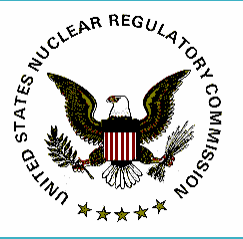


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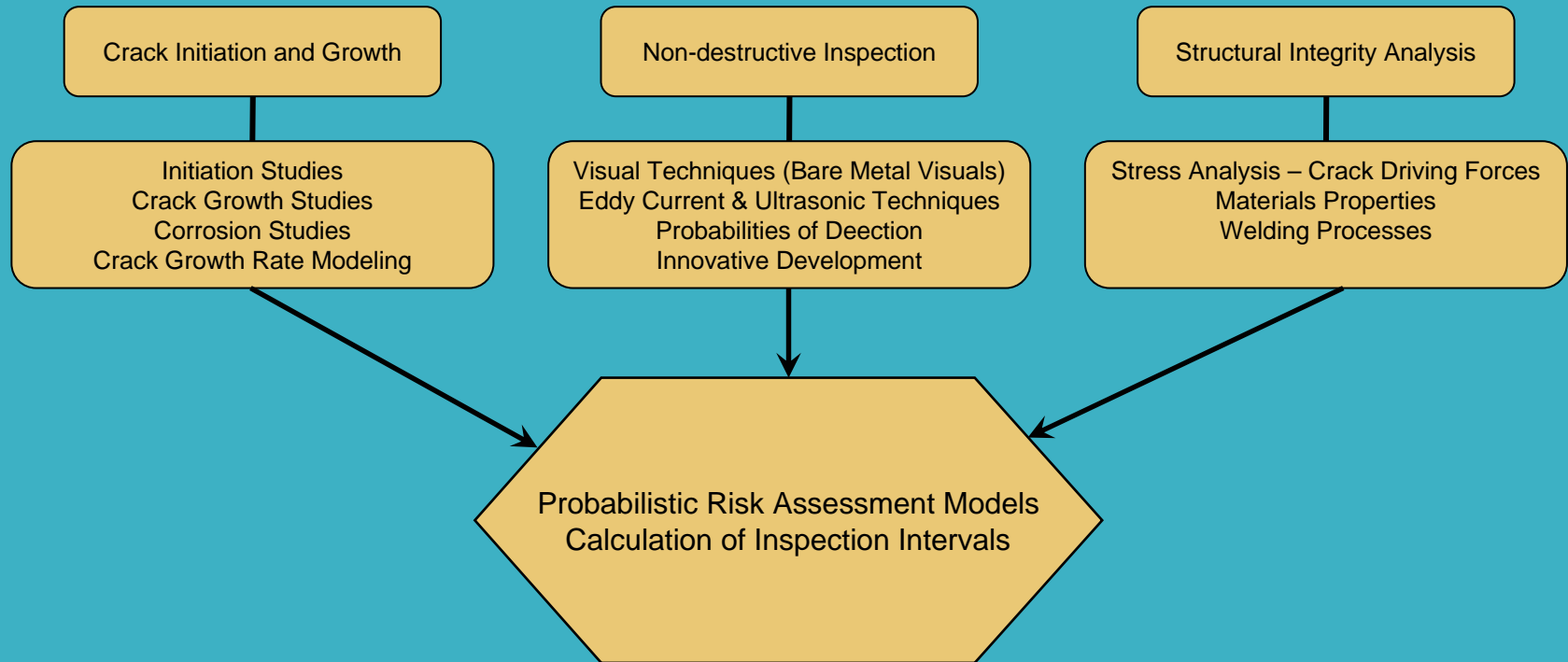
## Content of Boric Acid Corrosion Research Program

- **Crack Growth Rates of Alloys 600 & 182 from Davis-Besse Head**
  - Difficult to accomplish – small size of specimens
  - Metallography, yield strength suggest relatively good quality alloys
- **Computational Model, Probabilistic Assessment of:**
  - Statistics of Initiation, Probability of Detection & Accuracy of Sizing
  - Crack Growth Rate Variations, Stress Intensity Factor Gradients
- **Measure  $E_{cp}$  and wastage rates for range of solution compositions, temperatures (Tasks 3 & 4)**
  - Wastage (bulk corrosion) as function of temperature and solution concentration
    - Includes tests in molten boric acid
  - Electrochemical Potential and Polarization Measurements of Low-Alloy Steel, Alloys 600 & 182 in Concentrated Boric Acid Solutions



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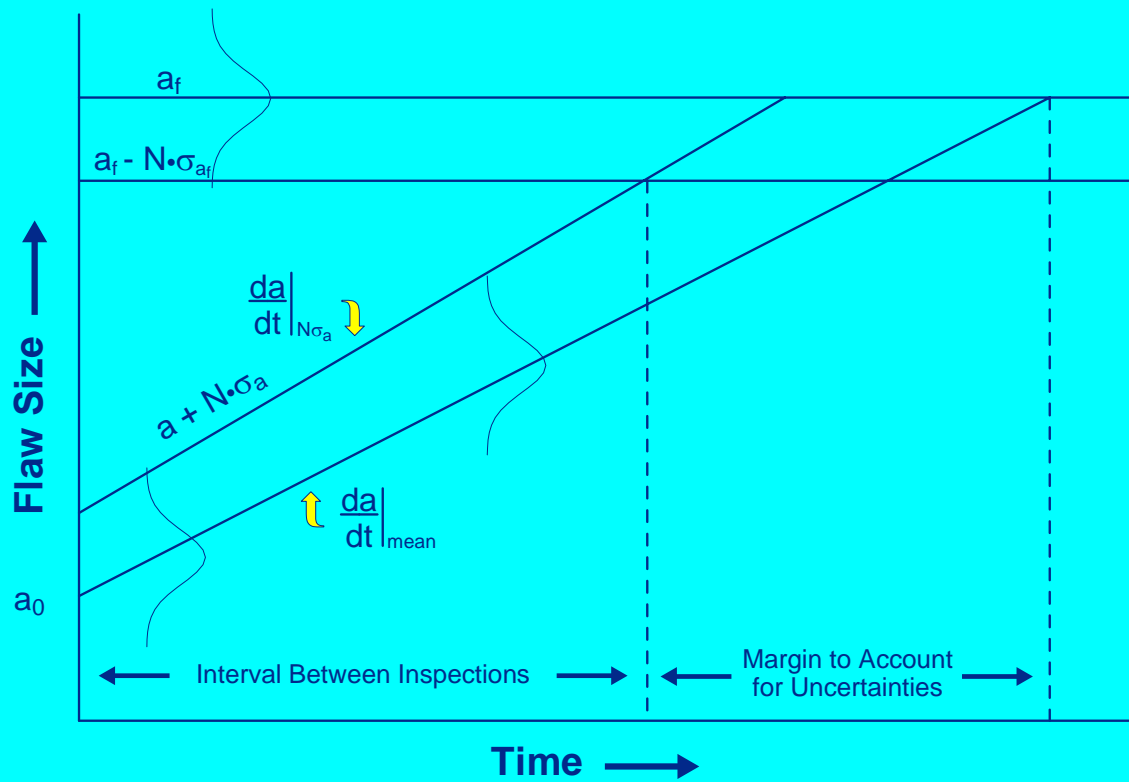
## Calculation Of Inspection Interval Is An Integrated Process





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## Integrated Inspection Model





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## Corrosion Tests

Determine the wastage rates and electrochemical potentials for:

**A533 Gr B and Type 308 SS weld (diluted by A533Gr B).**

- Flowing & quiescent, aerated and deaerated BA solutions
- T = 100-316°C (212-600°F)
- PWR (1000-wppm B + 2-wppm Li)
- 3500-wppm B + 2-wppm Li

