BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 31.09

PRODUCTION PROCESS STANDARD

CLEANING OF TITANIUM AND TITANIUM ALLOYS

Issue 21
- This standard supersedes PPS 31.09, Issue 20.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@aero.bombardier.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

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Signed original on file. Validation of paper prints is the responsibility of the user.

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for cleaning titanium and titanium alloy parts and assemblies during fabrication.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS shall be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.1.2 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

1.1.3 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. do not supersede the procedure or requirements specified in this PPS. Similarly, the procedure and requirements specified in this PPS are not applicable when use of a BAPS, MPS, LES or P. Spec. is specified.

2 HAZARDOUS MATERIALS

2.1 Before receipt at Bombardier Toronto, all materials shall be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the Bombardier Toronto Environment, Health and Safety Department.

3 REFERENCES

3.1 ASTM E1447 - Standard Test Method for Determination of Hydrogen in Titanium and Titanium Alloys by the Inert Gas Fusion Thermal Conductivity Method.

3.2 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.3 BAERD GEN-023 - Contamination Control for Compressed Air.

3.4 BAPS 180-031 - Cleaning and Deoxidizing Corrosion and Heat Resistant Alloys and Titanium Alloys.

3.5 EHS-OP-005 - Hazardous Materials Management - *Bombardier Toronto internal operating procedure*.

3.6 PPS 1.35 - Machining of Titanium Alloys.

3.7 PPS 1.36 - Forming of Titanium and Titanium Alloys.

3.8 PPS 13.13 - Personal Protective Respiratory Equipment.

3.9 PPS 13.26 - General Subcontractor Provisions.

3.10 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.11 PPS 20.03 - Fluorescent Penetrant Inspection.

3.12 PPS 31.02 - Cleaning Processes for Aluminum and Aluminum Alloys.

3.13 PPS 31.04 - Degreasing Processes.

3.14 PPS 31.17 - Solvent Usage.

3.15 PPS 34.08 - Application of Epoxy-Polyamide Primer (F19 & F45).

3.16 QDI-09-02 - Process Control - *Bombardier Toronto internal Quality procedure*.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Alkaline cleaning solution, as specified in PPS 31.02.

4.1.2 Ammonium bifluoride, technical grade.

4.1.3 Dapco 6001, Cytec Aircraft Products Co.

4.1.4 Hydrofluoric acid, 52%, MIL-A-24641.

4.1.5 Nitric acid, 42° Bé, A-A-59105.

4.2 Equipment

4.2.1 Compressed air shall meet the requirements of BAERD GEN-023.

4.2.2 Cotton gloves (e.g., DSC 422-1).

4.2.3 Neoprene gloves (e.g., DSC 422-5), boots and aprons.

4.2.4 Bombardier Toronto approved safety chemical goggles.

4.2.5 Neutral Kraft paper.

4.2.6 Scotch-Brite pads, Type A fine (maroon colour), 3M Canada Ltd.

4.2.7 Immersion tanks resistant to the chemicals and to the operating temperatures used.

4.2.8 Wiping cloths (e.g., DSC 378-2).

4.3 Facilities

4.3.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform cleaning of titanium and titanium alloy parts and assemblies during fabrication according to this PPS.

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities shall direct requests for approval to the appropriate internal Quality Manager.

4.3.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, if required. The facility report shall detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance with the requirements of this PPS. Any deviation from the procedure or requirements of this PPS shall be detailed in the facility report. Based upon the facility report, Bombardier Toronto Engineering may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification shall be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from Bombardier Aerospace Supplier Quality Management.

4.3.3.1 For approval of subcontractor facilities to perform cleaning of titanium and titanium alloy parts and assemblies during fabrication according to this PPS completion of a test program and submission of suitable test samples representative of production parts may be required. Test samples shall meet the requirements specified by Bombardier Toronto Engineering.

4.3.3.2 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

5 PROCEDURE

5.1 General

5.1.1 Do not use temporary marking or layout materials unless the marks will be totally removed by subsequent machining or trimming to size.

5.1.2 Do not use cadmium plated tools, clamps, etc. on titanium or titanium alloys.

5.1.3 Use only stainless steel, titanium or polyethylene baskets, racks or wire as spacers to suspend titanium parts in the cleaning solutions.

5.1.4 Rack parts in a position that prevents creation of air pockets and promotes solution drainage without entrapment in recesses or pockets.

