



Designation: A967/A967M – 17

## Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts<sup>1</sup>

This standard is issued under the fixed designation A967/A967M; 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.

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

### 1. Scope\*

1.1 This specification covers several different types of chemical passivation treatments for stainless steel parts. It includes recommendations and precautions for descaling, cleaning, and passivation of stainless steel parts. It includes several alternative tests, with acceptance criteria, for confirmation of effectiveness of such treatments for stainless steel parts.

1.2 Practices for the mechanical and chemical treatments of stainless steel surfaces are discussed more thoroughly in Practice **A380/A380M**.

1.3 Several alternative chemical treatments are defined for passivation of stainless steel parts. **Appendix X1 and Appendix X2** give some nonmandatory information and provides some general guidelines regarding the selection of passivation treatments appropriate to particular grades of stainless steel. This specification makes no recommendations regarding the suitability of any grade, treatment, or acceptance criteria for any particular application or class of applications.

1.4 The tests in this specification are intended to confirm the effectiveness of passivation, particularly with regard to the removal of free iron and other exogenous matter. These tests include the following practices:

- 1.4.1 *Practice A*—Water Immersion Test,
- 1.4.2 *Practice B*—High Humidity Test,
- 1.4.3 *Practice C*—Salt Spray Test,
- 1.4.4 *Practice D*—Copper Sulfate Test,
- 1.4.5 *Practice E*—Potassium Ferricyanide-Nitric Acid Test, and
- 1.4.6 *Practice F*—Damp Cloth Test, and
- 1.4.7 *Practice G*—Boiling Water Immersion Test.

NOTE 1—Free iron denotes iron present on the surface of the parts, including but not limited to iron contamination, iron-tool marks, residual-iron salts from pickling solutions, iron dust, atmospheric exposure, iron deposits in welds, embedded iron, and iron oxide.

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee **A01** on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee **A01.14** on Methods of Corrosion Testing.

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1.5 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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:<sup>2</sup>

**A380/A380M Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems**  
**B117 Practice for Operating Salt Spray (Fog) Apparatus**  
**B254 Practice for Preparation of and Electroplating on Stainless Steel**  
**B600 Guide for Descaling and Cleaning Titanium and Titanium Alloy Surfaces**  
**B912 Specification for Passivation of Stainless Steels Using Electropolishing**

#### 2.2 Federal Specification:<sup>3</sup>

**QQ-P-35C Passivation Treatments for Corrosion-Resistant Steels<sup>4</sup>**

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

<sup>4</sup> In accordance with QQ-P-35C Notice 3, September 11, 1998, Specification QQ-P-35C is cancelled and Specification A967/A967M should be used in its place for DoD activities other than aerospace applications.

\*A Summary of Changes section appears at the end of this standard



### 3. Terminology

3.1 *Definition of Term Specific to This Standard*—It is necessary to define which of the several commonly used definitions of the term *passivation* will be used in this specification. (See Discussion.)

3.1.1 *Discussion*—Stainless steels are autoperpassivating in the sense that the protective passive metal oxide film is formed spontaneously on exposure to air or moisture. The presence of exogenous surface contamination, including dirt, grease, free iron from contact with steel tooling, and so forth, may interfere with the formation of the passive metal oxide film. The cleaning of these contaminants from the stainless steel surface will facilitate the spontaneous passivation by allowing the oxygen uniform access to the surface. The passive metal oxide film may be augmented by chemical treatments that provide an oxidizing environment for the stainless steel surface.

3.1.1.1 In this specification, passivation, unless otherwise specified, is defined as the chemical treatment of a stainless steel with a mild oxidant, such as a nitric acid solution, for the purpose of the removal of free iron or other foreign matter, but which is generally not effective in removal of heat tint or oxide scale on stainless steel. In the case of stainless steels with additions of sulfur for the purpose of improved machinability, passivation may also include the removal of sulfides from the surface of the metal for the purpose of maximizing corrosion resistance.

3.1.1.2 The formation of the protective passive metal oxide film on a stainless steel, also called passivation in a more general context, will occur spontaneously in air or other oxygen-containing environment when the stainless steel surface is free of oxide scale and exogenous matter.

3.1.1.3 Chemical treatments, such as sodium dichromate solutions, may facilitate the more rapid formation of the passive film on a stainless steel surface already free of scale or foreign matter. Such treatments, also sometimes called passivation in common usage, are designated as post-cleaning treatments in this specification in order to distinguish them from chemical treatments capable of removing free iron from stainless steels.

3.1.1.4 The chemical treatments capable of removing heat tint or oxide scale from stainless steel and capable of dissolving the stainless steel itself, typically called pickling, are substantially more aggressive than treatments used for passivation, as defined in 3.1.1.1. The surface of stainless steel that has been pickled is free of scale, free iron, and exogenous foreign matter, and does not require a separate treatment for passivation as defined in 3.1.1.1. The passivation process defined in 3.1.1.2 will occur without further chemical treatment but may be augmented and improved by the post-cleaning treatments defined in 3.1.1.3.