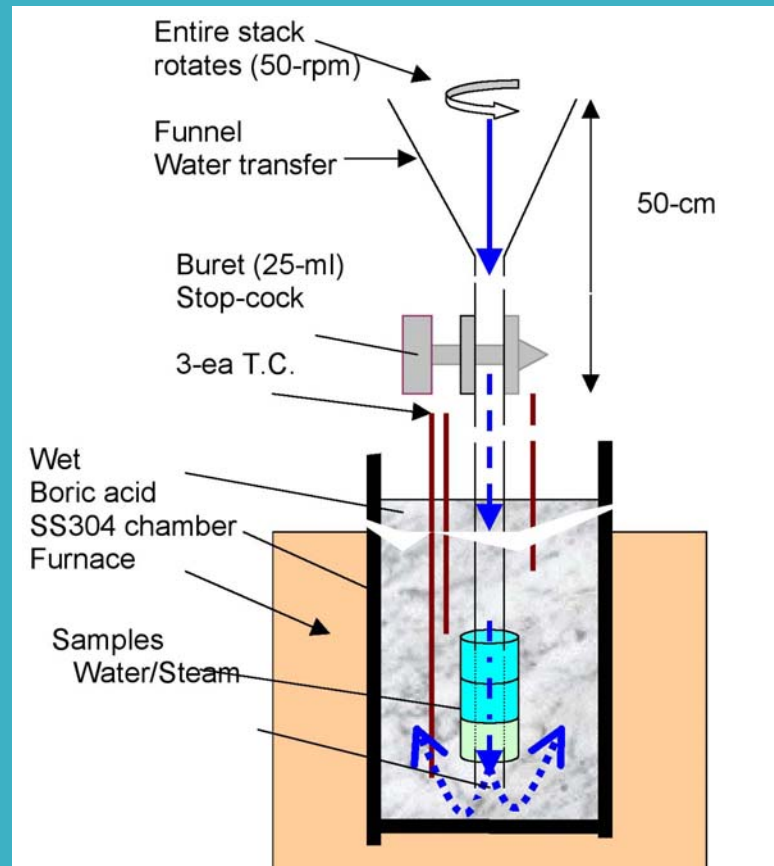
**and**

**Molten H-B-O conditions**



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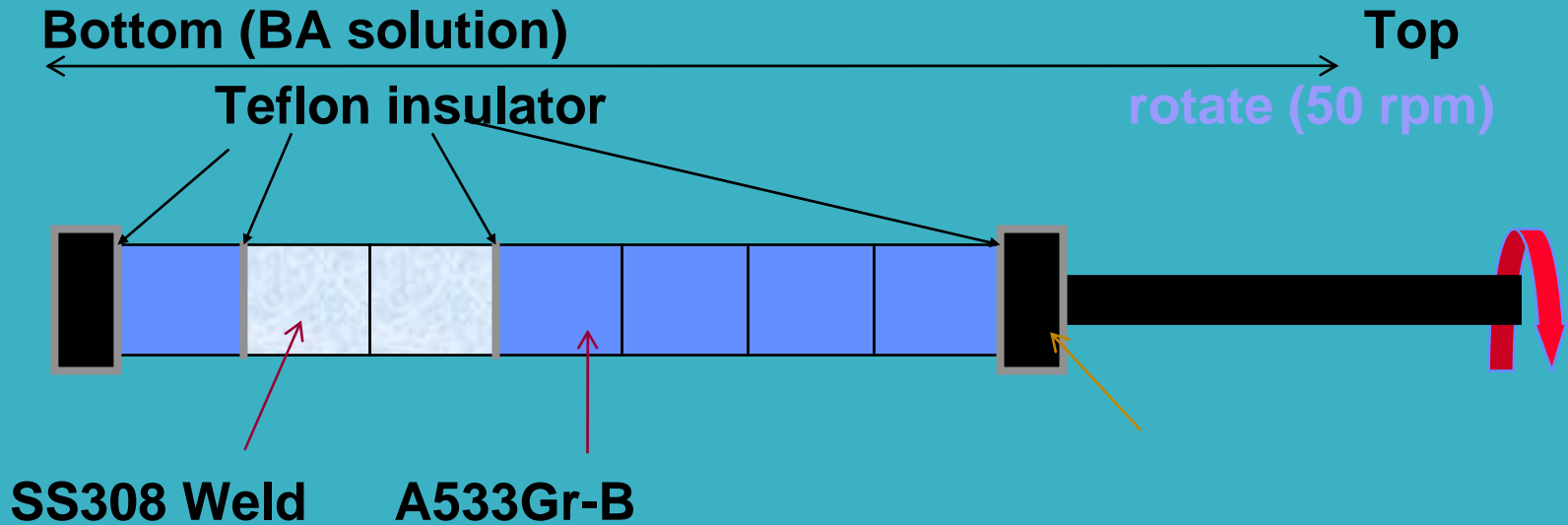
## Wastage test apparatus for the aqueous solution and molten boric acid systems



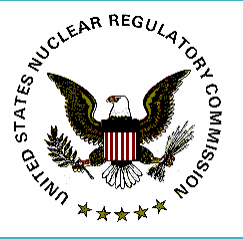


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## Wastage test sample assembly

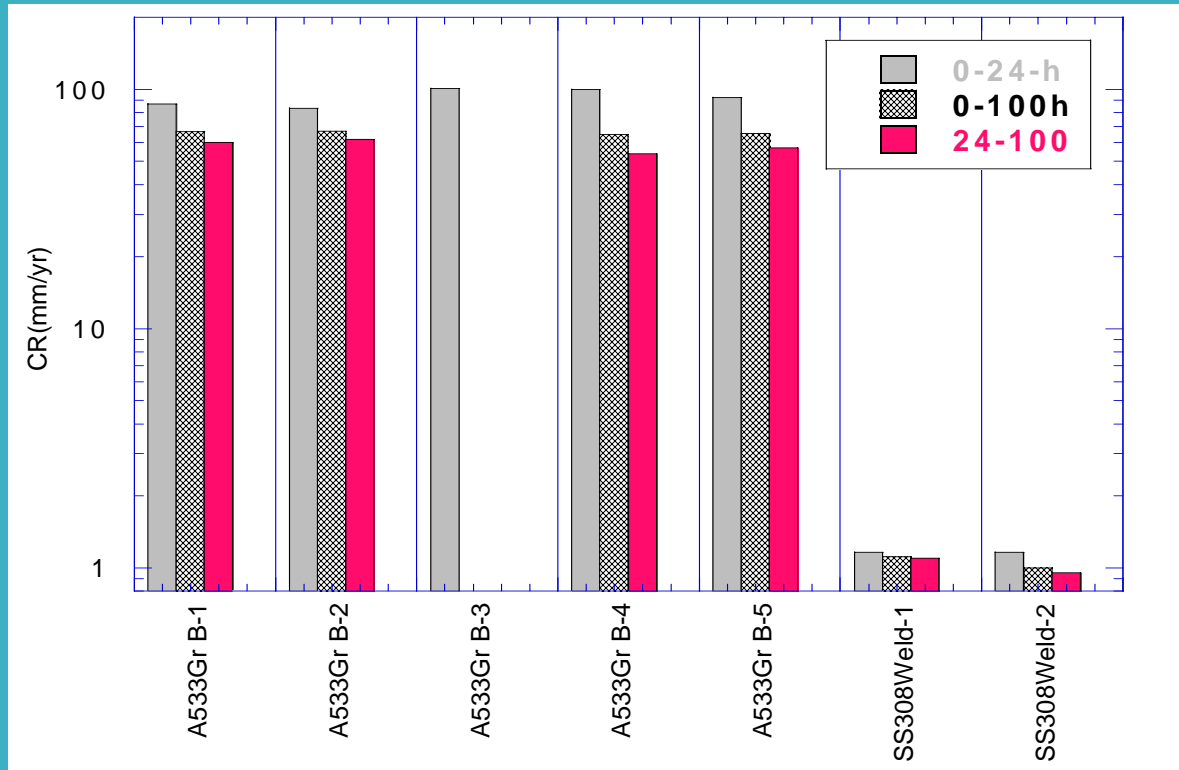


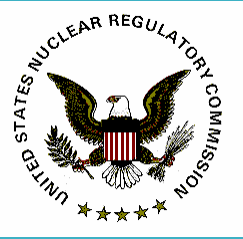
Sample: 6.5 gram, OD (0.50"), ID (0.275"), length (0.5")