5.1.5 Titanium and titanium alloys are susceptible to surface contamination. Take special care to ensure that the parts are properly cleaned before any heating operations. Take the following precautions during handling of all titanium material and parts to prevent contact with these contaminants or to ensure their prompt removal.

- Avoid contact with lubricants, oils or greases (other than approved machining or forming lubricants specified in PPS 1.35 or PPS 1.36) and chlorides (from fingerprints, etc.).
- Always wear clean cotton gloves when handling titanium.
- Wrap titanium in clean neutral Kraft paper during transportation and storage.

5.2 Preparation of Solutions

5.2.1 Prepare the solution baths as follows:

Step 1. Fill the tank half full with water.

Step 2. Add the required amount of chemicals according to Table I slowly into the tank.

Step 3. Fill the tank up to the operating level with water.

5.2.2 Agitate the bath for one minute once per day and after each new bath make-up.

5.2.3 A separate nitric/hydrofluoric acid solution tank shall be used exclusively for the treatment of titanium and titanium alloys. However, corrosion resistant steel is allowed to be treated in this tank but all other materials are not.

TABLE I - SOLUTION MAKE-UP

BATH TYPE (NOTE 2)	SOLUTION COMPONENT	MAKE-UP (NOTE 1)			OPERATING TEMPERATURE
		IMPERIAL UNIT	METRIC UNIT	U.S. UNIT	
HNO_3/HF Acid Pickling Solution 1 (Note 3)		according to BAPS 180-031			
HNO_3/HF Acid Pickling Solution 2 (Note 3)	HNO_3 (42° Bé)	40 gal/100 gal	40 L/100 L	40 gal/100 gal	60 - 90°F
	HF (52%)	5.5 gal/100 gal	5.5 L/100 L	5.5 gal/100 gal	
Alkaline Cleaning Solution		according to PPS 31.02			

Note 1. It is acceptable for subcontractors to deviate from the specified make-up of solutions provided that the control requirements of Table II are met.
Note 2. The tank material shall be resistant to the chemicals and to the operating temperatures used.
Note 3. It is strongly recommended that 2 to 4% of the old solution be used in the make-up of a new solution to promote bath stability.

5.3 Cleaning of Titanium and Titanium Alloys

5.3.1 Detail Parts

5.3.1.1 Except as noted below, clean detail parts according to Flow Chart 1 before assembly or priming.

- For detail parts that have been heat treated according to PPS 30.14, remove residual scale inhibiting agent by mechanically cleaning using Scotch-Brite pads before cleaning according to Flow Chart 1.
- Only if **etching** before fluorescent penetrant inspection of titanium alloy parts is specified by PPS 20.03 or the engineering drawing, etch the parts according to Flow Chart 2. Under most circumstances, **cleaning** before fluorescent penetrant inspection according to Flow Chart 1 is all that is required.

5.3.1.1.1 Except for surfaces that are to be primed, heat treat scale and discoloration are permitted on parts after acid cleaning. Surfaces that will be primed shall be free of heat treat scale and discoloration. If necessary, scrub surfaces with Scotch-Brite pads after acid cleaning.

5.3.2 Assemblies

5.3.2.1 Manually clean assemblies that are to be primed as follows:

Step 1. Solvent wipe part surfaces according to PPS 31.17. Clean only small areas at a time (approximately 1 square foot). Pay special attention to part edges, recesses, etc. where contaminants may accumulate.

Step 2. Thoroughly wet the part surfaces with the alkaline solution and scrub vigorously, by hand, using a clean Scotch-Brite pad or with an air driven vibratory sander.

Step 3. Wash scrubbed surfaces with a clean cloth soaked in the alkaline solution.

Step 4. Rinse parts thoroughly with de-ionized water. While rinsing, wipe the surfaces with a clean cloth and ensure that a water break-free surface exists on the parts. A water break-free surface is defined as a surface on which a continuous water film will remain continuous for a period of at least 30 seconds without discontinuity or breaks.

5.3.2.2 Except as noted in paragraph 5.3.2.3, assemblies that are not to be primed require no further cleaning.

5.3.2.3 If an approved dispositioned Report of Non-Conformance (RNC) specifies in-situ localized cleaning of specific areas on assemblies according to this PPS, clean as follows. Take extreme care at all times to prevent ingress and/or seepage of cleaning solutions/rinse water, and to prevent contact with sealant and/or materials sensitive to cleaning solutions/rinse water.

Step 1. Suitably protect the surrounding structure (e.g., mask) around the area to be cleaned to prevent contamination with cleaning solutions (e.g., solvent, alkaline cleaners, acid cleaning solutions, etc.).

