insights into ELECTROPOLISHING & MECHANICAL POLISHING Technology

ASTRO PAK
DEFINITIONS

Anode – the positive electrode into which metallic anions flow off of the work-piece or component

Cathode - the negative electrode from which cations flow onto the copper conductor

Electrolyte – the ionic solution (usually phosphoric acid blend) that carries the metal ions from the anode towards the cathode

Electropolish – An electrolytic polishing process that removes metallic ions from the anodic work-piece in a reducing environment through an acidic solution
POLISHED SURFACES ATTRIBUTES

Mechanical Polishing
- Scratches
- Surface imperfections

Electropolishing
- Cleanability
- Featureless

Microscopic Appearance
Ra readings = 15 Ra_{max}
EP PROCESS TECHNOLOGY

- Electrical power forms anodic film
- Film thickness regulates speed of material removal
- Peaks are removed faster than valley areas – anodic leveling
- Surface becomes smooth and featureless
- Removes surface damage
TOPICS COVERED

Surface Conditioning Services

• Passivation
• Rouge (Iron Oxide) Removal
• CO$_2$ Ice Pellet Impingement Cleaning
• Abrasive Blasting
• Mechanical Polishing
• Thermal Arc Spray Metal Deposition
PASSIVATION

Mechanism of Chloride Pitting

\[
\text{Cr}_2\text{O}_3 + 10\text{Cl}^- + 2\text{H}_2\text{O} \leftrightarrow 2\text{CrCl}_3 + 4\text{HClO}
\]

\[
2\text{Fe} + 3\text{ClO}^- \leftrightarrow \text{Fe}_2\text{O}_3 + 3\text{Cl}^-
\]
**MECHANICAL POLISHING**

**Mechanical Polishing** (ASME BPE approved for 2014 edition): a process by which abrasive media is applied to a surface with intent to smoothen until a desired and/or specified surface roughness (Ra) is achieved.

**Process**
- Sanding operation
- Aluminum oxide abrasive used to restore original surface Ra
- Required Utilities: 110V electric and or compressed air (100 psi)

**Where Applicable**
- Where restoration of original metal surface Ra is required
- After Dry Ice Blasting, Bead Blasting or, Thermal Arc Spraying

**Benefits**
- Process used to meet specific Ra or aesthetic requirements
BENEFITS OF EP SURFACES

- Optimum surface finish
- Higher corrosion resistance
- Removal of Bielby damage layer
- Minimizes surface area
- Improves cleanability
- Featureless microscopic surface
- Lowered rouge formation
- Improved sterility
COMPARISON OF MP vs. EP

500x

ELECTROPOLISHED

MECHANICAL POLISHED

2000x
MECHANICAL POLISHING

MP technique performed in-situ in vessel
MECHANICAL POLISHING

Inspection

• Inspection after derouging will show areas that need MP to resolve pitting or scratches

• Rouge removal prior to Electro-Cleaning allows closer inspection of surface.

• White streaks or heavy hazed areas require MP prior to Electro-Cleaning or EP

• Visible pitting will require MP
MECHANICAL POLISHING

Debris on Surface

- Polishing debris consists of stainless steel particles, abrasives and adhesives
- Wipe test of surface illustrates its presence
- Removal of debris from surface – wiping with alkaline cleaner
- EP removal of surface damage – includes MP debris, cold worked surface cracking, and microscopic scratches
BUFFING – DETRIMENTAL EFFECTS

- Entraps stainless particles, polishing debris and organic compounds
- Decreases corrosion resistance
- Not recommended for high purity applications
- Smears damage into the surface
- Looks shiny, but surface damage is hidden
IN-SITU EP OPERATIONS

Electropolishing Tool is moved over the surface as the electrolyte is pumped to it and recirculated.

Spot Electropolishing Tool on Work Surface

- Negative Cable

+ Positive Cable connected to Tank

Electrolyte Pump

Electrolyte Recovery Tub

Power Supply to Electropolishing Tool
IN-SITU EP OPERATIONS

Electropolishing of vessel interior
REASONS TO EP IN-SITU

• Reduce downtime and subsequent re-validation because no removal / replacement is needed
• Customer can monitor work progress and provide immediate approval for return to service
• Repair corrosion damage
• Remove small scratches and shallow pitting
• Smooth microscopic surface
• Improve cleanability
• Reduce corrosion potential
• Restore original factory surface condition
ELECTROLYTIC CLEANING

Process access is required

- Tank Entry Safety Program
- May be completed from outside vessel

What does it remove?