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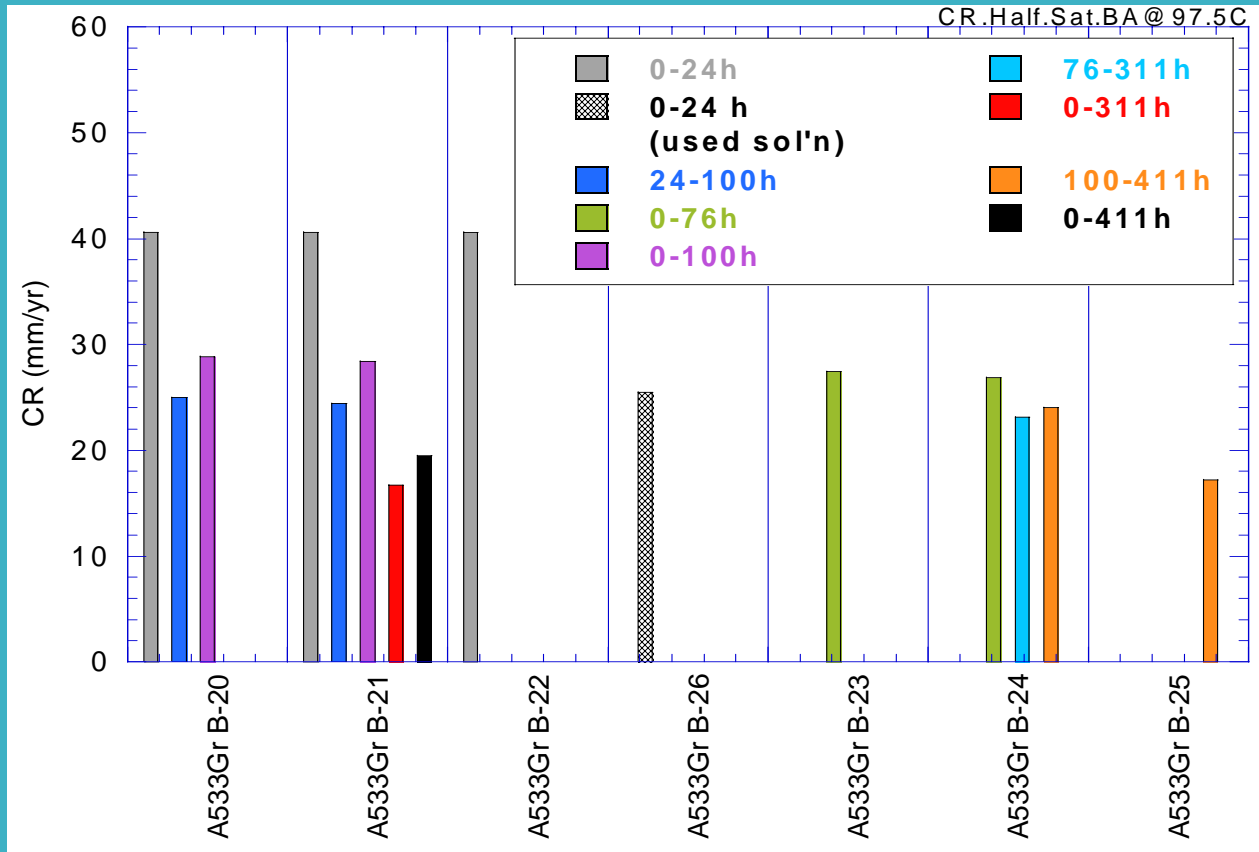
## CR for A533-Gr. B & SS 308 in sat'd BA sol'n (40,514 wppm-B) at 97.5°C





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## Corrosion rates for A533-Gr. B half-saturated BA solution (20,257 Wppm-B) at 97.5°C

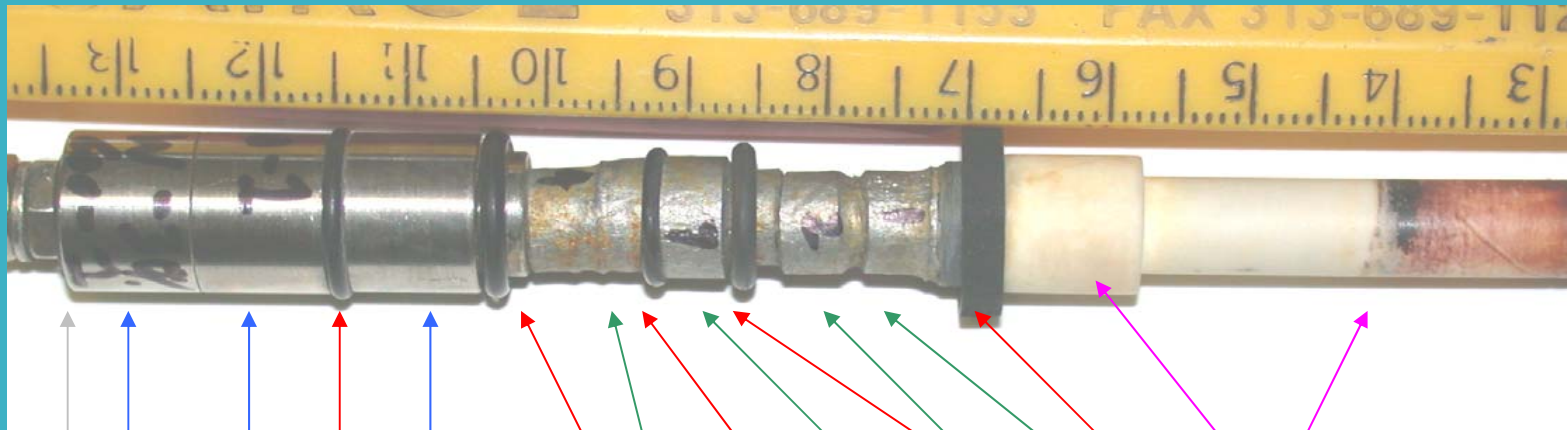






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**Sample stack view for A533Gr-B, A600, SS308 after exposure for 311 or 411 h in sat'd BA solution at 97.5°C**



**A B C D E F G H I J K L M N O**

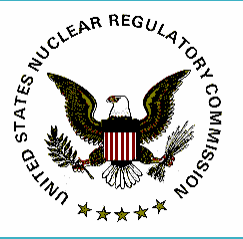
**A:** Screw tightening mechanism with flat O-ring at the bottom