Step 2. Solvent clean the area to be cleaned according to PPS 31.17.

Step 3. Locally apply alkaline cleaning solution to the area to be cleaned using a brush or swab. Allow the alkaline cleaning solution to dwell for 10 minutes, applying additional alkaline cleaning solution as needed to prevent drying during the dwell time. Take care to prevent contamination (e.g., splashing) of the surrounding structure with alkaline cleaner.

Step 4. Locally rinse the area to be cleaned using a brush, or swab, and cold water. Take care to ensure thorough rinsing to remove all trace of alkaline cleaning solution without adversely affecting the surrounding structure.

Step 5. Check for a water break-free surface; if the area is not water break free repeat from Step 3 above.

Step 6. Locally apply nitric/hydrofluoric acid cleaning solution to the area to be cleaned using a brush or swab. For standard cleaning, allow the nitric/hydrofluoric acid cleaning solution to dwell for 2 minutes; if the RNC specifies etching allow the nitric/hydrofluoric acid cleaning solution to dwell for the time required to remove 0.0002" - 0.0004" from the surface. During the dwell time, apply additional nitric/hydrofluoric acid cleaning solution as needed to prevent drying during the dwell time. Take care to prevent contamination (e.g., splashing) of the surrounding structure with nitric/hydrofluoric acid cleaning solution.

Step 7. Locally rinse the area to be cleaned using a brush, or swab, and water. Take care to ensure thorough rinsing to remove all trace of nitric/hydrofluoric acid cleaning solution without adversely affecting the surrounding structure.

Step 8. Remove materials used to protect the surrounding structure and allow the area to dry.

5.4 Handling of Cleaned Parts

5.4.1 Do not touch surfaces of cleaned parts with bare hands. Wear clean cotton gloves at all times when handling cleaned parts.

5.4.2 Parts to be transported for further processing shall be completely wrapped or interlaced with Kraft paper to prevent exposing the cleaned surfaces.

6 REQUIREMENTS

6.1 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

6.2 Cleaned parts shall be free of any oil, grease, soil, dust, fingerprints or die pickup.

6.3 Ensure that parts to be primed are free of smut and other impurities, chemically cleaned and water break-free. A surface free of smut is one which, when wiped with a clean white cleaning cloth, shows no visible deposits on the cloth.

6.4 Visually verify that there is no evidence of pitting on parts that have been chemically cleaned. Parts showing signs of pitting are not acceptable.

7 SAFETY PRECAUTIONS

7.1 Observe standard plant safety precautions when performing the procedure specified herein.

7.2 Do not keep, handle or eat food in the vicinity of cleaning baths.

7.3 Do not use baths, including water baths, for heating or cooling food or drinks.

7.4 Avoid ingestion of any of the materials specified herein. If ingestion occurs, obtain immediate medical attention.

7.5 Wash hands thoroughly after working with chemical baths.

7.6 Do not keep street clothes in the vicinity of chemical baths.

7.7 Wear neoprene gloves, boots and aprons and chemical goggles when operating chemical baths.

7.8 Avoid skin contact with chemical solutions. If skin contact occurs, wash the affected area with large quantities of clean water. If skin irritation occurs, immediately contact the Health Centre.

7.9 Operators who have any broken skin or open wounds on hands or wrists shall not work with chemical baths.

7.10 Avoid eye contact with the materials specified herein. If eye contact occurs, immediately flush eyes in a directed stream of water for at least 15 minutes while forcibly holding eyelids apart to ensure complete irrigation of all eye and lid tissue. Contact the Health Centre and a physician.

7.11 Ensure that sufficient ventilation is provided when using the chemical solutions specified herein. Consult the Environment, Health and Safety Department for the threshold limit values.

7.12 Wear protective respiratory equipment as specified in PPS 13.13 when operating chemical baths.

7.13 Refer to PPS 31.17 for the safety precautions for handling and using solvents.

8 PERSONNEL REQUIREMENTS

8.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39. Refer to PPS 13.39 for personnel requirements.

9 MAINTENANCE OF EQUIPMENT AND SOLUTIONS

9.1 Maintenance of Equipment

9.1.1 Once a year, calibrate all instruments (i.e., gauges and regulators).

9.2 Alkaline Cleaner

9.2.1 Maintain the alkaline cleaning solution according to PPS 31.02.

9.3 Rinse Water

9.3.1 Submit samples of the rinse water for testing according to Table II.

9.3.2 If the rinse water fail to meet the requirements specified in Table II, suspend the applicable process until the rinse water has been re-adjusted to meet these requirements. Re-analyze the rinse water within 24 hours of any adjustments.

