more than 300 cracks/cm (750 cracks/in) (method for measurement is given in Appendix D) in any direction over the whole of the significant surface, and having a minimum thickness of 0.8 μm (0.03 mil), unless it can be demonstrated by the plater that equally good performance can be obtained with a lower thickness.

6. The sulfur contents are specified in order to indicate the type of nickel plating solution that is to be used. Although no simple method exists for determining the sulfur content of a nickel deposit on a coated article, the x-ray fluorescence technique can be used. A chemical determination is possible on a specially prepared test specimen.
7. The sulfur contents are specified in order to indicate the type of nickel plating solution that is to be used. Although no simple method exists for determining the sulfur content of a nickel deposit on a coated article, the x-ray fluorescence technique can be used. A chemical determination is possible on a specially prepared test specimen.

TABLE 1—NICKEL/CHROMIUM COATINGS ON STEEL[1]

Service Condition No.	Classification No.	Equiv. Nickel Thickness, mile (approx)[2]	Corrosion Test Duration, h Case ASTM B 368	Corrosion Test Duration, h Corrodkote ASTM B 380	Corrosion Test Duration, h Acetic-Salt ASTM B 287
SC 4	FE/NI40D/CRR	1.6[3]	22	20	144
	FE/NI30D/CRMC	1.2	22	20	144
	FE/NI30D/CRMP	1.2	22	20	144
SC 3	FE/NI30D/CRR	1.2[3]	16	16	96
	FE/NI25D/CRMC	1.0	16	16	96
	FE/NI25D/CRMP	1.0	16	16	96
	FE/NI40P/CRR	1.6	16	16	96
	FE/NI30P/CRMC	1.2	16	16	96
	FE/NI30P/CRMP	1.2	16	16	96
SC 2 [4]	FE/NI20B/CRR	0.8	—	—	24
	FE/NI15B/CRMC	0.6	—	—	24
	FE/NI15B/CRMP	0.6	—	—	24
SC 1[4]	FE/NI10B/CRR	0.4	—	—	8

1. When agreed by the purchaser and the manufacturer, copper may be used as an undercoat for the nickel but is not substitutable for any part of the nickel thickness specified.
2. 1 mil = 0.001 in = 25.4 μm.
3. Copper can contribute to the protection of the basis metal. This protection is enhanced when the chromium deposit is microcracked or microporous and the final nickel layer is an active sulfur-containing nickel deposit.
   In double nickel system, buffing one of the nickel deposits may be beneficial to the corrosion resistance
4. P or D nickel may be substituted for B nickel and MC or MP chromium may be substituted for R
   chromium in service condition No. 1; P or D nickel may be substituted for B nickel in service condition No. 2.

TABLE 2—COPPER/NICKEL/CHROMIUM COATINGS ON ZINC ALLOY(1)

Service Condition No.	Classification No.	Equiv. Nickel Thickness, mils (approx)(2)	Corrosion Test Duration, h Cass ASTM B 368	Corrosion Test Duration, h Corrodkote ASTM B 380	Corrosion Test Duration, h Acetic-Salt ASTM B 287
SC 4	ZN/NI40D/CRR	1.6	22	20	144
	ZN/NI30D/CRMC	1.2	22	20	144
	ZN/NI30D/CRMP	1.2	22	20	144
SC 3	ZN/NI30D/CRR	1.2	16	16	96
	ZN/NI25D/CRMC	1.0	16	16	96
	ZN/NI25/CRMP	1.0	16	16	96
	ZN/NI40P/CRR	1.6	16	16	96
	ZN/NI30P/CRMC	1.2	16	16	96
	ZN/NI30P/CRMP	1.2	16	16	96
SC 2 (3)	ZN/NI20B/CRR	0.8	4	4	24
	ZN/NI15B/CRMC	0.6	4	4	24
	ZN/NI15B/CRMP	0.6	4	4	24
SC 14	ZN/NI10B/CRR	0.4	—	—	8

1. All these coatings shall be applied over an undercoat of copper or yellow brass having a minimum thickness on significant surfaces of 5 μm (0.2 mil) as measured in accordance with ASTM A 219, Methods of Test for Local Thickness of Electrodeposited Coatings.
2. 1 mil = 0.001 in = 25.4 μm.
3. P or D nickel may be substituted for B nickel and MC or MP chromium may be substituted for R chromium in service condition No. 1; P or D nickel may be substituted for B nickel in service condition No. 2 or 1.