**B:** A600 (30%CW), **C:** A600-1, **E:** SS308 clad weld

**D, F, H, J, & M:** O-rings,

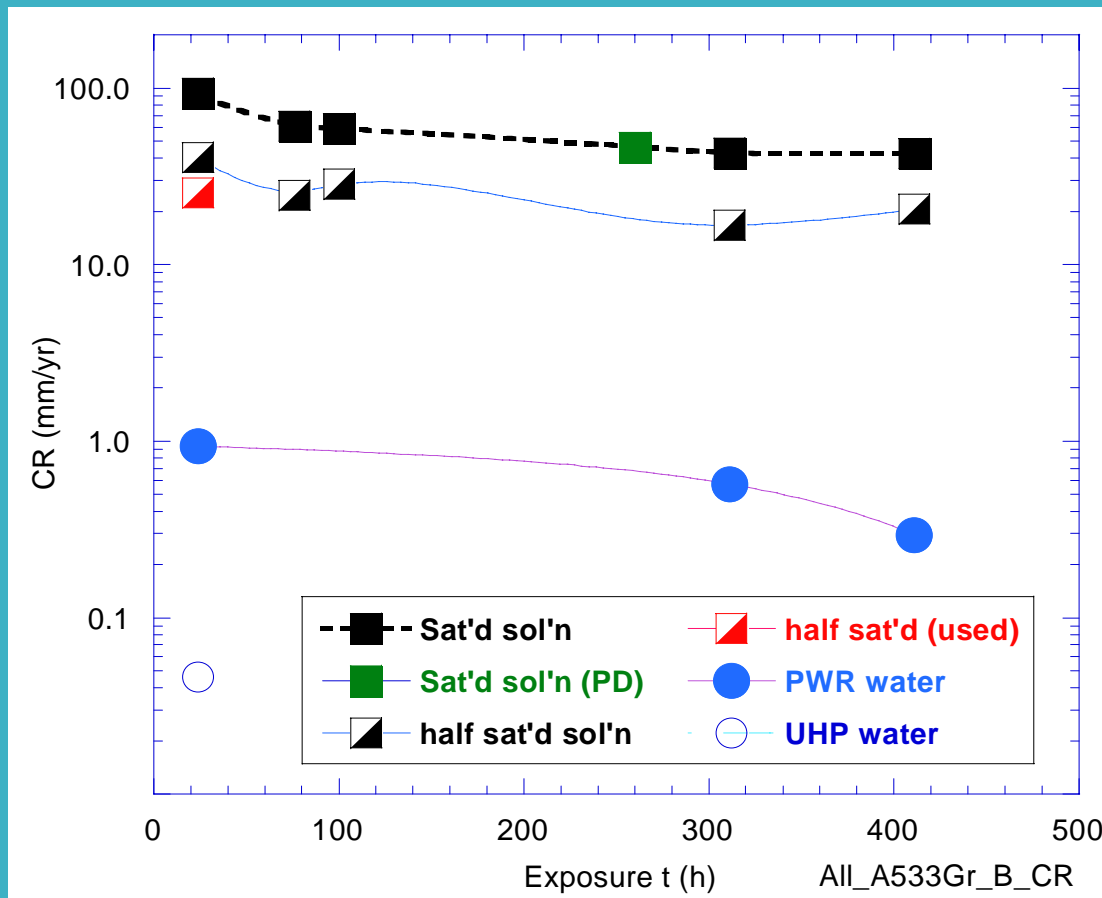
**G, I, K, & L:** A533Gr-B #1, 2, 4, & 7.

**N & O:** Alumina (N, in the sol'n & O, interface solution/vapor)

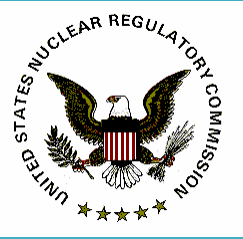


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## Corrosion Rates of A533Gr-B in various BA solutions at 97.5°C

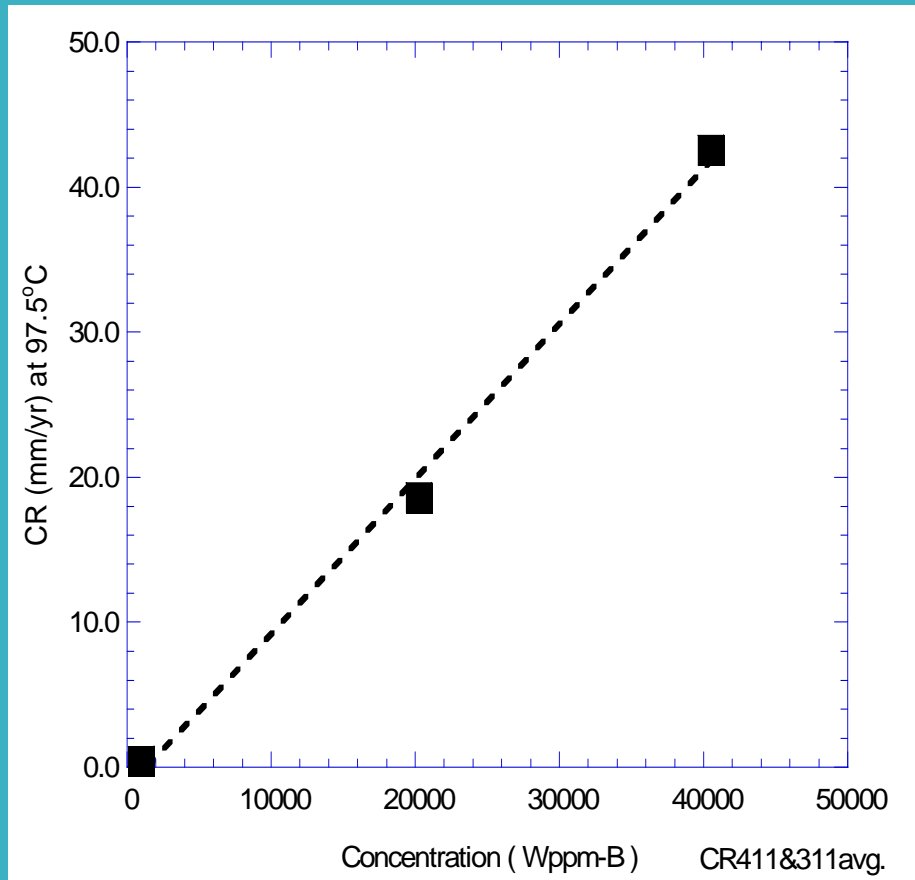


Note:  
CR determined for times between 24 and 411 h.



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# Corrosion Rates vs. Wppm-B for A533Gr-B in BA solutions at 97.5°C