3.1.1.5 Electrochemical treatments, including electropolishing and electropolishing capable of removing heat tint or oxide scale from stainless steel and capable of dissolving the stainless steel itself, are substantially more aggressive than treatments used for passivation, as defined in 3.1.1.1. The surface of stainless steel resulting from these treatments is free of scale, free iron, and exogenous foreign matter, and does not require a separate treatment for passivation as defined in 3.1.1.1. The

passivation process defined in 3.1.1.2 will occur without further chemical treatment, but may be augmented and improved by the post-cleaning treatments defined in 3.1.1.3. Statements regarding chemical treatments, unless otherwise specified, are taken to include electrochemical treatments.

### 4. Ordering Information

4.1 This specification was written for the purpose of providing an alternative to United States Federal Specification QQ-P-35C. Determination of the suitability of this specification for that purpose is the responsibility of the purchaser.

4.2 Unless specified by the purchaser, the chemical treatment applied to the stainless steel parts shall be selected by the supplier from among the listed passivation treatments. (See 5.1.)

4.3 Unless specified by the purchaser, the test practice(s) and test frequency applied to the stainless steel parts shall be selected by the supplier from among the listed test practices. (See Section 13.)

4.4 The purchaser may also specify additional requirements, including the following:

4.4.1 Post-cleaning treatments. (See Section 10.)

4.4.2 Availability of reports and records. (See 5.2.2 and Section 17.)

### 5. Materials and Preparation for Passivation Treatments

5.1 The passivation treatments shall be of one or more of the following types. The effectiveness of a particular treatment for a particular grade of stainless steel in a particular application is demonstrated by meeting the specified testing requirements:

5.1.1 Treatments in nitric acid solutions (see Section 6),

5.1.2 Treatments in citric acid solutions (see Section 7),

5.1.3 Treatments in other chemical solutions, including electrochemical treatments (see Section 8),

5.1.4 Rinsing and neutralization (see Section 9), and

5.1.5 Post-cleaning treatments (see Section 10).

#### 5.2 Materials:

5.2.1 The chemicals used for passivation treatments shall produce passivated surfaces that meet the requirements of one or more of the tests of this specification. Attention shall be given to maintaining adequate volume appropriate to the size and amount of stainless steel to be treated, as well as concentration and temperature control appropriate to the selected treatment. (See Note 2.)

NOTE 2—Attention should also be given to maintaining good cleanliness of the passivation solution to ensure the production of acceptable surfaces that meet the requirements.

5.2.2 The supplier shall maintain a record with regard to concentration and temperature of the passivation solution sufficient to demonstrate that the specified passivation conditions were maintained for each lot of stainless steel parts processed. Such records shall be available for inspection when specified in the purchase order. The supplier is not required by this specification to reveal the precise composition of proprietary chemical mixtures but shall maintain a unique identification of the mixture that will ensure its accurate representation for subsequent use.



5.2.3 The supplier shall be responsible for the safe disposal of all material generated by this process.

### 5.3 *Preparation for Passivation Treatments:*

5.3.1 Any pretreatment methods and procedures used prior to the passivation treatment, including mechanical and chemical methods, singly or in combination, for descaling and pickling, shall be in accordance with Practice A380/A380M. When electrochemical cleaning is required, it shall be performed in accordance with Practice B254.

5.3.2 The resulting pretreated surface shall be substantially free of oil, grease, rust, scale, and other foreign matter.

5.3.3 When the final pretreatment of a part includes pickling of the entire surface of the part, no further passivation treatment is required prior to testing of the surface unless specified by the purchaser.

## 6. Treatments in Nitric Acid Solutions

### 6.1 *Passivation Treatment:*

6.1.1 Stainless steel parts shall be treated in one of the following aqueous solutions and maintained within the specified temperature range for the specified time. Where immersion is impractical, other methods of maintaining contact between the stainless steel surface and the solution within the specified temperature range for the specified time may be used.

6.1.1.1 *Nitric 1*—The solution shall contain 20 to 25 volume percent of nitric acid and  $2.5 \pm 0.5$  weight percent of sodium dichromate dihydrate. The parts shall be immersed for a minimum of 20 min at a temperature in the range from 50 to 55°C [120 to 130°F].

6.1.1.2 *Nitric 2*—The solution shall contain 20 to 45 volume percent of nitric acid. The parts shall be immersed for a minimum of 30 min at a temperature in the range from 20 to 30°C [70 to 90°F].

6.1.1.3 *Nitric 3*—The solution shall contain 20 to 25 volume percent of nitric acid. The parts shall be immersed for a minimum of 20 min at a temperature in the range from 50 to 60°C [120 to 140°F].

6.1.1.4 *Nitric 4*—The solution shall contain 45 to 55 volume percent of nitric acid. The parts shall be immersed for a minimum of 30 min at a temperature in the range from 50 to 55°C [120 to 130°F].

6.1.1.5 *Nitric 5*—Other combinations of temperature, time, and concentration of nitric acid, with or without other chemicals, including accelerants, inhibitors, or proprietary solutions, capable of producing parts that pass the specified test requirements.

6.2 *Water Rinse*—Immediately after removal from the passivating solution, the parts shall be thoroughly rinsed, using stagnant, countercurrent, or spray washes, singly or in combination, with or without a separate chemical treatment for neutralization of the passivation media (see Section 9), with a final rinse being carried out using water with a maximum total solids content of 200 ppm.

NOTE 3—Each of the nitric acid solution treatments listed are recommended for different grades of stainless steel. See X1.3 or X2.1.

