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Standard Specification for Passivation of Stainless Steels Using Electropolishing[1]

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1. Scope

1.1 This specification covers the passivation of stainless steel alloys in the 200 (UNS2XXXX), 300 (UNS3XXXX), and 400 (UNS4XXXX) series, and the precipitation-hardened alloys, using electropolishing procedures.

NOTE 1—Surface passivation occurs simultaneously with electropolishing under proper operating conditions. The quality of passivation will depend on the type of stainless steel, the formulation of the electropolishing solution, and the conditions of operation. Free iron on the surface of the stainless steel is removed resulting in improved corrosion resistance. Surface smoothing obtained by electropolishing will also improve corrosion resistance. Electropolishing will also remove heat tint and oxide scale.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This specification may involve hazardous materials, operations, and equipment. This specification 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A380 Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems

A967 Specification for Chemical Passivation Treatments for Stainless Steel Parts

B117 Practice for Operating Salt Spray (Fog) Apparatus

B322 Guide for Cleaning Metals Prior to Electroplating

B374 Terminology Relating to Electroplating

B602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings

D3951 Practice for Commercial Packaging

2.2 *ISO Standards:*[3]

ISO 2080 Electroplating and Related Processes—Vocabulary

ISO 4519 Electrodeposited Metallic Coatings and Related Finishes—Sampling Procedures for Inspection by Attributes

ISO 9227 Corrosion Tests in Artificial Atmospheres—Salt Spray Tests

ISO 15730 Metallic and Other Inorganic Coatings—Electropolishing as a Means of Smoothing and Passivating Stainless Steels

3. Terminology

3.1 *Definitions:*

3.1.1 *electropolishing, n*—electrochemical process in which the article(s) to be passivated are treated anodically in a suitable acid medium.

3.1.2 *passivation, n*—rendering of a stainless steel surface into a lower state of chemical reactivity.

3.1.2.1 *Discussion*—Passivated surfaces are characterized by the absence of free iron, as defined by Practice A380.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 Definitions of terms in this specification can be found in Terminology B374 and ISO 2080.

4. Ordering Information

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

4.1.1 *Alloy Designation*—When ordering articles passivated in accordance with this specification, the purchaser shall state, in addition to the ASTM designation number, the date of issue, the alloy designation number, and the testing method(s) by which the article will be evaluated (see 5.3).

4.1.2 *Appearance*—The purchaser shall specify the appearance required, for example, bright or dull. Unless otherwise specified by the purchaser, a bright luster shall be acceptable. Alternatively, samples showing the required finish, or range of finish, shall be supplied or approved by the purchaser. When

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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.

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

required, the basis material may be subjected, before electropolishing, to such mechanical polishing as may be required to yield the desired final surface characteristics.

4.1.3 *Contact Marks*—Visible contact marks may occur. The location of electrical contact marks shall be agreed upon between purchaser and supplier.

4.1.4 *Metal Removal*—Some metal is removed from the surface of the article during electropolishing, typically 5 to 10 µm. As much as 50 µm may be removed for additional smoothing. The ordering document shall include the maximum amount of metal to be removed.

4.1.5 Any requirement for certification—See Section 9.

4.1.6 Any requirement for packaging—See Section 10.

5. Product Requirements

5.1 *Visual Defects*—When specified, the significant surfaces of the article to be passivated by electropolishing shall be free of clearly visible defects such as pits, roughness, striations, or discoloration when examined with 20/20 eyesight at a distance of approximately 0.5 m.

NOTE 2—Defects in the surface of the basis material such as scratches, porosity, inclusions, and so forth, may adversely affect the appearance and performance of the article. Visible examination shall include wearing correctional glasses if the inspector normally wears them.

5.2 *Process:*

5.2.1 *Surface Preparation*—Preparatory procedures and cleaning of the basis material may be necessary; see Practices A380 and B322.

5.2.2 *Electropolishing*—Following the preparatory operations, the articles are introduced into the electropolishing solution for a period of time at the current density and temperature required to produce the passive surface and required surface finish, if any.

NOTE 3—A typical electropolishing solution and operating conditions suitable for many stainless steel alloys is shown in Appendix X1. Proprietary electropolishing solutions are available offering special features such as low sludging, better bright throwing power, longer life, or better performance with specific stainless steel alloys.

NOTE 4—Intricately shaped articles may not receive the same degree of passivation in recessed area as a result of low-current densities. Increasing time or overall current density, or both, or the use of auxiliary cathodes, may be used to improve electropolishing in these areas and to pass subsequent passivation tests.

5.2.3 *Post Dip*—Articles withdrawn from the electropolishing solution will have a residual film that may adversely affect the appearance or performance of the product. The preferred method of removing this film is by rinsing the articles in a room-temperature solution of 10 to 30 % v/v nitric acid (specific gravity 1.42, 70 % w/w).

5.2.3.1 Where local conditions prevent the use of nitric acid (nitrates) for film removal, other options may be used as long as the articles meet the requirements of 5.3.

NOTE 5—A 60-g/L solution of citric acid has been used for film removal; however, note that this procedure may pose waste treatment difficulties. The use of other mineral acids, such as sulfuric or hydrochloric acids, is not recommended as the passive film may be compromised. Neutralization procedures such as immersion in alkaline solutions should not be used as they can have a tendency to "set" the residual film and detract from appearance and performance.

5.2.4 *Final Rinsing*—Rinsing subsequent to passivation is necessary to remove all traces of acidified water that may affect the appearance and performance of the passive part. Deionized or distilled water may be used to avoid water spots.