9.4 Nitric/Hydrofluoric Acid Pickling Solution

9.4.1 A sample of the nitric/hydrofluoric acid solution shall be tested according to Table II by an laboratory as specified in paragraph 4.3.3.2. Thoroughly mix the solutions before sampling.

9.4.2 Maintain operating temperature according to Table I.

9.4.3 Test the concentration of hydrofluoric acid by etch rate to ensure the solution meets the requirements of Table II. Weigh, then immerse one LAB 068-1 (titanium) test panel in the nitric/hydrofluoric pickling bath for a timed period (e.g., 15 minutes) and then re-weigh the test panel to calculate the etch rate using the following formula. Control the nitric/hydrofluoric acid solution to maintain an etch rate of 2.5 - 5.0 mils/surface/hour.

$$\text{Etch Rate (mils/surface/hour)} = \frac{30\,(W_1 - W_2)\,T}{W_1\,t} \times 1000$$

W_1 = weight before etching, grams
W_2 = weight after etching, grams
T = original thickness, inches
t = etch time, minutes

9.4.4 Immediately following a new bath make-up and once per month thereafter, test the nitric/hydrofluoric acid solution to ensure the amount of hydrogen being absorbed by the titanium is within the limits specified in Table II. Perform hydrogen absorption testing according to ASTM E1447. Test for hydrogen contamination by immersing one LAB 068-1 (titanium) test panel in the nitric/hydrofluoric solution for the time required to remove 0.001" of test panel surface. Calculate the immersion time as follows:

$$\text{Immersion time (minutes)} = \frac{0.001"}{\text{Etch Rate}} \times 60$$

9.4.5 If the nitric/hydrofluoric acid solution fails one or more of the requirements specified in Table II, suspend the nitric/hydrofluoric acid cleaning process until the solution has been adjusted, re-analyzed and meets the requirements specified in Table II. If necessary, dispose of the acid solution (e.g., according to EHS-OP-005) and prepare a new solution according to section 5.2.

9.5 Reports on Solution Testing

9.5.1 Prepare a weekly report of the analysis of the solutions (e.g., according to QDI-09-02). If additions of chemicals are required, indicate the amount to be added. Also indicate in the report (e.g., on a Process Bath Analyses Form, DH4989), that the recommended adjustments have been made. Re-analyze the solution within 24 hours of any adjustment. Maintain records of the solution tests (e.g., according to QDI-09-02).

TABLE II - CONTROL OF SOLUTIONS (NOTE 1)

BATH TYPE	SOLUTION COMPONENT	CONCENTRATION			TEST FREQUENCY (NOTE 5)	
		IMPERIAL	METRIC	U.S.	STANDARD	EXTENDED
Hot De-ionized Water Rinse (Note 2)	De-ionized Water	Temperature: 140 - 180°F; pH: 4.0 - 7.0; and maximum conductivity: 220 µmhos (220 µS/cm)			Weekly and immediately following bath make-up	Weekly and immediately following bath make-up
Cold Demineralized Water Rinse	Demineralized Water	pH: 4.0 - 7.0 and maximum conductivity: 50 µmhos (50 µS/cm).				
Cold Tap Water Rinse	Tap Water	Total solids: ≤ 500 ppm (800 µS/cm); chlorides (Cl): ≤ 30 ppm; pH: 5.0 - 9.0 Subsequent processing shall not expose parts to temperatures greater than 554°F (290°C)				
Cold Recirculating Water Rinse (Note 4)	Tap Water	Use recirculating water			n/a	
Nitric/Hydrofluoric Acid Pickling Solution 1		according to BAPS 180-031				
Nitric/ Hydrofluoric Acid Pickling Solution 2	HNO_3	48 - 108 wt oz/gal	300 - 674 g/L	40 - 90 wt oz/gal	Weekly and immediately following bath make-up	Monthly and immediately following bath make-up
	HF	To maintain an etch rate of 2.5 - 5.0 mils/surface/hour on Ti surface (Note 3)				
	Hydrogen	The nitric/hydrofluoric etch solution shall not increase the level of hydrogen by more than 25 ppm during the time required to remove 0.001" of surface material. Also, the maximum hydrogen content shall not exceed 125 ppm.			Monthly and immediately following bath make-up	Every 3 months and immediately following bath make-up
	Dissolved Metal (Fe & Ti combined)	3.6 wt oz/gal maximum	22.5 g/L maximum	3.0 wt oz/gal maximum	Every 3 months	Every 3 months
Alkaline Cleaning Solutions		according to PPS 31.02				

Note 1. All testing specified in this table shall be performed by either the Bombardier Toronto Materials Laboratory or an alternative Bombardier approved laboratory.