## 7. Treatments in Citric Acid Solutions

### 7.1 *Passivation Treatment:*

7.1.1 Stainless steel parts shall be treated in one of the following aqueous solutions and maintained within the specified temperature range for the specified time. Where immersion is impractical, other methods of maintaining contact between the stainless steel surface and the solution within the specified temperature range for the specified time may be used.

7.1.1.1 *Citric 1*—The solution shall contain 4 to 10 weight percent of citric acid. The parts shall be immersed for a minimum of 4 min at a temperature in the range from 60 to 70°C [140 to 160°F].

7.1.1.2 *Citric 2*—The solution shall contain 4 to 10 weight percent of citric acid. The parts shall be immersed for a minimum of 10 min at a temperature in the range from 50 to 60°C [120 to 140°F].

7.1.1.3 *Citric 3*—The solution shall contain 4 to 10 weight percent of citric acid. The parts shall be immersed for a minimum of 20 min at a temperature in the range from 20 to 50°C [70 to 120°F].

7.1.1.4 *Citric 4*—Other combinations of temperature, time, and concentration of citric acid, with or without other chemicals to enhance cleaning, including accelerants, inhibitors, or proprietary solutions, capable of producing parts that pass the specified test requirements.

7.1.1.5 *Citric 5*—Other combinations of temperature, time, and concentration of citric acid, with or without other chemicals to enhance cleaning, including accelerants, inhibitors, or proprietary solutions, capable of producing parts that pass the specified test requirements. Immersion bath to be controlled at a pH of 1.8 to 2.2.

7.2 *Water Rinse*—Immediately after removal from the passivating solution, the parts shall be thoroughly rinsed, using stagnant, countercurrent, or spray washes, singly or in combination, with or without a separate chemical treatment for neutralization of the passivation media (see Section 9), with a final rinse being carried out using water with a maximum total solids content of 200 ppm.

NOTE 4—For some grades of stainless steel, additional considerations may be recommended. See X2.3 and X2.5.

## 8. Treatments in Other Chemical Solutions, Including Electrochemical Treatments

8.1 It is recognized that the purpose of removal of all exogenous matter from a stainless steel surface, including the removal of free iron, can be accomplished by different media, with potential for benefits to be gained from use of proprietary skills and art, including proprietary passivation media. Such treatments may include externally applying an electrical potential on the stainless steel parts, as in the case of electropolishing. The suitability of such passivation treatments for use in meeting the requirements of this specification shall be determined by the capability of the processed parts meeting the specified test requirements.

8.2 Stainless steel parts shall be treated in a specified aqueous solution, with or without externally applied electrical potential, and maintained within a specified temperature range for a time sufficient for the processed parts to meet the specified test requirement.

**8.3 Water Rinse**—Immediately after removal from the passivating solution, the parts shall be thoroughly rinsed, using stagnant, countercurrent, or spray washes, singly or in combination, with or without a separate chemical treatment for neutralization of the passivation media (see Section 9), with a final rinse being carried out using water with a maximum total solids content of 200 ppm.

NOTE 5—See also Specification B912.

## 9. Rinsing and Neutralization

9.1 The chemical reactions of the passivating media on the surface of the stainless steel shall be stopped by rinsing of the stainless steel part, with or without a separate neutralization treatment.

9.2 The suitability of a neutralization procedure is determined by the capability of the processed parts meeting the specified test requirements. (See Note 6.)

NOTE 6—The selection of medium and procedures for a neutralization depends of the chemistry of the passivation and on economic considerations. An example of a neutralizing treatment would be immersion of the part for a minimum of 30 min in a solution of 5 % NaOH at 70 to 80°C [160 to 180°F], followed by a water rinse.

## 10. Post-Cleaning Treatments

10.1 Although the passive metal oxide film characteristic of stainless steel will form spontaneously in air or any other oxygen-containing environment, the supplier shall, when specified by the purchaser, apply a chemical treatment that will accelerate the formation of the passive metal oxide film on a chemically clean stainless steel surface. Examples of mediums that serve to accelerate the formation of the passive film but do not contribute to the removal of free iron from the stainless steel surface are aqueous solutions of sodium dichromate or peroxide.

10.2 When specified by the purchaser, within one hour after the final water rinse as required in 6.2, 7.2, or 8.3, all ferritic and martensitic steel parts shall be immersed in an aqueous solution containing 4 to 6 weight percent of sodium dichromate at a temperature in the range from 60 to 70°C [140 to 160°F] for a minimum of 30 min, followed by a rinse in accordance with 6.2, 7.2, or 8.3. The parts shall then be thoroughly dried.

10.3 The purchaser may specify other post-cleaning treatments.

## 11. Finish

11.1 The passivated parts shall exhibit a chemically clean surface and shall, on visual inspection, show no etching, pitting, or frosting resulting from the passivation procedures.

## 12. Testing Agency

12.1 When required, the purchaser shall be permitted to perform such inspections as necessary to determine that the testing agency is capable of performing the specified test.

