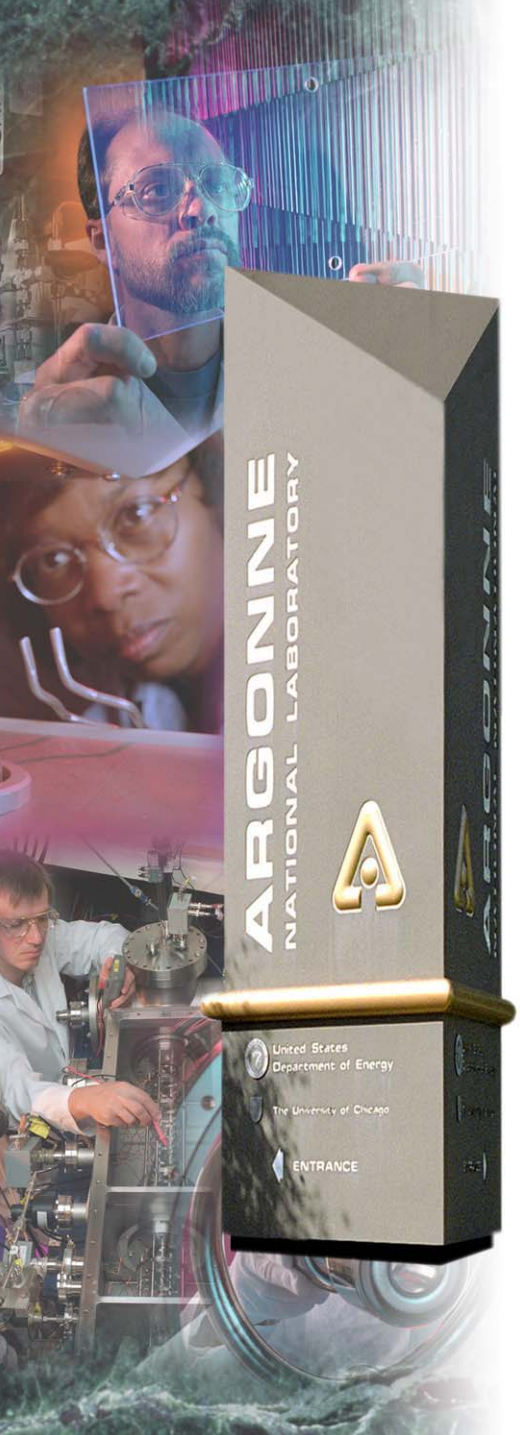


Degradation of RPV Boundary Components in Concentrated Boric Acid Solutions

Tasks 3:

Corrosion of Reactor Steels in Concentrated Boric Acid Solutions

BAC testing kickoff meeting for NRC Y6722 program on October 29-30, 2003

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

Project Goals

Corrosion Tests

1. Ambient environment, 1 atm & T= 100°C BA solutions
2. Molten H-B-O conditions
3. High T(100 to 316°C) and P(1,300-1,800 psi)

Determine the wastage rates:

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

- Flowing & quiescent O-bearing BA solutions
- T = 100-316ºC (212-600ºF)
- PWR (1000-wppm B + 2-wppm Li)
- 3500-wppm B + 2-wppm Li
- Higher concentration be decided base on above

Milestones on BA solution Test (TASK #3)

- **Establish Test Equipment based on the results of Task#4**

- **<u>Wastage tests</u>:**
  A533Gr B and Type 308 SS weld under the following conditions.
  I. Hi-T & P
  288°C, 1300 psi and 316°C, 1800 psi
  3500 wppm-B and a higher value TBD
  II. Hi-T molten solution (235-316°C)
  III. Low T (97.5°C) sat'd BA solutions

