Process Specification for Passivation of Metallic Materials

Engineering Directorate

Structural Engineering Division

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REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version	5/96
A	Formatting, modified callout, replacement of canceled QQ-P-35C with AMS-QQ-P-35, addition of pickling of Monel	11/16/98
B	Moved requirement from section 5 to section 6, allowed Type VI passivation for precipitation-hardened stainless steels, added alternate embedded iron verification test, modified other periodic testing.	5/17/01
C	Allowed a shop option for choosing the passivation type in section 3.0; wording changes in section 6.2; wording changes in section 9.0, and added requirement that personnel certification be written; and modified the definition of "Passivation" in section 10.	1/25/02
D	Moved paragraph 3.1 to paragraph 6.1 and updated, renumbered and renamed remaining paragraphs in section 6.	10/19/05
E	Removed alternate embedded iron verification test. Reworded first paragraph of section 8. Added Custom 465 and 21-6-9 to list of alloys.	09/08/06
F	Updated references and signature page. Corrected Table for 420, 416, 416se alloys and added Nitronic 60 alloy. Corrected the reference paragraph to 3.2.1.1 from 4.4.1.2.for the humidity test. Removed type VII and VIII passivation because these chemistries are not used on JSC hardware.	7/15/2019
G	Moved caution notes to beginning of section 3.0. Moved Table 1 from section 3.0 to section 6.0. Deleted SOP 009.66 from section 3.0. Clarified that JSC hardware is required to be Method 1 and Class 4. Specified pre and post treatments. Prohibited descaling prior to passivation. Added Type VII and Type VIII to Table 1 for historical continuity. Combined general passivation and special passivation requirements and section 6.2 and 6.3. Combined general pickling requirements into pickling requirements and renumbered section. Alphabetized and formatted definitions section 10. Updated formatting and drawing note examples.	1/22/2021
H	Removal of pickling processing in PRC-5002 for nickel copper alloys – changes to Title, Section 1.0, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0. PRC-5001 has references to pickling. Section 3.0 and Table 1.0 added reference to "Method 1". Section 3 added clarification reference for use of AMS 2700 (Passivation of Corrosion Resistant Steels). Removed reference to Inco Huntington Publishing and MPCV 701556 reference to Section 4.0 and added AMS-QQ-P-35 and SOP 009. 66. Section 5.0	03/27/2026

	added content for material requirements highlighted in AMS 2700 and SOP 009.66. Added manufacturing sequencing to Section 6.1. Significant update to Section 6.2 with addition of cleanliness of hardware, removal of high quality water standard, addition of rinsing control using TDS, added dwell times for immersion, and control of iron concentration in passivation tanks. Section 7.0 added process qualification content that previously stated "none". Section 8.0 added rejection criteria for salt fog testing and total immersion of part for copper sulfate test. (spot testing is not valid for verification of passivation on entire surface.) Added note of false positives for copper sulfate test. Section 9.0 Updated definition for Water Break Free Testing to match ASTM F22.	

1.0 SCOPE

This process specification establishes technical requirements for the passivation of corrosion-resistant steel in the manufacture of JSC flight hardware.

Note: All references in this document to passivation refer to corrosion-resistant steel.

2.0 APPLICABILITY

This process specification covers passivation treatments for use on austenitic, ferritic, martensitic, and precipitation-hardening corrosion-resistant steels.

3.0 USAGE

NOTE: Do not passivate stainless steel parts that have hardened surfaces from nitriding, carbonitriding, or from other similar diffusion treatments. Severe corrosion and/or severe pitting of the hardened surfaces could occur.

NOTE: Do not passivate carburized stainless steels. The chromium combines with the carbon to form chromium carbides along the surface, which do not benefit from passivation.

Call out this process specification on the engineering drawing by using a drawing note that identifies the process specification and the type of passivation. For example:

PASSIVATE PER NASA/JSC PRC-5002, METHOD 1, TYPE VI

If the passivation process is not critical to a particular design use:

PASSIVATE PER NASA/JSC PRC-5002

When no passivation type is specified, then the process type will be selected by the shop from Table 1 (Section 6.2). The decision to allow this shop option should be coordinated in advance with the cognizant Materials and Processes engineer.

The types of passivation processes performed on JSC hardware are:

Method 1,Type II	Medium-temperature nitric acid solution with sodium dichromate additive
Method 1, Type VI	Low-temperature nitric acid solution
Method 1, Type VII	Medium Temperature Nitric Acid **(not recommended for new design)**
Method 1, Type VIII	Medium Temperature, High Nitric Acid Concentration **(not recommended for new design)**

Type VI is the preferred process when permitted by Table 1. Type VI is the only in-house process at JSC. It utilizes no hazardous hexavalent chromium and is available in more metal finishing facilities. Older drawings that have Type VII and Type VIII listed should be updated to Type VI whenever possible. Type VII and Type VIII are not recommended for new design.