## 13. Lot, Frequency of Testing, and Selection of Test

13.1 *Definition of Lot*—A lot shall consist of one of the following, at the option of the supplier:

13.1.1 The passivated parts of similar alloy and manufacturing methods that are pretreated and passivated in a single day or within a time frame that will ensure consistent passivation results;

13.1.2 The passivated parts of the same product of one size from one heat in one shipment; or

13.1.3 When few parts are involved, the passivated parts from an entire production run.

13.2 Unless a greater frequency of testing is specified by the purchaser, one test per lot shall be sufficient.

13.3 One of the tests listed in Section 14, or more when specified on the purchase order, shall be performed on each lot of stainless steel parts to verify the effectiveness of the passivation treatment. It is important to note that not all of the following tests are suitable for all grades of stainless steel. (See Note 7.)

13.3.1 *Practice A*—Water Immersion Test (see 14.1),

13.3.2 *Practice B*—High Humidity Test (see 14.2),

13.3.3 *Practice C*—Salt Spray Test (see 14.3),

13.3.4 *Practice D*—Copper Sulfate Test (see 14.4),

13.3.5 *Practice E*—Potassium Ferricyanide-Nitric Acid Test (see 14.5),

13.3.6 *Practice F*—Damp Cloth Test (see 14.6), and

13.3.7 *Practice G*—Boiling Water Immersion Test (see 14.7).

NOTE 7—Some of the tests may produce positive indications not associated with the presence of free iron on the stainless steel surface. An example would be application of Practice C on some lesser-alloyed martensitic or ferritic stainless steels.

## 14. Verification Tests

14.1 *Practice A*—Water Immersion Test

14.1.1 This test is used for the detection of free iron or any other anodic surface contaminants on stainless steel.

14.1.2 The sample representing the lot of passivated parts shall be alternately immersed in a non-rusting tank of distilled water for  $1\text{ h} \pm 3\text{ min}$  and allowed to dry in air for at least 1 h. If the tank is metallic, the parts shall not be in contact with it; a polymeric support should be used. This cycle shall be repeated a minimum of twelve times.

14.1.3 The tested sample shall not exhibit rust or staining attributable to the presence of free iron particles embedded in the surface.

14.2 *Practice B*—High Humidity Test

14.2.1 This test is used for the detection of free iron or any other anodic surface contaminants on stainless steel.

14.2.2 The test shall be performed using a humidity cabinet capable of maintaining the specified test conditions.

14.2.3 The sample representing the lot of passivated parts shall be subjected to  $97 \pm 3\%$  humidity at 35 to 40°C [95 to 105°F] for a minimum of 24 h.

14.2.4 The tested sample shall not exhibit rust or staining attributable to the presence of free iron particles embedded in the surface.

14.3 *Practice C*—Salt Spray Test

14.3.1 This test is used for the detection of free iron or any other anodic surface contaminants on stainless steel.



14.3.2 The sample representing the lot of passivated parts shall be tested by the salt spray test conducted in accordance with Practice B117 for a minimum of 2 h using a 5 % salt solution.

14.3.3 The tested sample shall not exhibit rust or staining attributable to the presence of free iron particles embedded in the surface.

#### 14.4 Practice D—Copper Sulfate Test

14.4.1 This test is recommended for the detection of free iron on the surface of austenitic stainless steels in the 200 and 300 series, duplex stainless steels, precipitation hardened stainless steels, and ferritic 400 series stainless steels having a minimum of 16 % chromium. This test is not recommended for martensitic 400 series stainless steels or for ferritic 400 series stainless steels with less than 16 % chromium because these steels may give a positive indication irrespective of the presence or absence of anodic surface contaminants.

14.4.2 The test solution is prepared by dissolving 4 g of copper sulfate pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ) in 250 mL of distilled water to which 1 mL of 95 to 100 % sulfuric acid ( $\text{H}_2\text{SO}_4$ ) has been added.

14.4.3 The test solution is applied to the surface of the sample representing the lot of passivated parts, applying additional solution as needed to keep the surface wet for a period of at least 6 min. At the end of this period, the surface shall be carefully rinsed and dried with care taken to not disturb copper deposits if present.

14.4.4 The tested sample shall not exhibit copper deposits.

#### 14.5 Practice E—Potassium Ferricyanide-Nitric Acid Test

14.5.1 This test is recommended when detection of very small amounts of free iron is required. It is recommended for detection of free iron on austenitic 200 and 300 series stainless steels and duplex stainless steels. This test is not recommended for detection of free iron on ferritic or martensitic 400 series stainless steels, because these steels may give a positive indication irrespective of the presence or absence of anodic surface contaminants. This test shall not be applied to parts to be used in food processing.

14.5.2 The test solution is prepared by adding 10 g of chemically pure potassium ferricyanide to 500 mL of distilled water, adding 30 mL of 70 % nitric acid, agitating until all of the ferricyanide is dissolved, and diluting to 1000 mL with distilled water. The test solution shall be mixed fresh on the day of the test since it changes color on standing.

14.5.3 The test solution is applied to the surface of the sample representing the lot of passivated parts. Valid methods include, but are not limited to, swabbing and misting. Spraying a fine mist of the solution onto the test sample may produce a more rapid indication. The formation of a dark blue color within 30 s denotes the presence of metallic iron. A slower developing, paler blue color usually indicates the presence of iron oxides.

14.5.4 The tested sample shall not exhibit the dark blue color indicative of free iron on the surface.

14.5.5 When the test is negative for iron, the surface shall be thoroughly washed with warm water to remove the test solution. When the test is positive, the dark blue stain shall be

removed with a solution of 10 % acetic acid and 8 % oxalic acid, followed by a thorough hot water rinse.