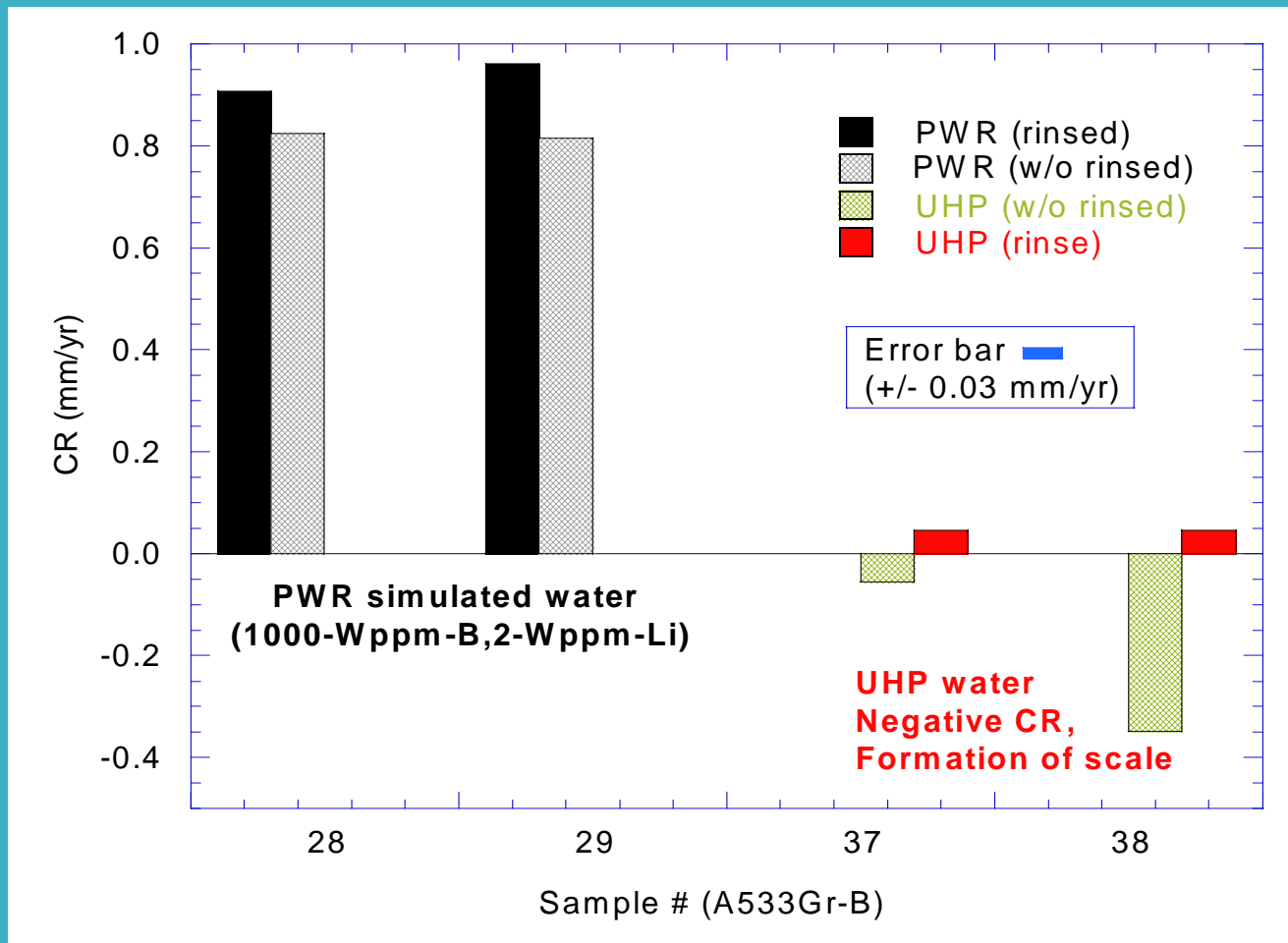


Note:  
Corrosion rates based  
on 311 & 411 h exposure



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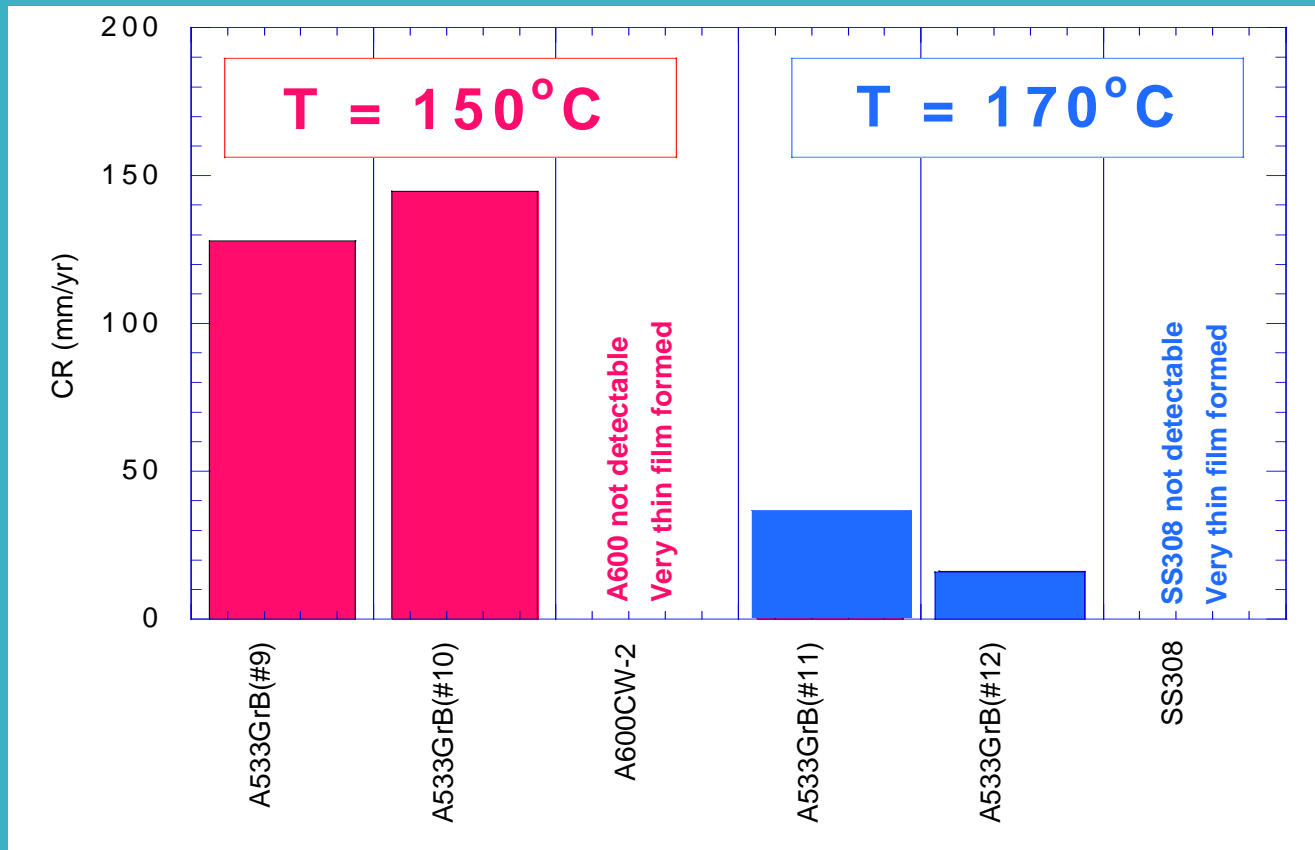
## CRs of A533Gr-B in oxygenated PWR & UHP @97.5°C

