Drinking Water Corrosion Control and POU/POE Treatment

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• Symptoms of Corrosion
• Types & Causes of Corrosion
• Lead & Copper Rule
• Regulatory Environment
• Corrosion Prevention & Remediation
• POU Devices
• Challenges & Opportunities
Symptoms of Corrosion

- Color in water
- Color on surfaces
- Tastes & Odors
- Sediment and Particulate
- Leaks in Tubing/Piping, Appliances or Fixtures
Types of Corrosion

Group I: identifiable by visual inspection
- Uniform Corrosion
- Pitting
- Crevice Corrosion
- Galvanic Corrosion

Group II: identifiable with special inspection tools
- Erosion
- Cavitation
- Fretting
- Intergranular
- Exfoliation
- De-Alloying

Group III: identifiable by microscopic examination
- Cracking
- High Temperature Attack
- Stress Corrosion Cracking
- Corrosion Fatigue
- Scaling
- Internal Attack
Causes of Corrosion

- High Velocity
- High Conductivity/TDS
- Low pH
- High Temperature
- Chlorine, Chloramines, and Chlorides
- DIC – Dissolved Inorganic Carbonates
- Dissimilar Metal contact – Direct or via electrolyte
- Biofilm Accumulation – Microbially Induced Corrosion
Electrochemical Corrosion of Iron

Oxidation = LOSS of electrons

$\text{Fe}^{2+}$ $\text{OH}^-$

$\text{O}_2$ $\text{H}_2\text{O}$

e$^{-}$
## Dissimilar Metals

### Anode (Most Active)
- Magnesium
- Zinc
- Aluminum (2S)
- Cadmium
- Aluminum (175T)
- Steel or Iron
- Cast Iron
- Lead - Tin solder
- Lead
- Nickel
- Brass
- Copper
- Bronze
- Stainless Steel (304)
- Monel Metal
- Stainless Steel (316)
- Silver
- Graphite
- Gold

### Cathode (Least Active)

<table>
<thead>
<tr>
<th>Metal</th>
<th>Index (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold, solid and plated, Gold-platinum alloy</td>
<td>0.00</td>
</tr>
<tr>
<td>Rhodium plated on silver-plated copper</td>
<td>0.05</td>
</tr>
<tr>
<td>Silver, solid or plated; monel metal. High nickel-copper alloys</td>
<td>0.15</td>
</tr>
<tr>
<td>Nickel, solid or plated, titanium alloys, Monel</td>
<td>0.30</td>
</tr>
<tr>
<td>Copper, solid or plated; low brasses or bronzes; silver solder; German silvery high copper-nickel alloys; nickel-chromium alloys</td>
<td>0.35</td>
</tr>
<tr>
<td>Brass and bronzes</td>
<td>0.40</td>
</tr>
<tr>
<td>High brasses and bronzes</td>
<td>0.45</td>
</tr>
<tr>
<td>18% chromium type corrosion-resistant steels</td>
<td>0.50</td>
</tr>
<tr>
<td>Chromium plated; tin plated; 12% chromium type corrosion-resistant steels</td>
<td>0.60</td>
</tr>
<tr>
<td>Tin-plate; tin-lead solder</td>
<td>0.65</td>
</tr>
<tr>
<td>Lead, solid or plated; high lead alloys</td>
<td>0.70</td>
</tr>
<tr>
<td>2000 series wrought aluminum</td>
<td>0.75</td>
</tr>
<tr>
<td>Iron, wrought, gray or malleable, plain carbon and low alloy steels</td>
<td>0.85</td>
</tr>
<tr>
<td>Aluminum, wrought alloys other than 2000 series aluminum, cast alloys of the silicon type</td>
<td>0.90</td>
</tr>
<tr>
<td>Aluminum, cast alloys other than silicon type, cadmium, plated and chromate</td>
<td>0.95</td>
</tr>
<tr>
<td>Hot-dip-zinc plate; galvanized steel</td>
<td>1.20</td>
</tr>
<tr>
<td>Zinc, wrought; zinc-base die-casting alloys; zinc plated</td>
<td>1.25</td>
</tr>
<tr>
<td>Magnesium &amp; magnesium-base alloys, cast or wrought</td>
<td>1.75</td>
</tr>
<tr>
<td>Beryllium</td>
<td>1.85</td>
</tr>
</tbody>
</table>

Maintain < 0.15V Differential wherever possible
## Health Effects of Corrosion Byproducts

<table>
<thead>
<tr>
<th>Lead</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low birth weight</td>
<td>Stomach Distress</td>
</tr>
<tr>
<td>Retarded development</td>
<td>Intestinal Distress</td>
</tr>
<tr>
<td>Lower IQ</td>
<td>Liver Damage</td>
</tr>
<tr>
<td>Damaged hearing</td>
<td>Kidney Damage</td>
</tr>
<tr>
<td>Reduced attention span</td>
<td>Wilson’s Disease Complications</td>
</tr>
<tr>
<td>Kidney Damage</td>
<td></td>
</tr>
<tr>
<td>Reproductive damage</td>
<td></td>
</tr>
</tbody>
</table>