5.3 *Passivation Testing:*

5.3.1 Passivation by electropolishing shall be evaluated by one or more of the following test methods (see Section 6 for test procedures):

5.3.1.1 Water immersion test,

5.3.1.2 Humidity test,

5.3.1.3 Salt spray test,

5.3.1.4 Copper sulfate test, and

5.3.1.5 Modified "ferroxyl" test for free iron.

6. Test Procedures

6.1 *Water Immersion Test (Specification A967)*—The article(s) shall be alternately immersed in distilled water for 1 h, then allowed to dry for 1 h for twelve wet-dry cycles (24 h total). Failure is indicated by the presence of red rust or staining as a result of the presence of free iron on the surface.

6.2 *Humidity Test (Practice A380, Specification A967)*—The article(s) shall be subjected to 100 % humidity at 38 ± 2°C in a suitable humidity cabinet for a period of 24 h. Failure is indicated by the presence of red rust or staining as a result of the presence of free iron on the surface.

6.3 *Salt Spray (Fog) Testing (Practice B117 (ISO 9227))*—The article(s) shall be subjected to the prescribed test for a minimum of 2 h in an accredited cabinet. Failure is indicated by the presence of red rust or staining as a result of the presence of free iron on the surface.

6.4 *Copper Sulfate Test (Practice A380, Specification A967)*—See Appendix X2. The article is swabbed with an acidified solution of copper sulfate. Failure is indicated by the presence of a copper-colored deposit or copper-colored spots, or both. This test is not to be used on martensitic 400 series stainless steels.

6.5 *Modified "Ferroxyl" Test (Practice A380, Specification A967)*—See Appendix X3. The article is swabbed with a solution of potassium ferricyanide. Failure is indicated by the presence of a dark blue color within 30 s.

7. Sampling Requirements

7.1 Test Method B602 (ISO 4519) can be applied to finishes such as electropolished surfaces.

7.2 A random sample of the size required by Test Method B602 shall be selected from the inspection lot (see 7.3). The articles in the lot shall be inspected for conformance to the requirements of this specification and the lot shall be classified as conforming or not conforming to each requirement according to the criteria of the sampling plans in Test Method B602.

NOTE 6—Test Method B602 contains four sampling plans for the original inspection of coated articles. Three are to be used when the test methods are nondestructive; that is, the test method does not make the articles nonconforming. The fourth plan is used when the test method is destructive. If it is not clear whether the test is destructive or nondestructive, the purchaser should identify which test methods are

destructive and which are nondestructive. In some instances, both destructive and nondestructive test methods may exist for the testing of the conformance of a finish to a particular requirement. The purchaser should state which is to be used.

7.3 An inspection lot shall be defined as a collection of articles that are of the same kind, that have been produced to the same specifications, that have been finished by a single supplier at one time, or at approximately the same time, under essentially identical conditions, and that are submitted for acceptance or rejection as a group.

7.4 If separate test specimens are used to represent the articles in a test, the specimens shall be of the nature, size, and number, and be processed as required in the test methods of this specification. Unless a need can be demonstrated, separately prepared specimens shall not be used in place of production articles for nondestructive tests and visual examination. For destructive tests, separately prepared specimens may be used.

8. Rejection and Rehearing

8.1 Parts that fail to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with test results, the producer or supplier may make a claim for a rehearing.

9. Certification

9.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

10. Packaging

10.1 If packaging requirements are necessary under this specification, they shall be in accordance with Practice D3951.

11. Test Report

11.1 The test report shall include the following information:
11.1.1 A reference to this standard,
11.1.2 A reference to the test method(s) used (see 5.3.1),
11.1.3 The location(s) of the test area(s) on each specimen,
11.1.4 The quantity of specimens tested,
11.1.5 The name of the operator and the testing laboratory,
11.1.6 The date on which the test(s) was (were) performed,
11.1.7 Any circumstances or conditions thought likely to affect the results or their validity,
11.1.8 Any deviation from the test method specified, and
11.1.9 The result(s) of the test(s) (see Section 6).

12. Keywords

12.1 electropolishing; passivation; stainless steel

APPENDIXES

(Nonmandatory Information)

X1. TYPICAL ELECTROPOLISHING SOLUTION

X1.1 *Electropolishing Materials:*

Sulfuric acid, 96 %/w	50 % v/v
Orthophosphoric acid, 85 %/w	50 % v/v
Current density	15 amp/dm^2 minimum
Temperature	75°C
Time, typical	2 to 4 min
Cathodes	stainless steel, copper, lead

X2. COPPER SULFATE TEST (FOR FREE IRON)

X2.1 *Materials*—Copper sulfate test solution:

Distilled water	100 mL
Sulfuric acid, 96 %/w	0.4 mL
Copper sulfate, ACS, ($CuSO_4$ $5H_2O$)	1.6 g

(dissolve all ingredients)

X2.2 *Procedure*—Using a cotton swab, apply the test solution to a clean area of the passivated surface to be tested, keeping the surface wet for a period of 6 min. The formation of a copper-colored deposit or copper-colored spots or both indicates failure. Parts used for testing should be discarded or reprocessed.

X2.3 *Storage*—The test solution shall be made up fresh every two weeks.

X3. MODIFIED "FERROXYL" TEST (FOR FREE IRON)

X3.1 *Materials*—Potassium ferricyanide test solution:

Distilled water	70 mL
Potassium ferricyanide, ACS ($K_3Fe(CN)_6$)	1.0 g
Nitric acid, Reagent Grade 70 ± 1 %/w, sp. gr. 1.415 to 1.420	30 mL
(dissolve all ingredients)	

X3.2 *Procedure*—Using a cotton swab, apply the test solution to a clean area of the passivated surface to be tested. Parts used for testing should be discarded or reprocessed.

X3.3 *Storage*—The test solution should be made fresh daily.