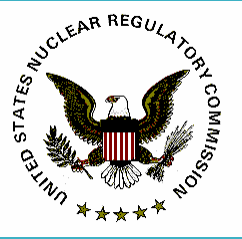




# United States Nuclear Regulatory Commission

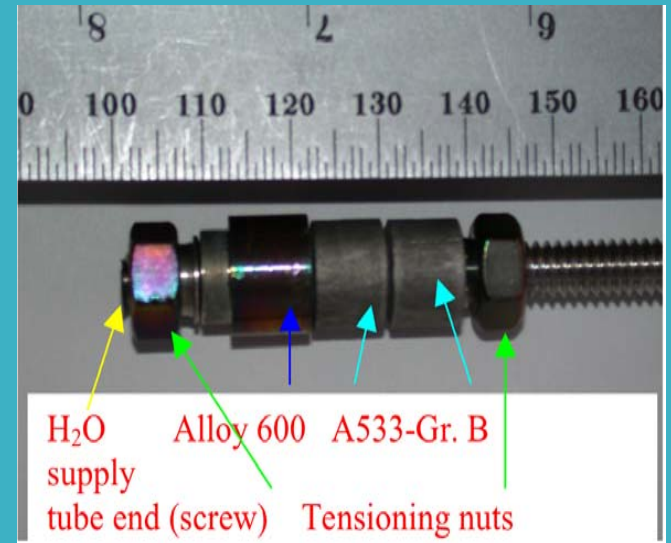
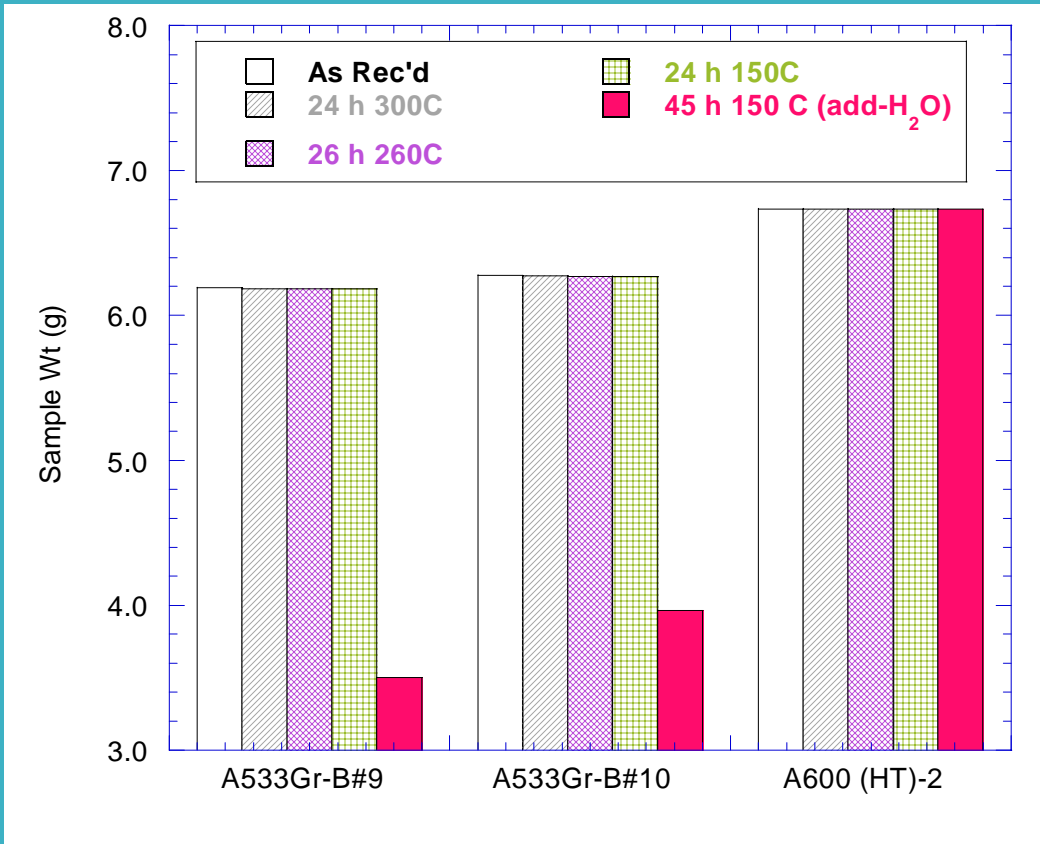
## A533-Gr. B, A 600, and SS 308 at 150°C & 170°C with H<sub>2</sub>O additions in molten H-B-O





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## Molten H-B-O wastage tests: A600 and A533-Gr. B with and without H<sub>2</sub>O additions

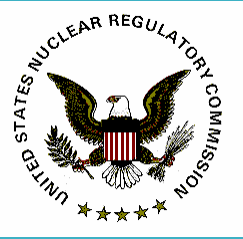




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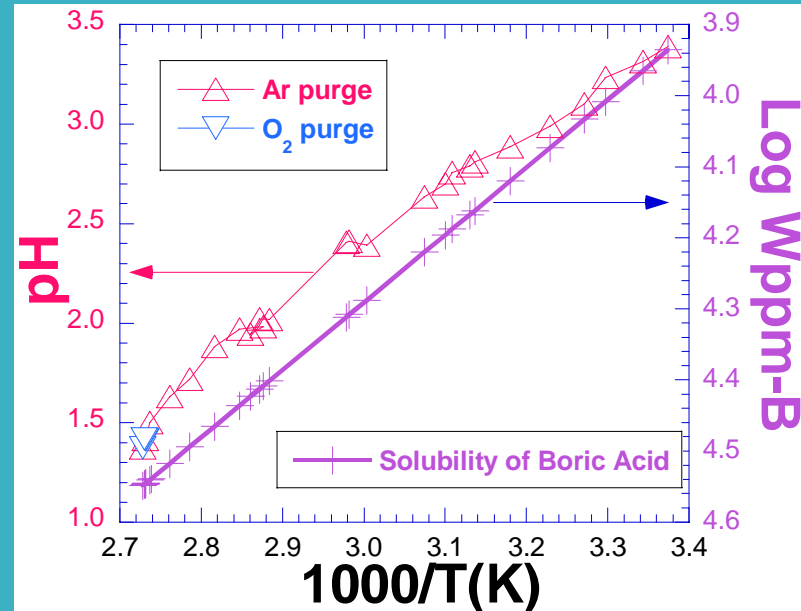
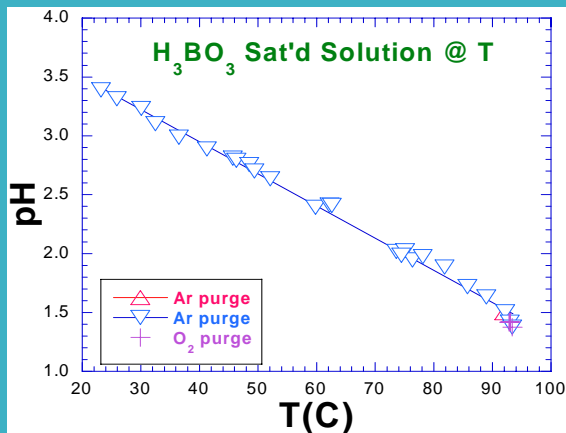
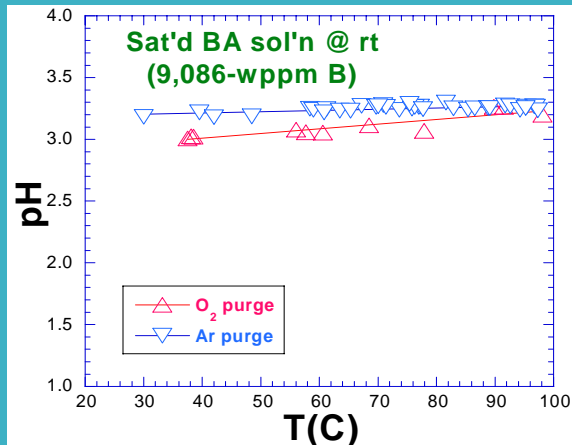
## Summary - (TASK #3)

- **Wastage tests for the A533Gr B in the BA solution at 97.5°C were completed.**
  - CR value of 2-in/yr in the saturated solution was highest
  - CRs shown to have a linear relationship with the concentration of BA
    - Note: CRs for A600 & SS308 were negligible when compared with those of A533Gr-B.
  
- **Wastage tests in the molten H-B-O at 150-290°C were performed.**
  - Without water addition, none of the metallic samples showed corrosion, except thin oxide scale formed on A600 & SS308.
  - With water addition, A533Gr B at 150°C showed the highest CR value, and higher the T the lower the CR.
  