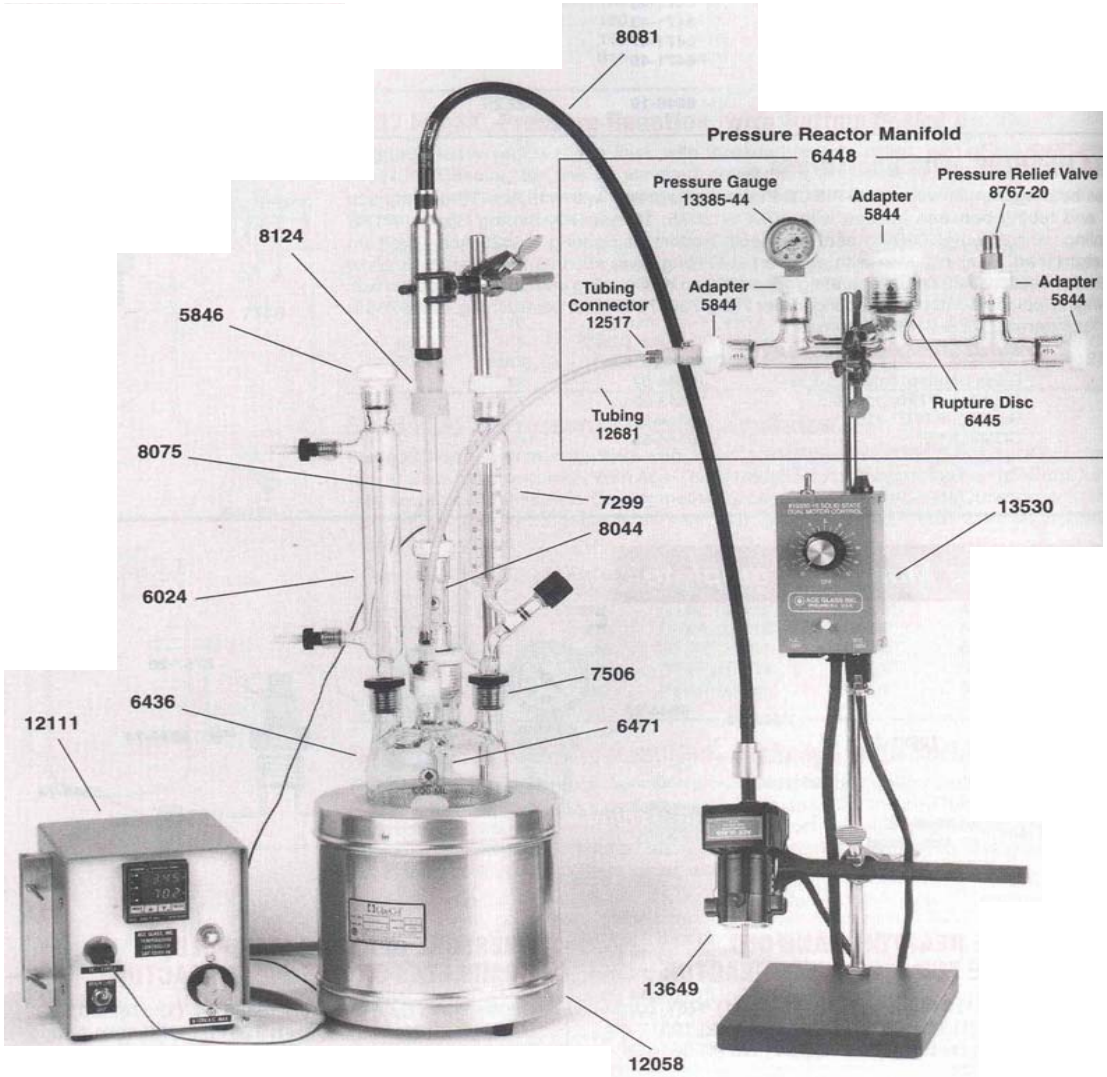
Team/Resources

- **BAD-Team members (Monthly meeting)**

  K. Natesan, O. K. Chopra, R. Clark, E. Listwan,
  J.-H. Park, W. Shack, and W. Soppet

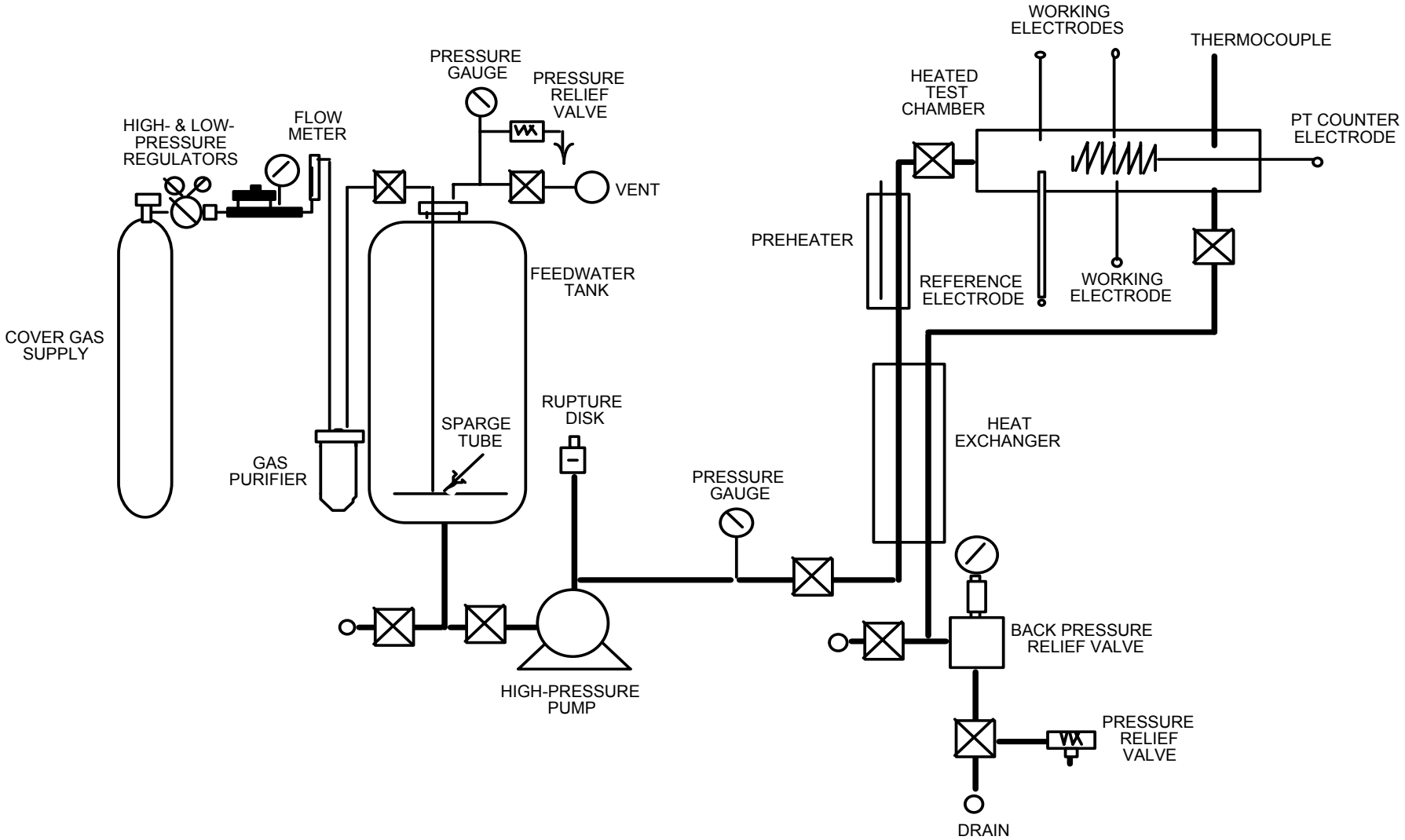
- **Resources allocated to this project**
  - Equipment purchased from Ace Glass and,
  - Installed/assembled ANL ET(212) G-137
  - Samples fabricated by ANL Central Shop (212 and 372)
  - X-ray crystallography by ANL Anal. Lab (205)
  - Bulk chem. analysis by Conam Kawin Inc., Glendale Hts, IL

