

Process Specification for Electropolishing of Corrosion Resistant Steel

Engineering Directorate

Structural Engineering Division

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Process Specification for Electropolishing of Corrosion-Resistant Steel

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REVISIONS		
VERSION	CHANGES	DATE
Baseline	Original version	1/14/99
A	Reviewed for accuracy, changed EM2 references to ES4, removed MMPTD references	3/29/02
B	Updated for organizational and technical changes. Removed HCl post dip and replaced with HNO3 post dip per ASTM 8912.	10/30/2019

1.0 SCOPE

This process specification (PRC) establishes the technical engineering requirements for electropolishing of corrosion-resistant stainless steel alloys. Electropolishing of aluminum, copper, or titanium alloys is not permitted. This specification is not intended to be used for electropolishing of parts with internal surfaces, such as tubing. In addition, this process specification is not intended to be used to electropolish parts with faying surfaces or deeply recessed areas where internal cathodes cannot be effectively applied.

2.0 APPLICABILITY

This specification applies to electropolishing treatments for use on austenitic, ferritic, martensitic, and precipitation-hardening corrosion-resistant steel alloys. In addition, it applies to heat and corrosion resistant materials, including cobalt and nickel alloys. When this electropolish process is used, passivation is not required. Also, electropolishing may be used in lieu of etching prior to dye penetrant inspection.

3.0 USAGE

This specification shall be called out on the engineering drawing by using a drawing note that identifies this process specification. A sample drawing note is:

ELECTROPOLISH PER NASA/JSC PRC-5009

Metal removal by this electropolishing process shall be between 0.0002 inches and 0.0005 inches per surface. If a different range or tighter tolerances are required, the engineering drawing must specify the range of material removal that is acceptable. For example:

REMOVE 0.0002 TO 0.0004 INCHES OF MATERIAL PER SURFACE

The designer should be aware that to electropolish, parts must be mounted in a rack and a positive electrode must be attached to the part. These location points will be determined by the electropolishing vendor at their discretion unless locations are specified on the drawing. If this is a problem for the design, it is recommended that the designer consult the JSC Materials and Processes Branch and the electropolish vendor to choose a location that will not affect part performance.

NOTE: Depending on the location of the electrodes, the surface that results from less material removal may have more of a matte finish than a uniformly shiny surface

4.0 REFERENCES

The following documents were used to develop this PRC. Documents listed are

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assumed to be the current revision unless a specific revision is listed.

AMS 2759/9	<i>Hydrogen Embrittlement Relief (Baking) of Steel Parts</i>
AMS 6875	<i>Heat Treatment of Steel Raw Materials</i>
ASTM B912	<i>Standard Specification for Passivation of Stainless Steels Using Electropolishing</i>
10107-70972D	<i>General Process Specification for Electropolishing of Corrosion Resistant Alloys, Oceaneering Space Systems</i>
SOP-007.1	<i>Preparation and Revision of Process Specifications (PRCs)</i>
JPG 8500.4	<i>Engineering Drawing System Manual</i>
MAO103-308E	<i>Electropolishing, Rockwell International</i>
MS 150.4	<i>Manufacturing Specification for Electropolishing of Corrosion Resistant Steel, NASA Marshall Space Flight Center.</i>

5.0 MATERIAL REQUIREMENTS

5.1 QUALIFICATION COUPONS

Qualification is performed once by the vendor, for each alloy and for each fixed process. The machining vendor shall provide a separate test coupon of appropriate, size, thickness and flatness to the electropolishing vendor for use as a process verification coupon for each alloy that needs electropolishing unless the electropolishing vendor will provide the coupon. Similarly, if the vendor has not qualified the process for a particular alloy, additional qualification coupons shall be provided. If the JSC Materials and Processes Branch determines that for specific part or alloy that the process verification must be performed on the same lot of materials used for production parts, verification coupons from the same lot of material shall be specified on the engineering drawing for pre-production, verification or both.

5.2 ELECTROPOLISH SOLUTION REQUIREMENTS

The electropolish solution shall be composed of a relatively concentrated acid mixture of either a glycolic-sulfuric acid or phosphoric-sulfuric acid composition. However, it is recognized that a rather large number of different electropolish formulations are commercially available. Exceptions to the above acid solution compositions must be submitted to JSC Materials and Processes Branch for approval. The solution chemistry and solution maintenance shall be fixed by the electropolishing vendor's written procedures and shall not be changed without requalification. Specific gravity of the solution

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at temperature and dissolved iron shall be checked at least every two weeks. The solution shall be maintained between 2.5% and 3.5% iron. If these limits are not met, the solution shall be removed and replaced.