#### 14.6 Practice F—Damp Cloth Test

14.6.1 This test is used for the detection of free iron on the surface of stainless steel. It is especially useful for large parts that have been uniformly cleaned but that are inconvenient for reasons of size of equipment or ease of handling of the part to place in the environments defined in Practices A (14.1), B (14.2), C (14.3), or G (14.7). Unless otherwise specified by the purchaser, the number of tests and the locations of the tests shall be at the option of the supplier to assure a representative testing of the part

14.6.2 The test is performed by placing a clean cloth pad that has been thoroughly soaked with distilled or demineralized water on the surface of the part at a part temperature of 10°C [50°F] or greater for a period of not less than 60 min. The cloth shall be in contact with the steel for an area of at least 130 cm<sup>2</sup> [20 in.<sup>2</sup>]. The pad shall be maintained wet through the test period, either by a method of retarding external evaporation, by the further addition of water, or by backing the pad with a sponge or similar water source. The cloth pad used shall be used for only one such test, being changed for each test so as to avoid risk of contamination. After removal of the cloth pad, the surface of the part shall be allowed to dry in air before inspection.

14.6.3 The tested part shall not exhibit rust or staining attributable to the presence of free iron particles embedded in the surface.

#### 14.7 Practice G—Boiling Water Immersion Test

14.7.1 This test is used for the detection of free iron or any other anodic surface contaminants on stainless steel.

14.7.2 The sample representing the lot of passivated parts shall be immersed in a non-rusting container of distilled water which is then heated to a temperature in the range from 95 to 100°C [200 to 212°F] and maintained within that range for a period of at least 30 min, while ensuring the sample remains immersed. If the tank is metallic, the parts shall not be in contact with it; a temperature-resistant polymeric support should be used. At the end of this period, the container shall be removed from the heat source and be allowed to cool for a period of 3 h ± 15 min. The sample is then removed from the container and set on a towel to air dry (ambient air) for 2 h ± 10 min.

14.7.3 The tested sample shall not exhibit rust or staining attributable to the presence of free iron particles embedded in the surface.

## 15. Rejection and Retest

15.1 Any lot failing to meet the specified requirements of the selected test practice(s) shall be rejected. A rejected lot may, at the option of the supplier, be re-passivated, with or without re-pretreatment, and then be retested. The number of samples tested from a lot subject to retest shall be twice the original specified test frequency, to the limit of the number of pieces in the lot. All samples must pass the specified acceptance criterion for the specified test for the retested lot to be accepted.

## 16. Precision and Bias

16.1 No statement is made concerning either the precision or bias of Practices A, B, C, D, E, F, and G because the results state merely whether there is conformance to the criteria for success specified in the procedure.

## 17. Certification

17.1 When specified in the purchase order, a report of the practice and tests used shall be supplied to the purchaser.

17.2 When specified in the purchase order, a record of process conditions used shall be supplied to the purchaser.

## 18. Keywords

18.1 cleaning of stainless steel; passivation; passivation tests; tests for cleanliness of stainless steels

# APPENDIXES

## (Nonmandatory Information)

### X1. HISTORICAL INFORMATION REGARDING PASSIVATION TREATMENTS

NOTE X1.1—The following information is based on a section of Federal Specification QQ-P-35C (Oct. 28, 1988) identified as information of a general or explanatory nature that may be helpful, but is not mandatory. Minor changes have been made in the text to facilitate references to the main document and to correct technical inaccuracies.

X1.1 *Intended Use*—The passivation treatments provided by this specification are intended to improve the corrosion resistance of parts made from stainless steels of all types.

X1.1.1 During processing operations such as forming, machining, tumbling, and lapping, iron particles or other foreign particles may become smeared over or embedded into the surface of stainless steel parts. These particles must be removed or they will appear as rust or stain spots. This condition may be prevented by chemically treating the parts to remove the iron particles or other foreign particles, and then allowing the passive film to form on the cleaned surface, with or without chemical enhancement of the formation of this oxide film.

X1.1.2 This specification is not intended for the black oxide coating of parts typically used for photographic or optical instruments.

X1.2 *Ordering Data*—Purchasers should select the preferred options permitted by this specification and include the following information in the purchase order:

X1.2.1 Title, number, and date of this specification;

X1.2.2 Identification of material by type and applicable product specification;

X1.2.3 Type of passivation treatment and test practices to be imposed (see 1.4);

X1.2.4 Definition of lot size, if other than described in this specification; and

X1.2.5 Required documentation, if other than the minimum required by this specification.

X1.3 *Grades of Stainless Steel*—Different types of stainless steel are selected on a basis of properties required, for example, corrosion resistance and design criteria, and fabrication requirements. Table X1.1 is a compilation that serves as a guide

for the selection of nitric acid passivation treatment for different grades, but is far from complete either in grades or in passivation treatments.

X1.3.1 For parts made of high carbon/high chromium grades (440), straight chromium grades with 12 to 14 % chromium (martensitic 400 series), or for corrosion-resistant steels containing relatively large amounts (0.15 %) of sulfur or selenium (for example 303, 303Se, 347Se, 416, 416Se, 430F, 430FSe and precipitation hardenable steels), Nitric 1 can be used.