- **Wastage tests in the Hi-T & P conditions - ongoing**

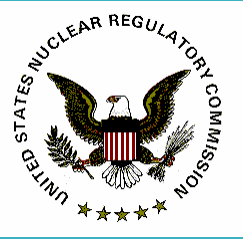


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## pH for BA & Sat'd BA (rt < T < 100°C)

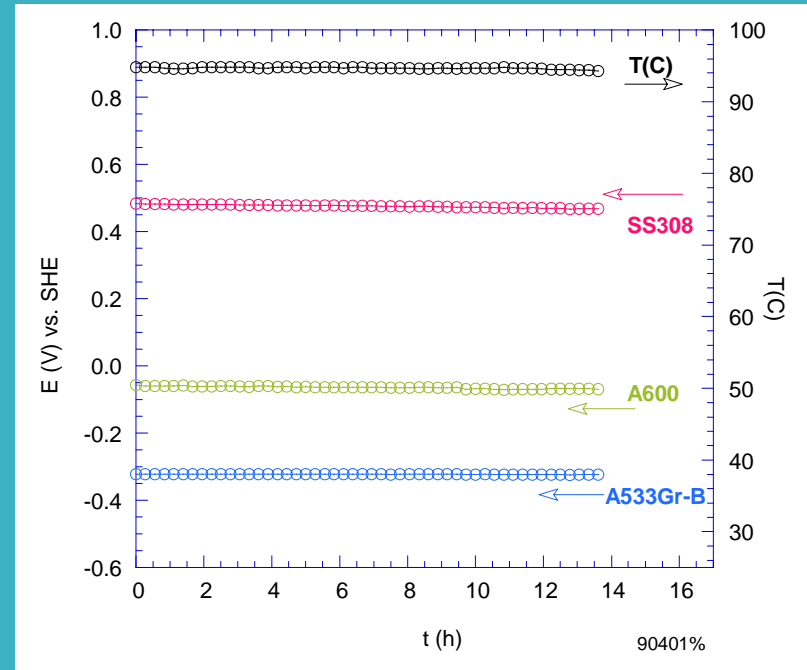
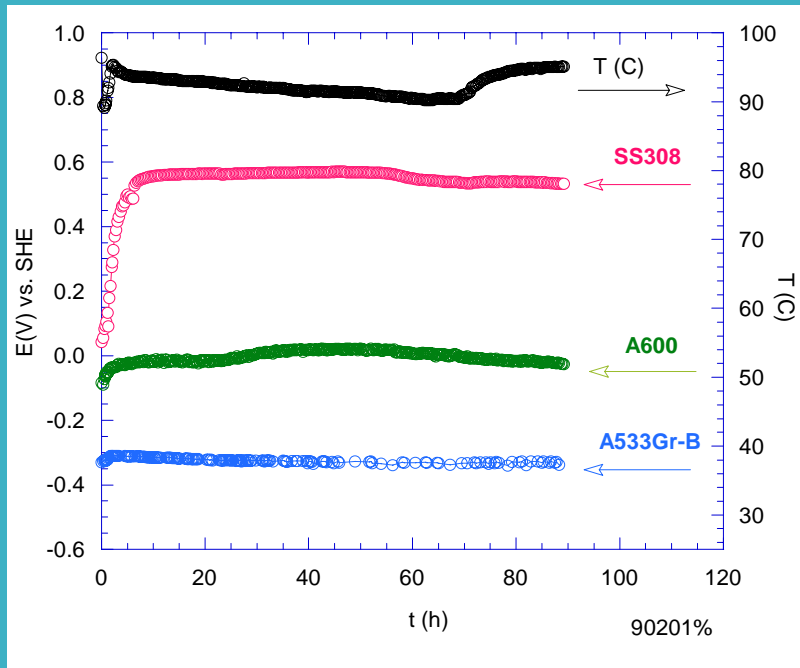






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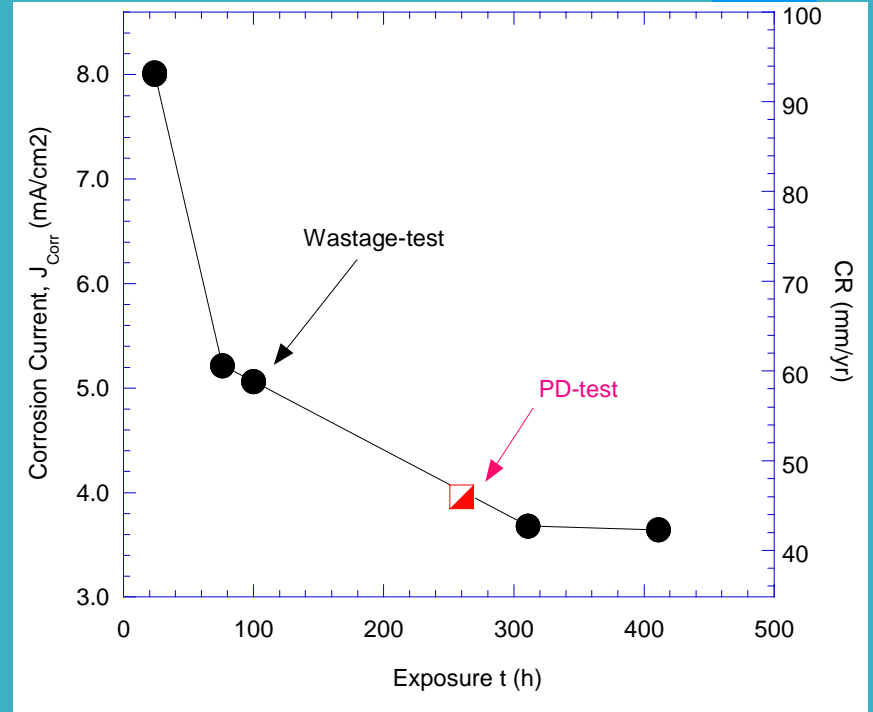
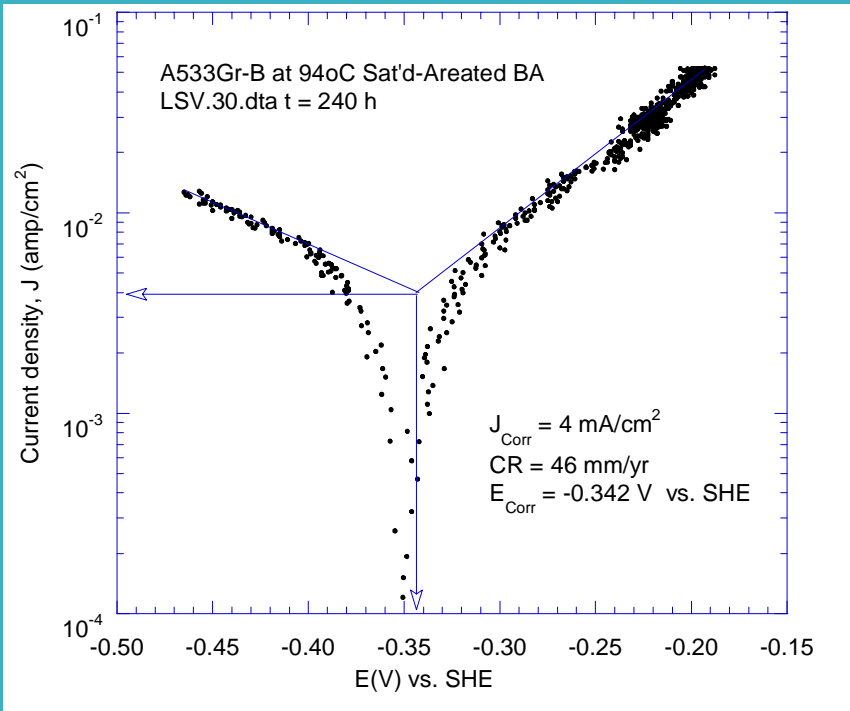
## E(V) vs. t in the Sat'd BA sol'n @97.5°C