TABLE 3—NICKEL/CHROMIUM COATINGS ON COPPER OR COPPER ALLOYS[1]

Service Condition No.	Classification No.	Equiv. Nickel Thickness, miles (approx)[2]	Corrosion Test Duration, h Cass ASTM B 368	Corrosion Test Duration, h Corrodkote ASTM B 380	Corrosion Test Duration, h Acetic-Ssalt ASTM B 287
SC 4	CU/NI30D/CRR	1.2	22	20	144
	CU/NI25D/CRMC	1.0	22	20	144
	CU/NI25D/CRMP	1.0	22	20	144
SC 3	CU/NI25D/CRR	1.0	16	16	96
	CU/NI20D/CRMC	0.8	16	16	96
	CU/NI20D/CRMP	0.8	16	16	96
	CU/NI30B/CRR	1.2	16	16	96
	CU/NI25B/CRMC	1.0	16	16	96
	CU/NI25B/CRMP	1.0	16	16	96
	CU/NI25P/CRR	1.0	16	16	96
	CU/NI20P/CRMC	0.8	16	16	96
	CU/NI20P/CRMP	0.8	16	16	96
SC 2[3]	CU/NI15B/CRR	0.6	—	—	24
	CU/NI10B/CRMC	0.4	—	—	24
	CU/NI10B/CRMP	0.4	—	—	24
SC 1[3]	CU/NI5B/CRR	0.2	—	—	8

1. All these coatings shall be applied directly to the basis metal or over a copper strike.
2. 1 mil = 0.001 in = 25.4 μm.
3. 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—COPPER/NICKEL/CHROMIUM COATINGS ON ALUMINUM(1)

Service Condition No.	Classification No.	Equiv. Nickel Thickness, mils (approx)(2)	Corrosion Test Duration, h Cass ASTM B 368	Corrosion Test Duration, h Corrodkote ASTM B 380	Corrosion Test Duration, h Acetic-Salt ASTM B 287
SC 4	AL/NI40D/CRR	1.6	22	20	144
	AL/NI30D/CRMC	1.2	22	20	144
	AL/NI30D/CRMP	1.2	22	20	144
SC 3	AL/NI30D/CRR	1.2	16	16	96
	AL/NI25D/CRMC	1.0	16	16	96
	AL/NI25D/CRMP	1.0	16	16	96
	AL/NI40P/CRR	1.6	16	16	96
	AL/NI30P/CRMC	1.2	16	16	96
	AL/NI30P/CRMP	1.2	16	16	96
SC 2 (3)	AL/NI20B/CRR	0.8	—	—	24
	AL/NI15B/CRMC	0.6	—	—	24
	AL/NI15B/CRMP	0.6	—	—	24
SC 1(3)	AL/NI10B/CRR	0.4	—	—	8

1. All these coatings shall be applied over an undercoat of copper having a minimum thickness on significant surfaces of 5 μm (0.2 mil) as measured in accordance with ASTM A 219, Methods of Test for Local Thickness of Electrodeposited Coatings.
2. 1 mil = 0.001 in = 25.4 μm.
3. P or D nickel may be substituted for B nickel and MC or MP chromium may be substituted for R chromium in service condition No., 1; P or D nickel may be substituted for B nickel in service condition Nos. 2 or 1.

MP—For microporous chromium, having a minimum thickness of 0.25 μm (0.01 mil) and containing a minimum of 10 000 pores per cm^2 (64 500 per in^2).

6.3.3 EXAMPLE OF COMPLETE CLASSIFICATION NUMBER—A coating on steel comprising 40 μm (1.6 mils) minimum bright nickel plus 0.8 μm (0.03 mil) minimum microcracked chromium has the classification number: FE/N140B/CRMC.

6.4 Coatings Appropriate to Each Service Condition Number—Tables 1, 2 and 3 show, for the various basis metals, the coating classification numbers appropriate for each service condition number.

6.5 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 tests described in Appendix B. The particular test or tests to be used shall be subject to agreement between the purchaser and the manufacturer.

6.6 Corrosion Resistance or Corrosion Protection of Coatings

6.6.1 Coated articles shall be subjected to one of the corrosion tests for the stated time shown in Tables 1, 2, 3, and 4 to be appropriate for the particular service condition number. The particular test to be used in any instance shall be specified by the purchaser or shall be the subject of agreement between the purchaser and the manufacturer. The tests are described in detail in the referenced ASTM documents.[8]

6.6.2 After subjecting the article to the treatment described in the relevant test method, it shall be examined for evidence of corrosion of the basis metal or blistering of the coating. Any evidence of basis metal corrosion or blistering of the coating shall be cause for rejection, unless otherwise agreed between the purchaser and the manufacturer.[9]

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 subject to agreement between purchaser and manufacturer.[9]

7. Sampling

7.1 Since test methods may be destructive and since 100% inspection is expensive and usually unnecessary, it is recommended that the purchaser select suitable sampling plans for the acceptance testing of lots of coated items. General information on sampling procedures is given in ASTM E 105 and ASTM E 122. Standard sampling plans have been published by several sources. In order that the manufacturer know the quality expected to be met, the plans selected should be made a part of the purchase contract.

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8. The corrosion tests indicated in Tables 1–4 are a means of controlling the continuity and quality of the coatings and the duration of the tests does not necessarily have a fixed relationship with the service life of the finished article.
9. 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 significantly defacing or otherwise deleterious to the function of the plated part.

APPENDIX A

DEFINITIONS OF SERVICE CONDITIONS FOR WHICH THE VARIOUS SERVICE CONDITION NUMBERS ARE APPROPRIATE

A.1 ***Service Condition No. SC 4 (Very Severe)***—Service conditions which include exposure to very severe, heavy corrosive environments such as those found in an area where there is heavy industry accompanied by snow and below-freezing temperatures, and conditions where parts are subjected to continued exposure in a salt water environment.