X1.3.2 Nitric 2 can be used to process austenitic 200 and 300 series chromium nickel and chromium grades with 17 % chromium or greater (with exception of the 440 series) corrosion-resistant steels.

X1.3.3 Nitric 3 can be used to process parts made of the following corrosion-resistant steels: austenitic 200 and 300 series chromium-nickel, chromium grades with 17 % chromium or greater (except 440 series).

X1.3.4 Nitric 4 can be used for parts made from high carbon and high chromium grades (400 series) and precipitation hardening stainless steels.

X1.4 *Clean Water*—Clean water is defined as water containing a maximum total solid content of 200 ppm. Rinsing can be accomplished by a combination of stagnant, countercurrent or spray rinses, or both, prior to final rinse.

X1.5 *Chemically Clean Surface*—A chemically clean surface is defined as a surface upon which water, when applied momentarily to the surface, will remain on that surface in an even, continuous film, and in addition is free of any foreign material or residual film deposit which would be detrimental to the quality of the part.

X1.6 *Test Specimens*—When using test specimens instead of parts, the specimens can effectively represent the parts only if they have been exposed to the same processing steps, such as machining, grinding, heat treating, welding, and so forth, as the parts they are to represent.



TABLE X1.1 Recommended Nitric Acid Passivation Treatments for Different Grades of Stainless Steel

| Grade              | Passivation Treatment |          |          |          | Grade                          | Passivation Treatment |          |          |          |
|--------------------|-----------------------|----------|----------|----------|--------------------------------|-----------------------|----------|----------|----------|
|                    | Nitric 1              | Nitric 2 | Nitric 3 | Nitric 4 |                                | Nitric 1              | Nitric 2 | Nitric 3 | Nitric 4 |
| <b>Austenitic</b>  |                       |          |          |          | <b>Free Machining</b>          |                       |          |          |          |
| S20100 (201)       |                       | •        | •        |          | S30300 (303)                   | •                     |          |          |          |
| S20200 (202)       |                       | •        | •        |          | S30310 (303X)                  | •                     |          |          |          |
| S30100 (301)       |                       | •        | •        |          | S30323 (303Se)                 | •                     |          |          |          |
| S30200 (302)       |                       | •        | •        |          | S30330 (303Cu)                 | •                     |          |          |          |
| S30400 (304)       |                       | •        | •        |          | S30345 (303MA)                 | •                     |          |          |          |
| S30409 (304H)      |                       | •        |          | •        | S30360 (303Pb)                 | •                     |          |          |          |
| S30403 (304L)      |                       | •        | •        |          | S34720 (347S)                  | •                     |          |          |          |
| S30430 (XM-7)      |                       | •        | •        |          | S34723 (347Se)                 | •                     |          |          |          |
| S30451 (304N)      |                       | •        | •        |          | S43020 (430F)                  | •                     |          |          |          |
| S30500 (305)       |                       | •        | •        |          | S43023 (430FSe)                | •                     |          |          |          |
| S30800 (308)       |                       | •        | •        |          | S41600 (416)                   | •                     |          |          |          |
| S30900 (309)       |                       | •        | •        |          | S41623 (416Se)                 | •                     |          |          |          |
| S30908 (309S)      |                       | •        | •        |          | S44020 (440F)                  | •                     |          |          |          |
| S30940 (309Cb)     |                       | •        | •        |          | S44023 (440FSe)                | •                     |          |          |          |
| S31000 (310)       |                       | •        | •        |          |                                |                       |          |          |          |
| S31008 (310S)      |                       | •        | •        |          | <b>Ferritic</b>                |                       |          |          |          |
| S31400 (314)       |                       | •        | •        |          | S40500 (405)                   | •                     |          |          | •        |
| S31600 (316)       |                       | •        | •        |          | S40900 (409)                   | •                     |          |          | •        |
| S31603 (316L)      |                       | •        | •        |          | S42900 (429)                   | •                     |          | •        | •        |
| S31609 (316H)      |                       | •        |          | •        | S43000 (430)                   |                       |          | •        |          |
| S32100 (321)       |                       | •        | •        |          | S43400 (434)                   | •                     |          | •        |          |
| S32109 (321H)      |                       | •        |          | •        | S43600 (436)                   | •                     |          | •        |          |
| S34700 (347)       |                       | •        | •        |          | S44200 (442)                   | •                     |          | •        |          |
| S34709 (347H)      |                       | •        |          | •        | S44600 (446)                   |                       |          | •        |          |
|                    |                       |          |          |          | S44625 (XM-27)                 | •                     |          | •        |          |
| <b>Duplex</b>      |                       |          |          |          |                                |                       |          |          |          |
| S31100 (311)       |                       | •        | •        |          | <b>Precipitation Hardening</b> |                       |          |          |          |
| S31500 (315)       |                       | •        | •        |          | S13800 (13-8Mo)                | •                     |          |          | •        |
| S32900 (329)       |                       | •        | •        |          | S15500 (15-5)                  | •                     |          |          | •        |
|                    |                       |          |          |          | S15700 (15-7Mo)                | •                     |          |          | •        |
| <b>Martensitic</b> |                       |          |          |          | S17400 (17-4)                  | •                     |          |          | •        |
| S40300 (403)       | •                     |          |          | •        | S17700 (17-7)                  | •                     |          |          | •        |
| S41000 (410)       | •                     |          |          | •        | S35000 (AM350)                 | •                     |          |          | •        |
| S41400 (414)       | •                     |          |          | •        | S35500 (AM355)                 | •                     |          |          | •        |
| S42000 (420)       | •                     |          |          |          | S36200 (Almar 362)             | •                     |          |          | •        |
| S43100 (431)       | •                     |          |          | •        | S66286 (A286)                  | •                     |          |          | •        |
| S44002 (440A)      | •                     |          |          | •        |                                |                       |          |          |          |
| S44003 (440B)      | •                     |          |          | •        |                                |                       |          |          |          |
| S44004 (440C)      | •                     |          |          | •        |                                |                       |          |          |          |