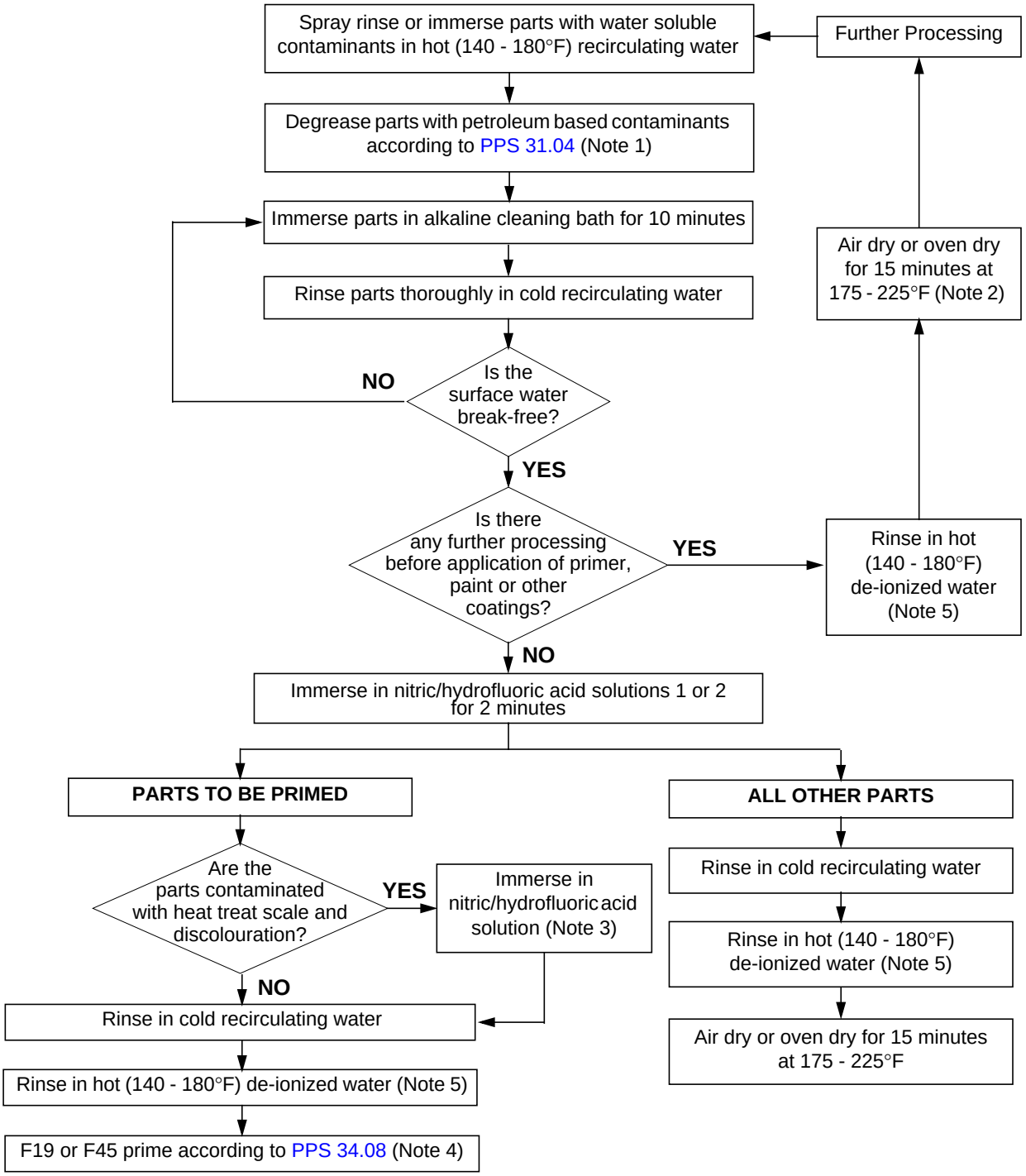
Note 2. Use of a hot de-ionized water rinse is preferred; however, as an alternative to hot de-ionized water rinse it is acceptable to rinse parts in cold demineralized water or cold tap water, provided the respective requirements specified in this table are met.