- Light levels of rouge or discoloration
- Smooths surface imperfections

What does it not remove?

- Electrically insulating residue
- Heavy rouge deposits (slow)
- Pits
BENEFITS OF ELECTROLYTIC CLEANING

- Removal of light rouge
- Removal of corrosion effects that generated the rouge
- Microscopic pitting/roughness is smoothed
- Smoother surface reduces corrosion rate
- Decreases frequency of derouging
BEFORE AND AFTER EP REPAIR

BEFORE

AFTER

BEFORE

AFTER
BIOFILM AND ROUGE

Surface Contamination on Product-Contact Surface

• Organic contamination, and in severe cases “biofilm”, occurs when bacteria form protective clusters on the metal surface.

• Surface roughness and porosity caused by corrosion promotes bio-colonization.

• Chemical cleaning and passivation can correct contaminated surfaces.
PASSIVATION AFTER ELECTROPOLISHING

- Chromium to Iron ratio testing with AES
- Passivation’s dramatic improvement
- Corrosion resistance increased
# ASME BPE REQUIREMENTS

## BPE SF-2 Acceptance Criteria

<table>
<thead>
<tr>
<th>Condition</th>
<th>Acceptance Criteria</th>
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<tbody>
<tr>
<td>Blistering</td>
<td>None Accepted</td>
</tr>
<tr>
<td>Buffing</td>
<td>None Accepted (following EP)</td>
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<tr>
<td>Cloudiness</td>
<td>None Accepted</td>
</tr>
<tr>
<td>Haze</td>
<td>None Accepted</td>
</tr>
<tr>
<td>End Grain Effect</td>
<td>Acceptable, if Ra max is met</td>
</tr>
<tr>
<td>Fixture marks</td>
<td>Acceptable, if Electropolished</td>
</tr>
<tr>
<td>Orange Peel</td>
<td>Acceptable, if Ra max is met</td>
</tr>
<tr>
<td>Stringer indications</td>
<td>Acceptable, if Ra max is met</td>
</tr>
<tr>
<td>Weld whitening</td>
<td>Acceptable, if Ra max is met</td>
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# ASTM B-912

**Passivation Using Electropolishing**

<table>
<thead>
<tr>
<th>ASTM B-912 Acceptance Criteria</th>
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<tbody>
<tr>
<td>Metal removal</td>
</tr>
<tr>
<td>Fixture marks</td>
</tr>
<tr>
<td>Visible defects such as pits, roughness, striations, or discoloration</td>
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<tr>
<td>Current density</td>
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<tr>
<td>Post dip or Passivation</td>
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<tr>
<td>Passivation testing per ASTM A-967 or A-380</td>
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<tr>
<td>Inspection, Testing &amp; Documentation</td>
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BPE
Electropolish Procedure Qualification

Procedure Method

Written Quality Control Program
- Pre-polish inspection process
- Pre-cleaning process
- Specific gravity range for electrolyte bath
- Conductivity of rinse water

Essential Variables
- Amperage/time
- Temperature range
- EP process
- Final rinse and clean process
- Final inspection

Documentation
- SEM photos of process qualification sample
- XPS data of 1.0 or greater
- Qualification samples for inspection
- Process control records
- EP procedure used
- Final Ra

Certificate of Compliance
- Vender company
- Customer name
- Description of component
- EP procedure used
- Final surface finish report
SUMMARY - CONCLUSIONS

- MP or Buffing can be a source of particles and corrosion
- Ra measurement does not reveal microscopically featureless surface
- EP Results in:
  - Removal of damaged layer
  - Removal of embedded polishing debris and abrasives
  - Featureless surface condition
  - Resistance to corrosion, rouge formation, and bioburden attachment
  - Meets ASME BPE requirements and ASTM B-912