PbSCC OF ALLOY 800NG STEAM GENERATOR TUBING IN ALKALINE ENVIRONMENTS

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Background (1)

- ODSCC degradation still results in tube repairs around the world
- Alloy 800 Nuclear Grade has been used throughout the world as an SG tube material
Background (2)

- Lead has been observed at crack tips for both Alloy 600MA and Alloy 600TT from pulled tubes.
- Laboratory testing has shown that Alloy 690 is susceptible to Pb-contaminated environments at sufficiently high pH levels.
Objective

- Investigate the susceptibility of Alloy 800NG to Pb contaminated environments similar to what could occur in crevice regions of a steam generator

- Specific Tasks include:
  - Testing at two pH values
  - Determining the effect of applied potentials
  - Investigating the surface oxide films formed
Test Procedures

Test Environment

- 3m NaCl, 500 ppm Pb, 6 ppm H₂ + NaOH
- pH 8.5 & 9.5 at 330°C (626°F)
  - Note: RT pH values of 12.6 and 13.7

Materials

- Two heats of Alloy 800NG
  - Solution Annealed (Alloy 800NG)
  - Cold worked plus shot peened (CW Alloy 800NG)

Sample preparation

- Reverse U-Bends (RUBs) with A600 bolts
- Mounted on electrically-isolated Ni rods

Test procedure

- Titanium autoclaves
- Metallography after various exposure times.
- Auger Electron Spectroscopy for surface film examination
Alloy 800NG and CW Alloy 800NG both showed through thickness cracking in under 1500 hours exposure at Open Circuit Potential (OCP)
$pH_{330^\circ C} 9.5$, OCP, Alloy 800NG Morphology

- Transgranular near surface, Intergranular deep into
- Oxide filled pockets near surface
Alloy 800NG (CW and non-CW) showed faster cracking than other SG tubing alloys
Alloy 800 showed an incubation time of approximately 3000 hours then significant crack propagation.
**pH_{330^\circ C} 8.5, OCP, Crack Morphology**

- No appearance of cracks at times up to around 3000 hours
- Branchy, transgranular cracks after onset of cracking
pH$_{330^\circ C}$ 8.5, OCP, Comparison to Other Alloys

Other alloys either showed no cracking or linear crack growth from start of test (no significant incubation times)
**pH$_{330^\circ C}$ 9.5, Effect of Applied Potential on Alloy 800NG**

- **Highest rate at +75 mV**
- **At -50 mV, similar to OCP – Supports use of reducing environments**
• $\text{pH}_{330^\circ\text{C}}$ 9.5 – Pb and Ti through Thickness
• $\text{pH}_{330^\circ\text{C}}$ 8.5 – Pb and Ti only near surface, possibly deposited on cooldown
**AES Cr:Ni Ratio**

- **pH_{330^\circ C} 9.5**: For high pH values, Cr should dissolve and Cr:Ni ratio should be low – Pb Changes Oxide
- **pH_{330^\circ C} 8.5**: Low, then high, then base indicating thin, expected oxide behavior
Summary

- Alloy 800NG was susceptible to cracking at high pH values in Pb contaminated caustic environments
- Significant incubation time at $\text{pH}_{330^\circ C}$ 8.5 (3000 hours)
- CW Alloy 800NG may be more susceptible to cracking especially when surface cold work layer is disturbed
- Mild effect of applied potential but does support operation in reducing environments
- AES shows changes in oxides that correspond with changes in cracking behavior
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