A.2 ***Service Condition No. SC 3 (Severe)***—Exposure which is likely to include severe industrial or seacoast environments and areas where frequent wetting by rain or dew is experienced.

Severe exposure is defined as that which is likely to include occasional or frequent wetting by rain, dew, or snow in an industrial or seacoast environment.

A.3 ***Service Condition No. SC 2 (Moderate)***—Moderate exposure is defined as that which is likely to include normally dry sheltered locations, but with coating subject to occasional condensation of moisture, wear, or abrasion.

A.4 ***Service Condition No. SC 1 (Mild)***—Exposure to normally warm, dry interior atmospheres.

APPENDIX B

TESTS FOR ADHESION OF COATINGS[10]

B.1 ***Bend Test for Adhesion***—The plated part shall be repeatedly flexed or deformed in some manner until fracture occurs. The ability to peel the coating or to separate the different layers of the coating, at other than the immediate area of the fracture, is evidence of failure to conform to the adhesion requirement.

B.2 ***File Test for Adhesion***—Saw a piece off the plated article, hold it in a vise, and apply a coarse file (12–20 cuts per in) to the cut edge in such a manner as to attempt to raise the deposit. Peeling of the coating away from the cut edge or separation of the different layers of the coating is evidence of failure to conform to the adhesion requirement.

B.3 ***Quenching Test for Adhesion***[11]—Heat the plated article for 1 h in an oven maintained at the following temperatures, within ±10°C:

Basis Metal	Temperature, °C (°F)
Steel	350 (662)
Zinc alloy	150 (302)
Copper or copper alloy	250 (482)
Aluminium	250 (482)

Quench the articles in water at room temperature.

Any lifting or blistering of the coating is evidence of failure to conform to the adhesion requirement.

10. There is no single satisfactory test for evaluating the adhesion of electrodeposited coatings. Those given above are widely used; however, other tests may prove more applicable in specific cases. If so, such tests should be made a part of the purchase order. A review of methods of measuring adhesion is given in the 50th Technical Proceedings of the American Electroplaters' Society (1963).
11. CAUTION: This test may have an adverse effect on the mechanical properties of the article tested.

APPENDIX C

DUCTILITY TEST[12]

C.1 ***Preparation of Test Piece***—Prepare a plated test strip, 150 mm long, 10 mm wide, and 1 mm thick (approximately 6 in x 0.4 in x 0.040 in), by the following method:

Polish a sheet of the appropriate basis metal, similar to that of the articles being plated, except that the sheet may be of soft brass if the basis metal is zinc alloy. (Use a sheet that is sufficiently large to allow the test strip to be cut from it after trimming off a border at least 25 mm (1.0 in) wide all around.) Place the sheet on one side with nickel to a thickness of 25 μm (1.0 mil) under the same conditions and in the same bath as the corresponding articles.

Cut the test strip from the plated sheet with a flat shear. Round or chamfer the longer edges of the test strip, at least on the plated side, by carefully filing or grinding.

C.2 ***Procedure***—Bend the test strip with the plated side in tension, by steadily applied pressure, through 180 deg over a mandrel of diameter 11.5 mm (0.45 in) until the two ends of the test strip are parallel. Ensure that contact between the test strip and the mandrel is maintained during bending.

C.3 ***Assessment***—The plating is deemed to comply with the minimum requirement of an elongation of 8% provided that after testing there are no cracks passing completely across the convex surface. Small cracks at the edges do not signify failure.

12. This test is used to check that the type of nickel deposit complies with the appropriate definition given in 6.3.1.1, and should not be used to assess the acceptability of a plated article.

APPENDIX D

DETERMINATION OF CHROMIUM DISCONTINUITY

D.1 Equipment

Metallurgical microscope (B & L 31-20-6637 or equivalent)

- Eyepiece 10X (B & L 31-15-09 or equivalent)
- Objective 5X (B & L 42-33-51 or equivalent)
- Objective 10X (B & L 42-33-53 or equivalent)
- Howard disc (B & L 31-16-15 or equivalent)
- Cross-line disc (B & L 31-16-30 or equivalent)

Stage micrometer (B & L 31-16-89)
Soft bristle brush
Hot alkaline cleaner (4 oz/gal trisodium phosphate plus 2 oz/gal sodium hydroxide)
Stainless steel beaker, 4000 mL capacity
Copper plating solution (28–32 oz/gal copper sulfate ($CuSO_4 \cdot 5H_2O$) plus 6–8 fluid oz/gal sulfuric acid (H_2SO_4))
Plastic plating tank—Capacity depending on parts to be tested
Copper anodes
Low voltage rectifier (E. H. Sargent Co., Cat. No. S-30968 or equivalent)
Platers tape (3M Co., Pressure Sensitive Tape No. 470, 3/4 in width)
Acid dip (5% by volume sulfuric acid in water)
Hot plate