Measurement of Wastage for A533Gr B @ 97.5°C

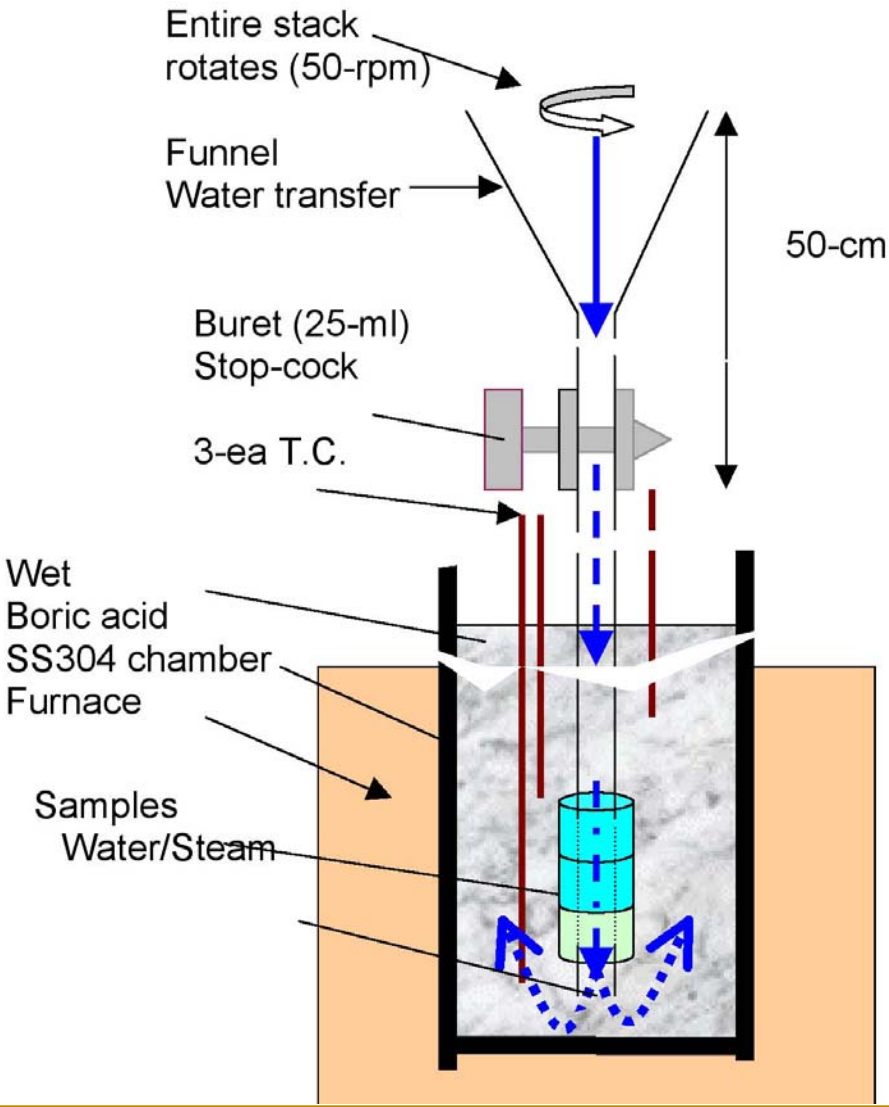


Pioneering Science and Technology

Corrosion tests facility in High–T & P of BA solutions at T up to 316°C



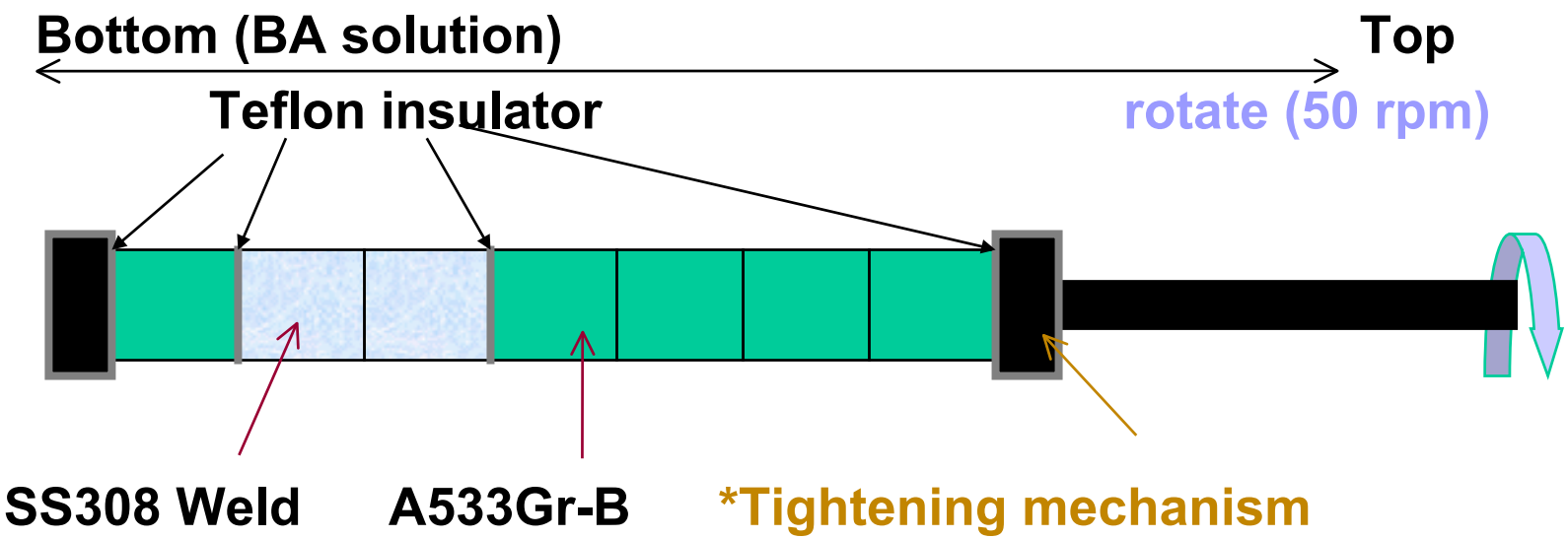
Wastage test apparatus for the molten system