6.0 PROCESS REQUIREMENTS

6.1 PROCEDURES

Documented procedures shall be generated for implementing this process specification. Procedures shall contain sufficient detail to ensure that the electropolishing process produces consistent, repeatable products that comply with this specification. Procedures shall contain adequate safety precautions and warning notes to ensure safety of the personnel, protection of the environment and facilities in fulfilling the requirements of this document.

For manufacturing performed at NASA-JSC facilities, work instructions shall consist of Detailed Process Instructions (DPI's).

At other facilities, the contractor shall be responsible for preparing, maintaining, and certifying written documented procedures for contracted work. The contractor shall be responsible of ensuring that the documented procedures meet the requirements of this specification.

6.2 FIXED PROCESS

The electropolishing process shall be fixed by the electropolishing vendor's written procedure and shall not be changed without requalification. This include temperature, time and cycles, current density, solution circulation and any other operational variables that can affect the rate and quality of the electropolishing.

6.3 DETAILED PROCESS

All forming, tube flaring, machining, and heat treatment must be performed prior to the electropolish process. If components have been heat treated, they may require a wet or dry blasting procedure to remove the heat tint and scale. Stainless steels 420, 440A, 4408, or 440C must be stress relieved at 300 to 700°F (50°F below the tempering temperature per AMS-H-6875) prior to electropolishing in order to prevent possible cracks.

All parts shall be cleaned with an organic solvent or non-etching detergent cleaner prior to electropolishing. After cleaning, parts shall be racked with attention to the following details:

- Ample spacing to permit proper current density and gas evolution
- Rack mark placement
- Proximity to cathodes

Racked components are placed in the electropolish tank and the positive connection is made.

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Metal removal by this electropolishing process shall not be less than 0.0002 inch nor greater than 0.0005 inch per surface.

NOTE: If tighter tolerances are specified on the engineering drawing, this process shall meet the specified range of material removal.

Automated air or mechanical agitation shall be used to produce uniform electropolishing. If the geometry of the part precludes this, the vendor shall obtain engineering approval from the customer prior to electropolishing the part.

Residual film after electropolishing shall be removed in a room temperature solution of 10-30 v/v % nitric acid (HNQ3) followed by a cold water rinse of deionized or distilled water. Other chemical processing procedures and plating procedures require bake outs in accordance to the requirements of AMS 2759/9 to prevent hydrogen embrittlement. Use of chemical brighteners as part of the final cleaning is specifically prohibited due to the potential for causing hydrogen embrittlement.

After cleaning, the parts shall be dried using clean, dry gas or low heat. The clean, dry parts shall be packaged in clean plastic bags or other containers, which shall be labeled with the part number or other suitable identification, unless further processing is needed.

7.0 PROCESS QUALIFICATION

Process qualification is required using coupons (a least one) for each material to be electropolished. After electropolishing, the qualification coupon(s) shall be inspected to ensure that all of the requirements of Section 8.0 are met. After successful vendor inspection, qualification coupon(s) shall be forwarded to JSC ES4 Materials and Processes Branch for a second party visual inspection before production parts are processed. Any change to the electropolishing process shall require requalification.

8.0 PROCESS VERIFICATION

The verification of adequate completion of the electropolishing process shall consist of a visual inspection of the parts for evidence of pitting, scale, localized material removal, preferential etching, burns, cloudy films, stains, oxidation, and gas streaks. Negative relief (grooving or undercutting) which occasionally results from electropolishing is specifically prohibited. Minor positive relief and/or minor surface discoloration is acceptable if it is at the positive connection point.

In addition, verification that metal removal is in the 0.0002-0.0005 inch per surface range shall be performed using traditional dimensional measurement techniques or go/no-go gages that are appropriate to the design. A calibrated current probe designed to measure metal removal for a specific material-solution combination and electropolish cycle may be used in lieu of a physical measurement.

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Parts not conforming to this specification or to authorized modifications shall be rejected or subject to a Materials Review Board (MRB).

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

All electropolishing treatments shall be performed by trained personnel. Proper training for electropolishing shall, at a minimum, be structured in such a way as to ensure that each trainee can apply an electropolish process that meets this specification. Training and certification records shall be kept.

10.0 DEFINITIONS

Electropolishing Procedure by which a very small amount of metal (typically 0.0002-0.0005 inches) is electrochemically removed from the part, thereby smoothing the surface and diminishing scratches, burrs, etc. It is a controllable process that is the reverse of plating.

Volume/volume (v/v %) A method to express a solution's concentration is volume/volume percent (v/v %) which is: $\text{Concentration solute (v/v \%)} = \frac{\text{volume solute (ml)}}{\text{total volume of solution (ml)}} \times 100\%$. A 10-30 v/v % nitric acid solution means 10 to 30 ml of nitric acid per 100 ml of solution.