[Kayser-Fleischer ring - Wilson’s Disease]
Lead & Copper Rule (LCR)

Lead and Copper Rule (LCR) 2, 56 FR 26460 - 26564, June 7, 1991

“To protect public health by minimizing lead (Pb) and copper (Cu) levels in drinking water, primarily by reducing water corrosivity”

Action Level:

15 ppb Lead
1.3 ppm Copper

Maximum Contaminant Level Goal:

0 ppb Lead
<1.3 ppm Copper
Decisions...

Should we address causes or symptoms?
Regulatory Environment

Safe Drinking Water Act (SDWA) defines <8% lead content by weight as “Lead-free”

After January 4th 2014, lead free means < 0.25% by weight for wetted surfaces

Shower valves and service saddles are exempt from Public Law 111-380, California, and Louisiana laws. Vermont and Maryland laws do not exempt service saddles.

No-Lead Brass is currently 25-40 percent more expensive than leaded brass
What is NSF/ANSI 61?
NSF/ANSI 61 is a performance-based standard established to measure contaminates introduced into drinking water from products. The contaminants include regulated metals including lead and copper, organics and pesticides. For more information on NSF 61 see: www.nsf.org/business/water_distribution/faq.asp#general

What is NSF/ANSI 61 Annex F?
NSF/ANSI 61 Annex F requirement reduces the allowable limit for lead extracted from test bodies from 15 ppb to 5 ppb (parts per billion). The Annex F requirement has an effective date of July 1, 2012.

What are NSF 61 Annex G and NSF 372?
NSF/ANSI 61 Annex G and NSF/ANSI 372 are lead content standards that can be used to verify the lead content of any product, material and component that conveys or dispenses water for human consumption.
POE Corrosion Prevention Strategies

- TDS –100 – 500 TDS Range
- pH range 7.0 – 10.0
- Raise total alkalinity
- Flow - Design to minimize turbulence
- Dissimilar Metals – Separation & Isolation
- External factors – Ground paths, peripheral metallic contact
- Dissolved/Entrained Gases
- Biofilm- Maintain a sanitary system, regularly disinfect POE equipment
Corrosion Remediation Strategies

- Identify Causal Factors
- Remove Causal Factors
- Identify Damaged Areas
- Replace Damaged Areas
- Chemicals & Coatings
Protecting Drinking Water

- Adopt a layered approach
- Control causal factors
- Reduce contaminants in general for the entire building
- Provide a “final-barrier” of protection for all drinking water locations
# POU Treatment Technologies

<table>
<thead>
<tr>
<th>Lead</th>
<th>Copper</th>
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</thead>
<tbody>
<tr>
<td>Ion Exchange</td>
<td>Ion Exchange</td>
</tr>
<tr>
<td>Reverse Osmosis</td>
<td>Reverse Osmosis</td>
</tr>
<tr>
<td>Distillation</td>
<td>Distillation</td>
</tr>
<tr>
<td>Deionization –EDI/CDI</td>
<td>Deionization –EDI/CDI</td>
</tr>
<tr>
<td>Carbon Block</td>
<td></td>
</tr>
<tr>
<td>Poly/Orthophosphates</td>
<td>Poly/Orthophosphates</td>
</tr>
</tbody>
</table>
Testing
Testing

- Multiple samples per jobsite
  - Untreated
  - Treated Cold
  - Treated Hot
- Clean sample container
- Rinse with water to be sampled
- Slow sample draw – avoid aeration

☑ Run water for at least 60 seconds at testing point for NON LCR tests
☑ Draw after sitting overnight for LCR test

If there is even a remote suspicion that human health could be at risk or if there is legal liability, take samples to a certified laboratory

Always follow manufacturer’s instructions
Challenges to Implementation

• **Compounding Chemistry**
  – Water that otherwise meets standards can become more corrosive after softening

• **Water Softeners/Conditioners**
  – Resin fouling & subsequent metal/mineral dumping
  – Regeneration malfunctions
  – Bacterial colonization

• **Media Filtration Systems**
  – Bacterial Colonization during regular service
  – Media Replacement frequency and sanitization
  – Chemical interactions

• **General Legal Issues**
  – Installation methods and materials
  – Follow-up testing
Closing Thoughts...

- Cities can’t realistically protect everyone, all the time
- Consumers don’t trust their drinking water to be 100% safe
- Most consumers don’t like the taste of city water
- Even when water meets “minimum standards”, most consumers/users believe that it isn’t good enough
- All drinking or process water should be filtered