Wastage test sample assembly in solution

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

plug shape



***Stack inside leak-tight filled with rubber tube between shaft**

Analysis

Corrosion rates

- Dimension measurement
- Wt. measurement

Microstructure/phase(s)

- Surface and cross section
- SEM/OM
- X-ray crystallography

Thermodynamic evaluation

- Based on the above results

Procedures

1. **Wastage test in saturated BA at 97.5°C (completed):**

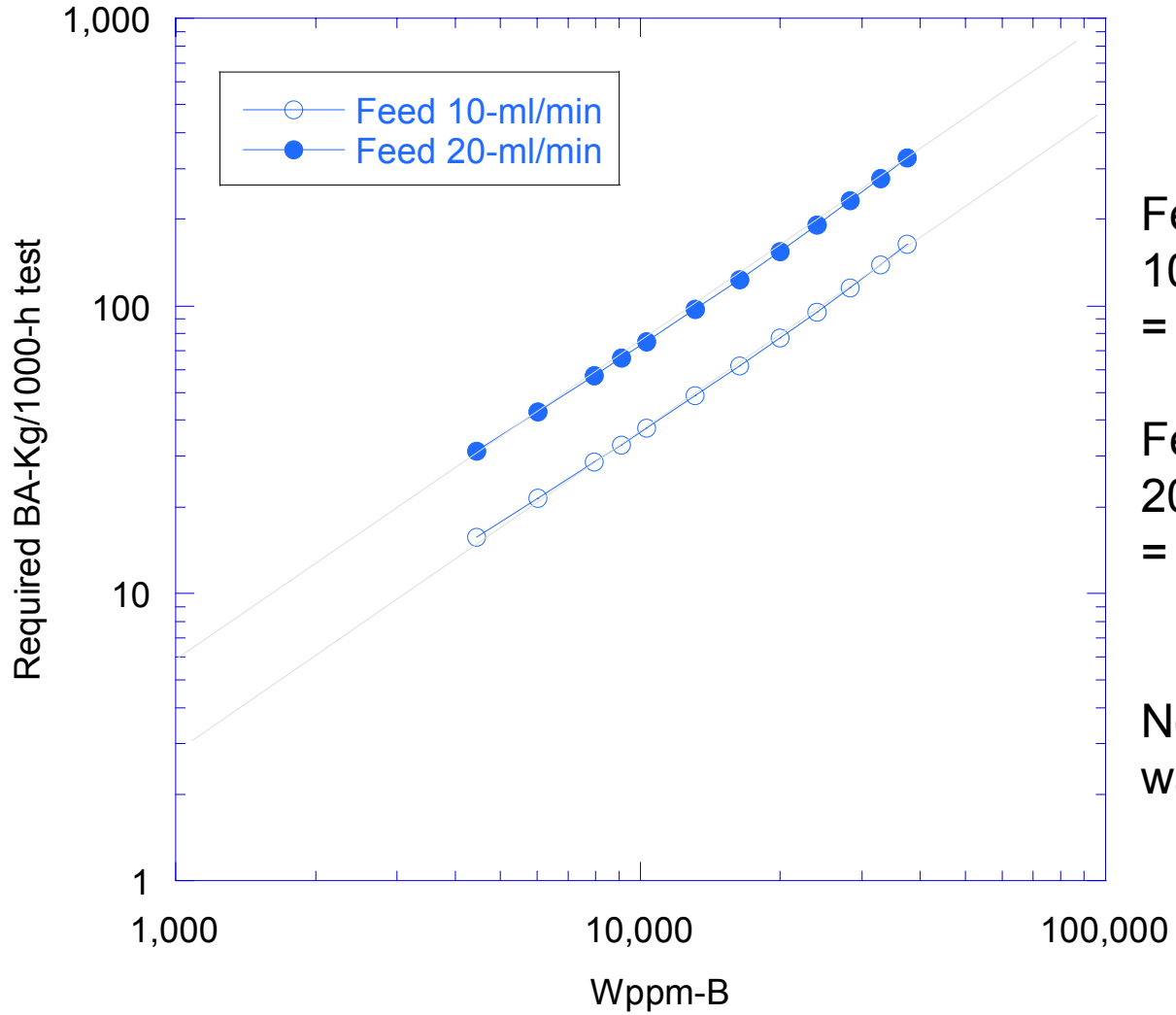
- Sample stack to be exposed and rotated.
- Samples to be taken out one by one at scheduled time, t = 24h, 76h, 100h, 311h, 411h.