Alloys not listed in Table 1 may be passivated to this specification when approved by the cognizant Materials and Processes engineer via engineering drawing. AMS 2700 can be used to passivate if drawing follows the appropriate type and classification listed for the alloy.

4.0 REFERENCES

SOP-007.1	Preparation and Revision of Process Specifications
JPR 8500.4	Engineering Drawing System Requirements
AMS 2700	Passivation of Corrosion Resistant Steels
ASTM B117	Standard Practice for Operating Salt Spray (Fog) Apparatus
AMS-QQ-P-35	Passivation of Corrosion Resistant Steels
AMS-STD-753	Corrosion-Resistant Steel Parts: Sampling, Inspection and Testing for Surface Passivation
SOP 009. 66	Cleaning Solution Control and Maintenance

5.0 MATERIALS REQUIREMENTS

JSC utilizes SOP 009. 66 Cleaning Solution Control and Maintenance for tank temperature and chemistry. Cleaning, deoxidizing, passivation, and rinsing tanks are controlled to ensure removal of free iron or less noble contaminants from the surface of corrosion resistant steel parts.

Passivation tanks shall control the chloride, and iron content to effectively passivate surface. Nitric acid used for processing shall be 42°Baume or 1.4 specific gravity.

Rinse tanks shall sufficiently clean previous processing tank constituents with a final rinse exhibiting a water break free surface. (Generally, a final rinse tank should have less than 200 ppm of dissolved solids to produce a water break free surface.)

6.0 PROCESS REQUIREMENTS

6.1 WORK INSTRUCTIONS

Perform all work to written procedures. The work instructions shall contain sufficient detail to ensure that the manufacturing process produces consistent, repeatable products that comply with this specification. Part manufacturing operations such as heat treatment, forming, joining, and media finishing can affect the condition of the passivation surface. Sequencing of the operations should be considered when a final passivation surface is desired on the part.

For work performed at JSC facilities, these work procedures are documented via Detailed

Process Instruction (DPI).

For contracted work, the contractor shall be responsible for preparing, maintaining, and certifying written work procedures that meet the requirements of this specification.

6.2 REQUIREMENTS FOR PASSIVATION

NOTE: Descaling or pickling before passivation is prohibited without additional direction being provided by the engineering drawing.

All passivation of corrosion-resistant steel shall be conducted according to the requirements of AMS 2700 *Passivation of Corrosion Resistant Steels*, with the modifications included in this process specification. Only Method 1 Nitric Acid shall be used when PRC-5002 is referenced on the engineering drawing. All corrosion resistance testing shall meet Class 4 inspection criteria for AMS-QQ-P-35 engineering references. When no passivation type is specified, the metal finishing facility has the option of using any type process, as allowed by Table 1.

Surface(s) being passivated shall be inspected for cleanliness prior to chemical treatment. Surfaces shall be free of fingerprints, oil, grease, and other contaminants in order to produce a water break free surface. No evidence of visible rust, scale, or foreign material prior to passivation

Pre-treatment shall consist of a detergent cleaning and deionized water. Rinse tanks shall sufficiently clean previous processing tank constituents with a final rinse exhibiting a water break free surface. Final rinse tanks shall control total dissolved solids to less than 200 ppm. .

Post treatment to passivation, parts should be rinsed with deionized water and dried.

Method I, Type II passivation shall have a minimum dwell time of 20 minutes. All other types of passivation shall process per AMS 2700 minimum immersion time.

The metal finishing facility shall maintain a record of the control procedures used for a given passivation treatment. The passivation solution shall be analyzed weekly to verify that the concentration of nitric acid (and sodium dichromate if applicable) meet the specified ranges in AMS 2700. The bath temperature of the passivation tank shall be verified before each use.

If a metal finishing facility uses the Type VI process for alloys in Table 1, the process bath shall be tested monthly to verify that the chloride concentration is less than 1000 ppm and iron content is less than 2%. Testing of bath for chloride and iron before parts are processed is also acceptable.

NOTE: This specification and some drawings use the Roman Numeral system for type from references to AMS-QQ-P-35.