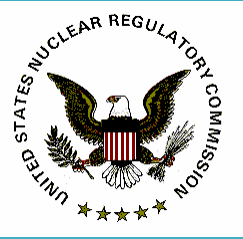


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## PD-test of A533Gr B in Sat'd BA solution at 97.5°C

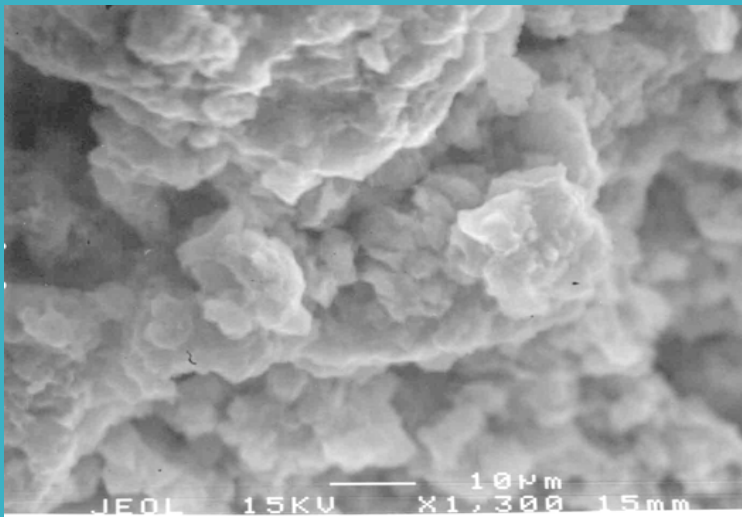


■ 42,000-ppm B (Sat'd BA)

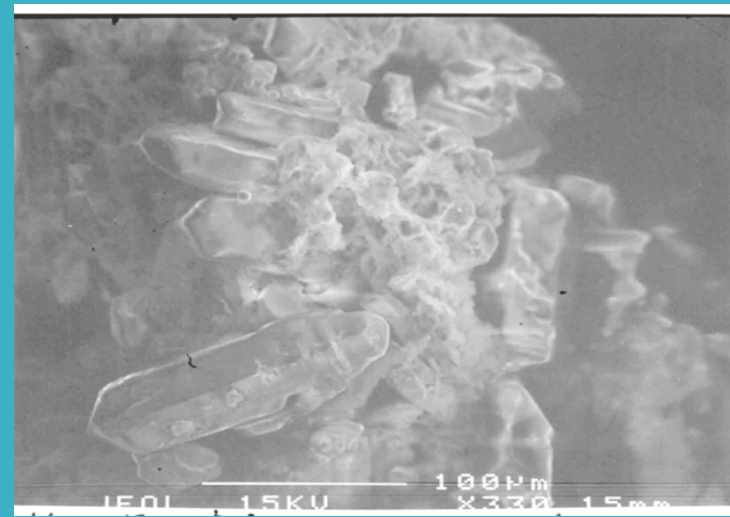


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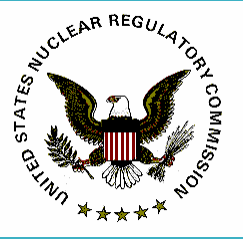
# Electrochemical Corrosion Products for the A533Gr B in Sat'd BA at 95°C



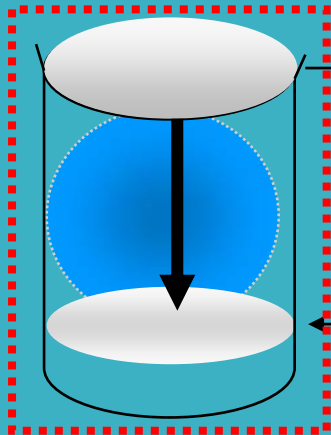
**Darker brown color precipitates bottom of the test chamber: X-ray analysis shows iron borate ( $\text{FeBO}_3$ )**



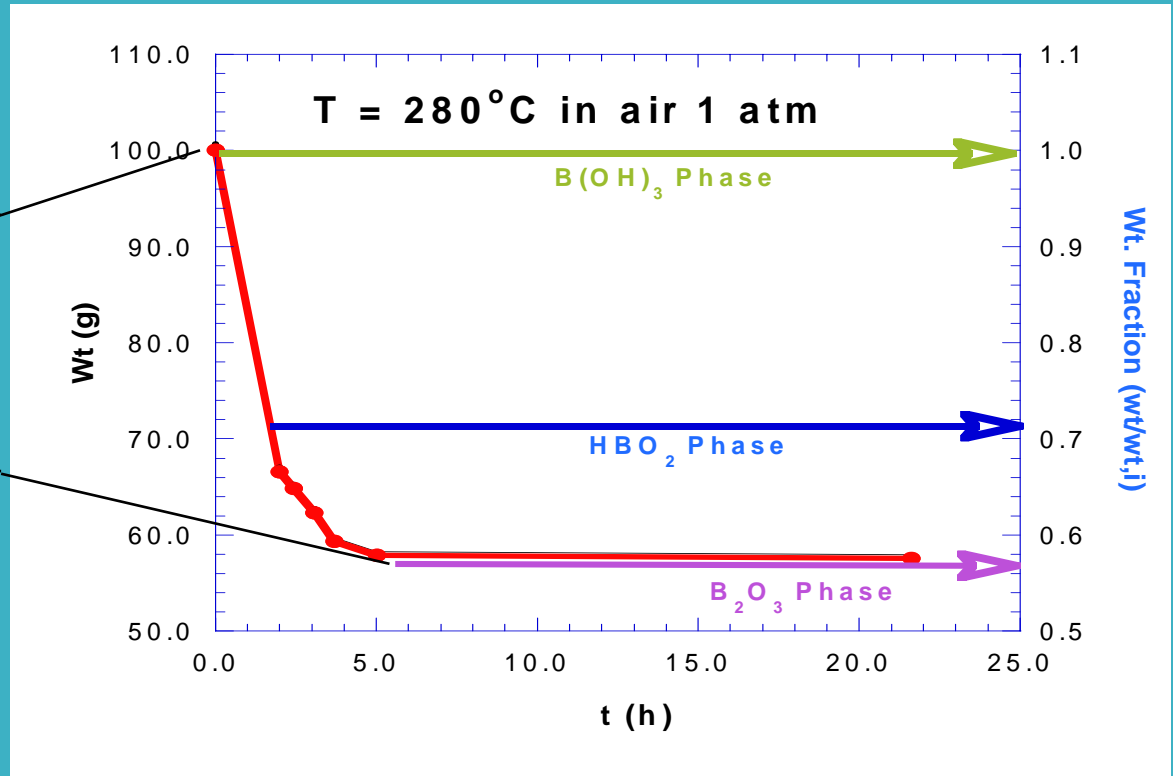
**Brown color slurry deposited around the A533B: X-ray diffraction shows boric acid ( $\text{H}_3\text{BO}_3$ )**



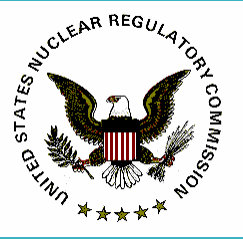
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Boric acid turned to snow-ball shape and then glass like transparent boric oxide



Note: 100-g Boric acid heated in air ( $p_{H_2O} = 3\%$ ) at 280°C



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## ECP for A533Gr-B, A600, SS308, and Pt in hydrogen covered UHP-water at 288 & 316°C