2. **Wastage test at 288 & 316°C (in progress):**

2-1) Test at 288°C, 1300 psi, 1,000 h
BA(1) 3,500-wppm-B
BA(2) Higher value TBD

2-2) Test at 316°C, 1800 psi, 1,000 h
BA(1) 3,500-wppm-B
BA(2) Higher value TBD

Amount of Boric Acid for the 1000-h tests?

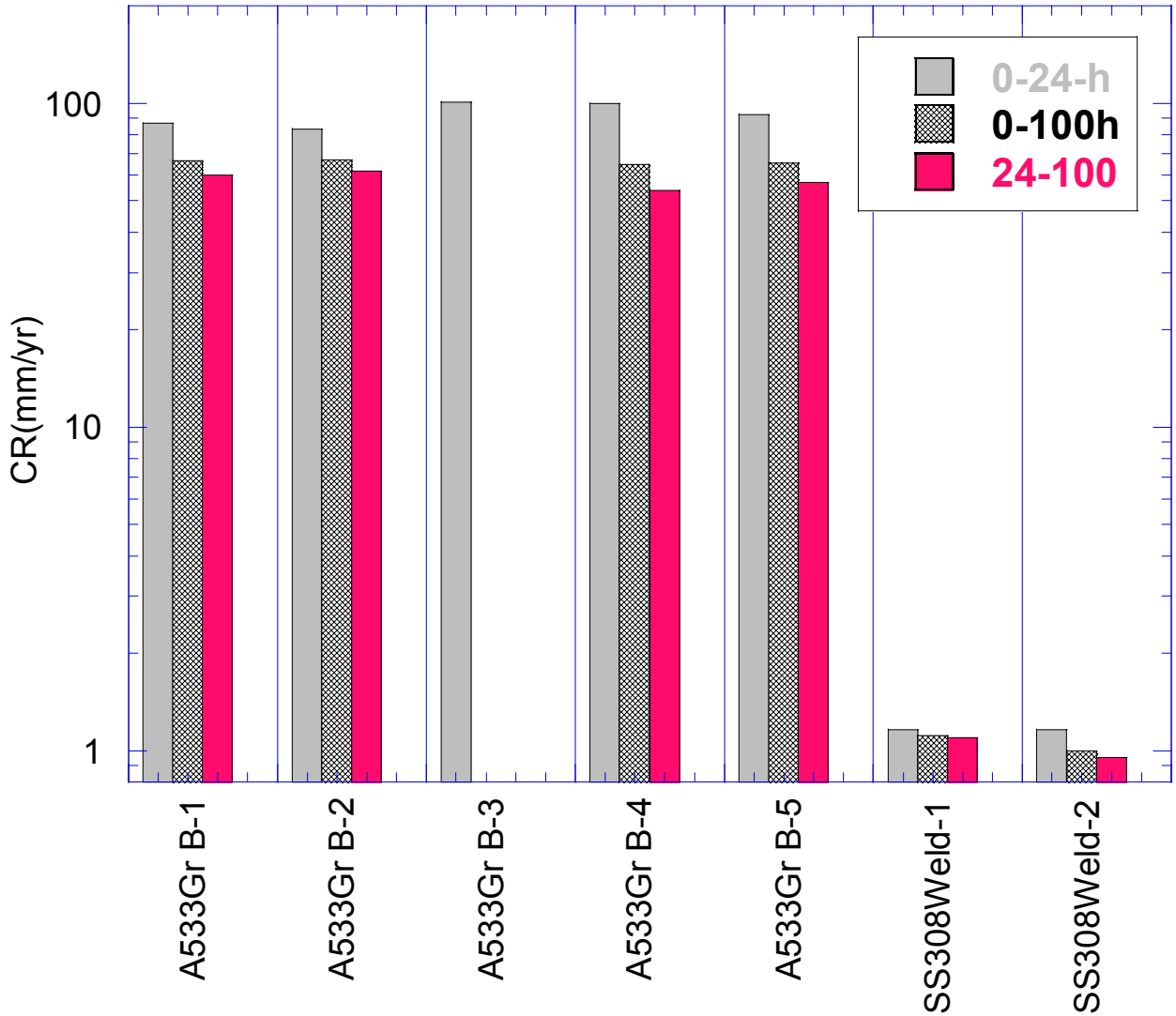


Feed 10-ml/min:
10-ml/min * 60*1000min
= 600-liters solution

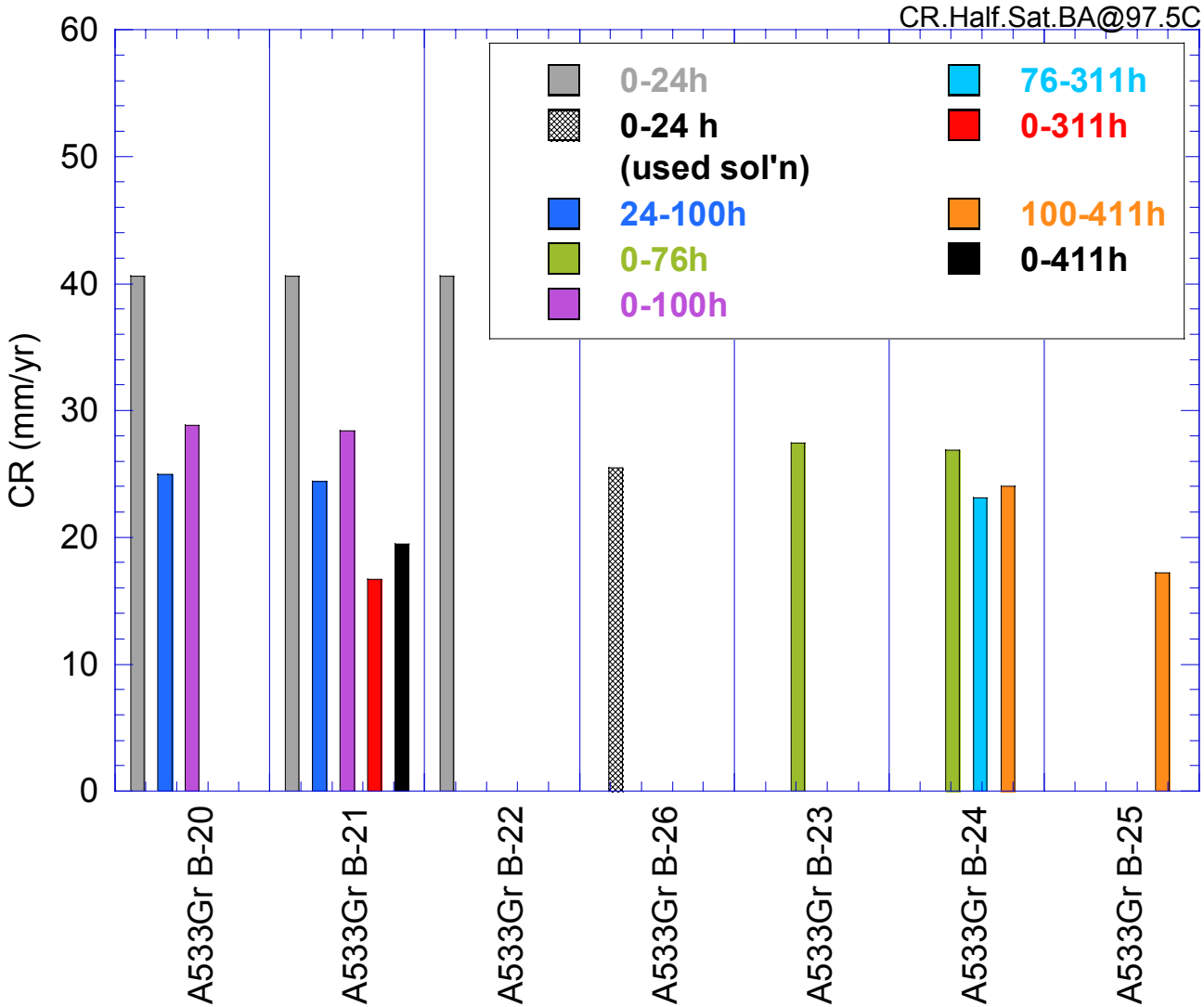
Feed 20-ml/min:
20-ml/min * 60*1000min
= 1200-liters solution