X1.7 *Carburized Surfaces*—Stainless steel parts with carburized surfaces cannot be passivated because the carbon combines with the chromium forming chromium carbides on the surface.

X1.8 *Nitrided Surfaces*—Stainless steel parts with nitrided surfaces should not be passivated because the treatment will severely corrode the nitrided case.

X1.9 This specification provides for the same passivation treatments as Fed. Spec. QQ-P-35C, but also includes a number of alternative passivation treatments. The effectiveness of any passivation treatment is demonstrated by the parts meeting the specified testing requirements after treatment.

X1.9.1 Between this specification and QQ-P-35C, Nitric 1 is analogous to Type II, Nitric 2 to Type VI, Nitric 3 to Type VII, and Nitric 4 to Type VIII.

X1.10 *Martensitic Grade 440C*—High-strength grades such as 440C are subject to hydrogen embrittlement or intergranular attack when exposed to acids. Cleaning by mechanical methods or other chemical methods is recommended.

NOTE X1.2—The above statement was written in regards to nitric acid passivation methods only.

X1.11 The salt spray test is typically used to evaluate austenitic stainless steels and may not be applicable to all martensitic or ferritic stainless steels.



## X2. ADDITIONAL INFORMATION REGARDING PASSIVATION TREATMENTS

X2.1 **Table X2.1** is a compilation that serves as a general guide for the selection of a passivation treatment for different grades based on standard alloy composition.

### X2.2 *Acid Content:*

X2.2.1 Nitric acid to be used in the formulations described in Section 6 is understood to be the typical commercially available concentrated aqueous solution of nitric acid containing 61.0 to 68.2 weight percent of  $\text{HNO}_3$  (also referred to as 42° Baumé).

X2.2.2 Citric acid to be used in the formulations described in Section 7 is understood to be anhydrous citric acid.

X2.2.3 Citric acid monohydrate added to water to a concentration of 4.4 to 10.9 weight percent is equivalent to 4 to 10 weight percent of anhydrous citric acid.

X2.3 For citric acid passivation treatments, ferritic, martensitic, and precipitation hardening grades may benefit from increasing the pH of the solution to not greater than 4.5 by means of buffering of the acid.

X2.4 *Heat Treatment*—Proper heat treatment of martensitic and precipitation hardening grades of stainless steel performed prior to the passivation treatment may be required to achieve effective passivation and good corrosion resistance.

X2.5 Grades with high sulfur content (in other words, free machining grades) or high carbon content may benefit from a pre- or post-treatment, or both, of immersion in an alkaline solution of pH 10 or higher, using similar time and temperature parameters as the acid passivation treatment. A water rinse shall be used between the alkaline and acid baths.

X2.6 *Rinsing and Residue*—The chemical composition of the passivation solution and the quality of rinsing shall be such that no chemical residue remains on the surface after completion of the final rinse. This is important for the complete formation of the passive metal oxide film, and also in some industries to ensure no contamination of materials that subsequently come into contact with the metal surface.

X2.7 *Marking*—Parts may be marked for identification purposes by vibratory, impact, chemical, laser, or other methods. Such marking should be performed prior to passivation if possible. If marking on stainless steel is performed after passivation, it should be evaluated whether a secondary passivation treatment is necessary or not.

X2.8 *Casting and Sintering*—Stainless steel parts with high surface porosity, including castings and sintered parts, may require additional surface preparation to achieve a desired level of passivation. Abrasive blasting, electropolishing, vacuum impregnation, increased solution temperature, additional immersion time, and the addition of other chemicals, including accelerants, inhibitors, or proprietary solutions, are examples of methods that may aid in producing parts that pass the specified requirements.

X2.9 *Non-ferrous Alloys*—Non-ferrous metals and alloys do not require a treatment as described in this specification in order to form a passive metal oxide film. However, exogenous surface contamination in the form of free iron (for example, due to contact with steel tooling) may develop into surface rust if not removed. (See 3.1.1.) Non-ferrous parts with known or potential free iron contamination may be treated and tested according to this specification in order to assure the removal of any surface iron present. The chemical treatment applied to the parts must be evaluated to ensure compatibility with the alloy. A treatment designated for austenitic grades of stainless steel will usually be sufficient. For titanium and titanium alloys, see also Guide B600.

X2.10 It is not implied nor should it be inferred that unpassivated parts should or necessarily will fail any or all of the test practices listed in Section 14. A semi-quantitative comparison of corrosion resistance can often be achieved by extending the time period of Practice B (High Humidity Test) or Practice C (Salt Spray Test in accordance with Practice B117).