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Table 1: Passivation Types for Specific Alloys

(All listed types are referenced for Method 1)

Type II	**Type VI**	**Type VII** (not recommended for new design)	**Type VIII** (not recommended for new design)
	MP159		
	MP35N		
	IN718		
A286	A286		A286
13-8Mo	13-8Mo*		13-8Mo
15-5PH	15-5PH*		15-5PH
15-7Mo	15-7Mo*		15-7Mo
17-4PH	17-4PH*		17-4PH
17-7PH	17-7PH*		17-7PH
Custom 455	Custom 455*		Custom 455
Custom 465	Custom 465*		
21-6-9 (Nitronic 40)	21-6-9 (Nitronic 40)		
AISI 201	AISI 201	AISI 201	
AISI 202	AISI 202	AISI 202	
AISI 218 (Nitronic 60)	AISI 218 (Nitronic 60)		
	AISI 301	AISI 301	
	AISI 302	AISI 302	
AISI 303			AISI 303
AISI 303Se			AISI 303Se
	AISI 304	AISI 304	
	AISI 304L	AISI 304L	
	AISI 304H		AISI 304H
	XM-7	XM-7	
	AISI 304N	AISI 304N	
	AISI 305	AISI 305	
	AISI 308	AISI 308	
	AISI 309	AISI 309	
	AISI 309S	AISI 309S	
	AISI 309Cb	AISI 309Cb	
	AISI 310	AISI 310	
	AISI 310S	AISI 310S	
	AISI 311	AISI 311	
	AISI 314	AISI 314	
	AISI 315	AISI 315	
	AISI 316	AISI 316	

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Type II	Type VI	Type VII (not recommended for new design)	Type VIII (not recommended for new design)
	AISI 316L	AISI 316L	
	AISI 316H		
	AISI 321	AISI 321	
	AISI 321H		
	AISI 329	AISI 329	
	AISI 347		
	AISI 347H		
AISI 347S			AISI 347S
AISI 347Se			AISI 347Se
AM350			AM350
AM355			AM355
Almar 362			Almar 362
AISI 403			AISI 403
AISI 405			AISI 405
AISI 409			AISI 409
AISI 410			AISI 410
AISI 414			AISI 414
AISI 416			AISI 416
AISI 416Se			AISI 416Se
AISI 420			AISI 420
AISI 429			AISI 429
		AISI 430	
AISI 430F			
AISI 430FSe			
AISI 431			AISI 431
AISI 434		AISI 434	
AISI 436		AISI 436	
AISI 440A			AISI 440A
AISI 440B			AISI 440B
AISI 440C			AISI 440C
AISI 440F			AISI 440F
AISI 440FSe			AISI 440FSe
AISI 442		AISI 442	
		AISI 446	
XM-27			

7.0 PROCESS QUALIFICATION

Calibration of equipment used to monitor time and temperature shall be documented.

Any significant non-use of tanks greater than a month shall test concentration prior to use and other controls found in SOP-009.66 for weekly and monthly evaluation. In addition, the performance of the passivation must be verified using a method in Section 8.0 prior to processing hardware.

8.0 PROCESS VERIFICATION

The post-treatment verification details are in Section 8.1 or 8.2. The method used and result(s) shall be included in the facility or vendor certificate of conformance of this process.

8.1 VERIFICATION OF PASSIVATION PROCESS

After the passivation process has been completed, the passivated components must exhibit chemically clean surfaces that show no etching, pitting, or frosting. A slight discoloration will be allowed if the subject surface passes the water break free test.

Each lot of parts shall be tested to verify corrosion resistance using one of the following four (4) test methods that are detailed in AMS 2700:

(1) Water Immersion
- Alternate Test Method per AMS-STD-753 (Method 100)

(2) High Humidity Test.

(3) Salt Spray Test for a minimum of 2 hours according to the procedures of ASTM B117. showing no signs of visible red rust upon completion of the test. If test panels are allowed by designated engineering documentation, then test panels shall match the alloy and temper of the part. Test panels must accompany all processing steps as hardware.

(4) Copper Sulfate Test with total part immersion. NOTE: Test is not recommended for Martensitic 400 series or ferritic 400 series alloys containing less than 16% chromium content due to false positives.
- Alternative Test Method 102 per AMS-STD-753 (Method 102) (for total part immersion. NOTE: Test is not recommended for Marsentitc 400 series or ferritic 400 series alloys containing less than 16% chromium content due to false positives.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

The supervisor shall certify personnel performing passivation of metallic materials. This training certification shall be written and records kept on file. For processes performed by an outside vendor, the development of an appropriate training program shall be the responsibility of the vendor.

10.0 DEFINITIONS

Corrosion-resistant steel	An alloyed steel that contains chromium in excess of 10.5 wt-%.
Passivation	The chemical treatment of a stainless steel alloy or iron based superalloy with a mild oxidizer, such as nitric acid, to remove free iron or other contaminants embedded in the surface, for example tool steel from machining. Passivation treatment also produces an oxide film with superior corrosion resistance to the oxide film that occurs naturally. Passivation is not generally effective in removing oxide scale or heat tint.
Water Break Free Test	A test to determine if a surface is chemically clean by the use of a distilled water rinse. If the surface is clean, the water will cascade over the surface and spread across the surface in a sheet-like manner. A contaminated surface will cause the water to form droplets and “bead” or break around a hydrophobic contaminant.