Note 3. Determine the etch rate according to paragraph 9.4.3.

Note 4. Use cold recirculating water only when specified. It is **not** acceptable to use a cold recirculating water rinse as an alternative to rinsing in hot de-ionized water.

Note 5. If, over a 12 month period, it can be demonstrated (through SPC charts, etc.) that the concentration of the applicable solution component is well within the requirements specified, then the analysis frequency may be reduced from “standard” to “extended”. However, in the event that the solution component analysis fails the requirements specified, revert back to the “standard” analysis frequency until a controlled process can again be demonstrated.

FLOW CHART 1 - CLEANING OF TITANIUM DETAIL PARTS



Note 1. Except for titanium tubing to be welded, parts shall be alkaline cleaned followed by acid cleaning immediately after degreasing. Solvent cleaning according to PPS 31.17 is also acceptable.

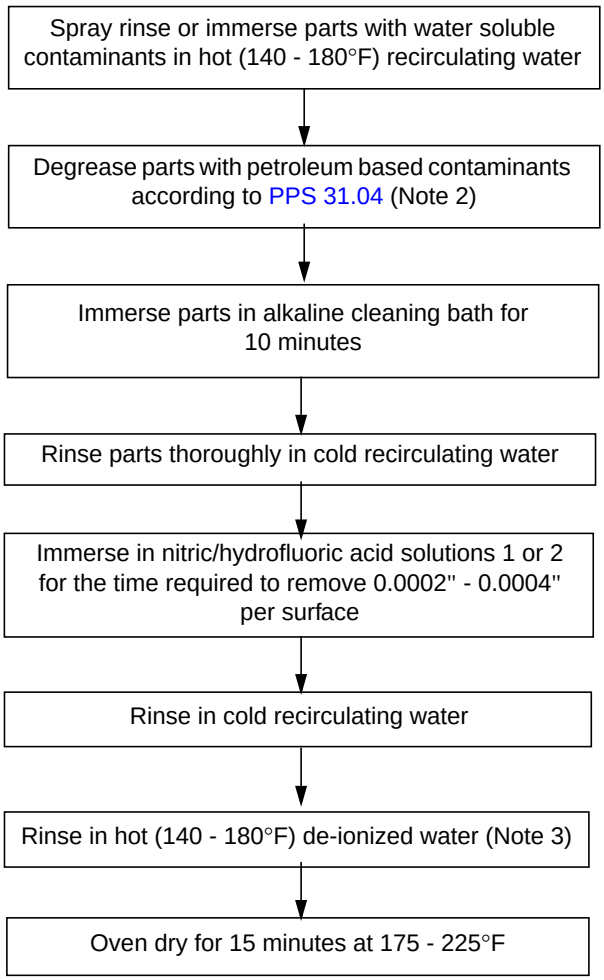
Note 2. Parts to penetrant inspected shall be oven dried. If necessary, blow out assembly seams with clean compressed air.

Note 3. Immerse parts in acid solution until a uniformly pickled, contamination free surface is obtained. Check parts every minute. Maximum immersion time is 3 minutes.

Note 4. Before priming, either chemical conversion coat the part according to PPS 32.02 or apply DSC 595 adhesion promoter according to PPS 34.23 within 5 minutes of surface cleaning. Allow chemical conversion coating to dry for a minimum of 8 hours at room temperature. Cure DSC 595 adhesion promoter according to PPS 34.23.

Note 5. Use of a hot de-ionized water rinse is preferred; however, as an alternative to hot de-ionized water rinse it is acceptable to rinse parts in cold demineralized water or cold tap water, provided the respective requirements specified in Table II are met.

FLOW CHART 2 - ETCHING OF TITANIUM DETAIL PARTS (Note 1)



Note 1. This process is applicable to **etching** before fluorescent penetrant inspection when specified by the engineering drawing or PPS 20.03 only. Under most circumstances, **cleaning** before fluorescent penetrant inspection according to Flow Chart 1 is all that is required.

Note 2. Except for titanium tubing to be welded, parts shall be alkaline cleaned followed by acid cleaning immediately after degreasing. Solvent cleaning according to PPS 31.17 is also acceptable.

Note 3. Use of a hot de-ionized water rinse is preferred; however, as an alternative to hot de-ionized water rinse it is acceptable to rinse parts in cold demineralized water or cold tap water, provided the respective requirements specified in Table II are met.