### X2.11 *Prior to Performing Verification Test:*

X2.11.1 Results produced in the verification tests (Section 14) may be improved if the sample part has been allowed

**TABLE X2.1 Recommended Passivation Treatments for Different Grades of Stainless Steel**

| Grade types                                                                                                                                                                   | Nitric 1 | Nitric 2 | Nitric 3 | Nitric 4 | Nitric 5 | Citric 1-5 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|----------|----------|----------|------------|
| Free Machining grades (including Austenitic, Ferritic, and Martensitic), in other words, containing high amount (value not set to a maximum) of sulfur, any selenium, or both | •        |          |          |          | •        | •          |
| Austenitic grades containing high amount of carbon (for example, “H” designated grades)                                                                                       |          | •        |          | •        | •        | •          |
| All other Austenitic grades                                                                                                                                                   |          | •        | •        |          | •        | •          |
| Duplex, Lean Duplex, and Super Duplex grades                                                                                                                                  |          | •        | •        |          | •        | •          |
| Precipitation Hardening grades                                                                                                                                                | •        |          |          | •        | •        | •          |
| Martensitic grades containing high amount (value not set to a maximum) of carbon and below 15 % chromium (for example, 420)                                                   | •        |          |          |          | •        | •          |
| All other Martensitic grades                                                                                                                                                  | •        |          |          | •        | •        | •          |
| Ferritic grades containing below 15 % chromium                                                                                                                                | •        |          |          | •        | •        | •          |
| Ferritic grades containing above 15 % chromium                                                                                                                                | •        |          | •        |          | •        | •          |



several hours dwell time in air between the completion of final rinsing and drying and the start of the test practice.

X2.11.2 The sample part used is expected to remain in a clean condition until the performance of the test.

X2.11.3 Sample parts that are not clean shall, prior to the performance of the test, be cleaned using an appropriate method, for example, some combination of the following:

X2.11.3.1 Immersion in acetone or methyl alcohol.

X2.11.3.2 Swabbing with clean gauze saturated with acetone or methyl alcohol.

X2.11.3.3 Scrubbing with a nonmetallic hard bristle brush, mild soap, and warm water followed by rinsing at room temperature in distilled water, 95 % ethyl alcohol, or isopropyl alcohol.

X2.11.3.4 The part shall be dried using a paper towel, soft cloth, inert atmosphere, or desiccated container.

X2.12 For test Practice D (Copper Sulfate Test) and Practice E (Potassium Ferricyanide-Nitric Acid Test), a “negative indication” or “pass” condition obtained on grades described as “not recommended” (ferritic or martensitic 400 series stainless steel) may be regarded as evidence of sufficient iron removal, while a “positive indication” or “failure” should be regarded as likely due to the limitation of the low amount of chromium in these alloys and not necessarily evidence of insufficient iron removal. If a “pass” condition cannot be obtained, a different test practice shall be used.

X2.13 *Martensitic Grade Adherent Copper Sulfate Test:*

X2.13.1 This test is recommended for the detection of free iron on the surface of hardened martensitic stainless steels.

X2.13.2 The test solution is prepared by dissolving 4 g of copper sulfate pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ) in 90 mL of distilled water to which 5.4 mL of 95 to 100 % sulfuric acid ( $\text{H}_2\text{SO}_4$ ) has been added.

X2.13.3 The test solution is applied to the surface of the sample representing the lot of passivated parts, applying additional solution as needed to keep the surface wet for a period of at least 6 min. At the end of this period, the surface shall be rinsed and dried.

X2.13.4 Copper deposits at the surface of such samples are wiped with moderate vigor to determine if the copper is adherent or nonadherent. Samples with nonadherent copper are considered acceptable. The tested sample shall not possess adherent copper deposits.

X2.14 *Additional Test Methods*—Highly quantitative methods to measure the surface chromium to iron ratio and metal oxide thickness, which can be correlated to corrosion resistance in stainless steel, include: Auger electron spectroscopy (AES), electron spectroscopy for chemical analysis (ESCA)/x-ray photoelectron spectroscopy (XPS), and glow-discharge optical emission spectroscopy (GD-OES).

## SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A967/A967M – 13) that may impact the use of this standard. (Approved July 1, 2017.)

- (1) Expanded Section 4 to include all applicable items mentioned later in the standard.
- (2) Revised 5.2.1.
- (3) Added new Note 2.
- (4) Changed “seller” and “processor” to “supplier” throughout.
- (5) Added mention of alternatives to immersion in 6.1.1 and 7.1.1.
- (6) Expanded dry time between immersion cycles for convenience in 14.1.2.
- (7) Moved cleaning and drying requirement in 14.2.3 to X2.10.

- (8) Removed restriction of copper sulfate test on food equipment in 14.4.1.
- (9) Expanded procedures in 14.4.3 and 14.5.3.
- (10) Added 14.7 (Practice G).
- (11) Added Appendix X2. Moved the previous X1.3.2 through X1.3.4 and X1.12 to Appendix X2.
- (12) Added X1.3.1 through X1.3.4 from QQ-P-35C. Adjusted Table X1.1 to correct errors and to be closer to the original QQ-P-35C table.

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