Why and How to Passivate Stainless Steels

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How the Corrosion Resistance of Stainless Steels Works

*a passive layer*

- SS & some other alloys have an active and passive state
- In active state in sea water, 304 has resistance of low alloy steels
- In passive state in sea water, 304 has resistance similar to silver and nickel-chromium alloys
The Passive Layer

• “Passive State” created by very thin, transparent, chromium-rich oxide layer
• Ideally layer is continuous, non-porous, & self healing in presence of oxygen
• Clean SS will passivate in air/moisture
• Pickled and electropolished surfaces properly rinsed essentially passivated
• SECRET – clean surface
Cleaning for Chemical Passivation

- If needed, flush to remove any debris or extraneous material
- Remove all grease, oil & other organic contamination
  - accomplished with alkaline, emulsion, solvent or detergent cleaners
- Water-Break test to check removal of oil, grease etc.
Heat Tint not removed by Chemical Passivation

- Heat tint caused by welding must be removed by grinding, pickling or electropolishing
- Most heat tint is on ID of tubing where grinding is impossible
- Use AWS D18.1 or D18.2 for acceptable heat tint levels. Chemical passivation of heat tint areas improves corrosion resistance, but not to level of clean surfaces
Checking for Free Iron

- **Water-Wetting & Drying test** – practical
  - water – preferably distilled or deionized
  - apply by spraying or by immersion
  - 24 hour test with alternate wetting & drying ~ one hour each

- **Ferroxyl Test** overly sensitive & not usable for food applications (cyanide)
Deposit Free Iron Causing Corrosion at “29”
Common Chemical Passivation Processes

*Removes free iron & enhances passive layer*

- Nitric acid 10 – 40% &, 30-90 min. @ ambient or higher temperature
- Citric acid 4 – 10%, longer time than nitric
- Chelant systems or with citric acid
- See ASTM A380 or A967 for more details
More about Passive Layer

• High Cr/Fe ratio of layer – higher cor. resistance
  - chemical passivation reduces Fe – resulting in higher Cr/Fe

• Cr/Fe ratio determined by: AES, ESCA/XPS or GD-OES

• Oxide depth ~ 15 angstrom min. desired
## Summary of the 316L CPP Measurements

<table>
<thead>
<tr>
<th>Sample</th>
<th>Unpassivated</th>
<th>Passivated</th>
</tr>
</thead>
<tbody>
<tr>
<td>As Welded (HAZ)</td>
<td>276 mV</td>
<td>525 mV</td>
</tr>
<tr>
<td>Color Cleaned (Scotch Brite)</td>
<td>230 mV</td>
<td>475 mV</td>
</tr>
<tr>
<td>Ground (120 grit finish)</td>
<td>343 mV</td>
<td>495 mV</td>
</tr>
<tr>
<td>Base Metal (2B Finish)</td>
<td>506 mV</td>
<td>494 mV</td>
</tr>
<tr>
<td>Weld (120 grit finish)</td>
<td>---</td>
<td>603 mV</td>
</tr>
</tbody>
</table>
Passivation Procedure Qualification

• ASME BPE Standard has non-mandatory method for qualifying 316L
• Similar to Welding Procedure Qual. - process description, essential variables, welded & non-welded coupons, coupon testing
• Cr/Fe ratio 1.0 or greater
• Oxide depth 15 angstrom min.
Passivation Chemical Sources

- Bradford Derustit Corp.  
  - [www.derustit.com](http://www.derustit.com)

- Avesta Finishing Chemicals|  
  - [www.avestafinishining.com](http://www.avestafinishining.com)

- Quality Welding Products Inc.  
  - [www.qwpinc.net](http://www.qwpinc.net)

- Many others including commercial chemical companies
Safety and Regulation Considerations

- Passivation chemicals & particularly pickling solutions must be handled with care to avoid harm to personnel & environment.
- Proper disposal of spent chemicals varies with the chemical and with local regulations.
Outsourcing Passivation Work

- Biotech & pharmaceutical industry often use specialty companies for cleaning/passivation/deroughing
- These companies handle the complete job including disposal of spent solutions
- Less used by dairy/food plants but might be considered for start-ups and large projects
Thank you

Any questions?