Note: normal
water tank 130 liter

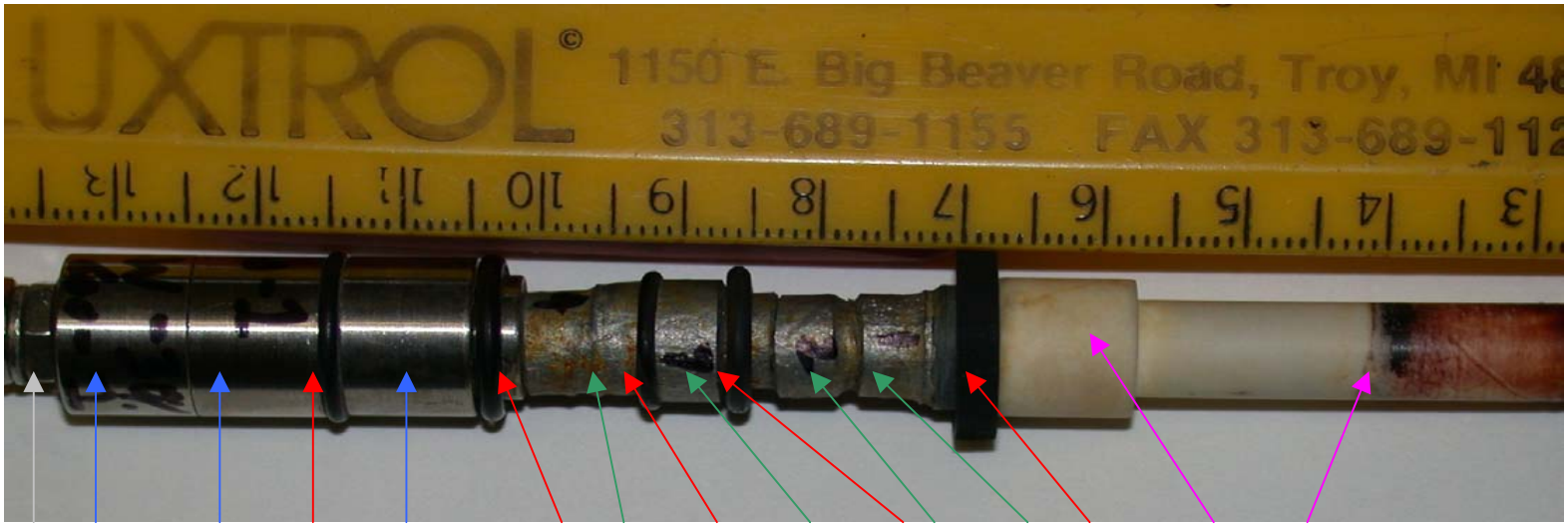
CR for A533-Gr. B & SS 308 in sat'd BA sol'n (40,514 wppm-B) at 97.5ºC



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



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



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

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

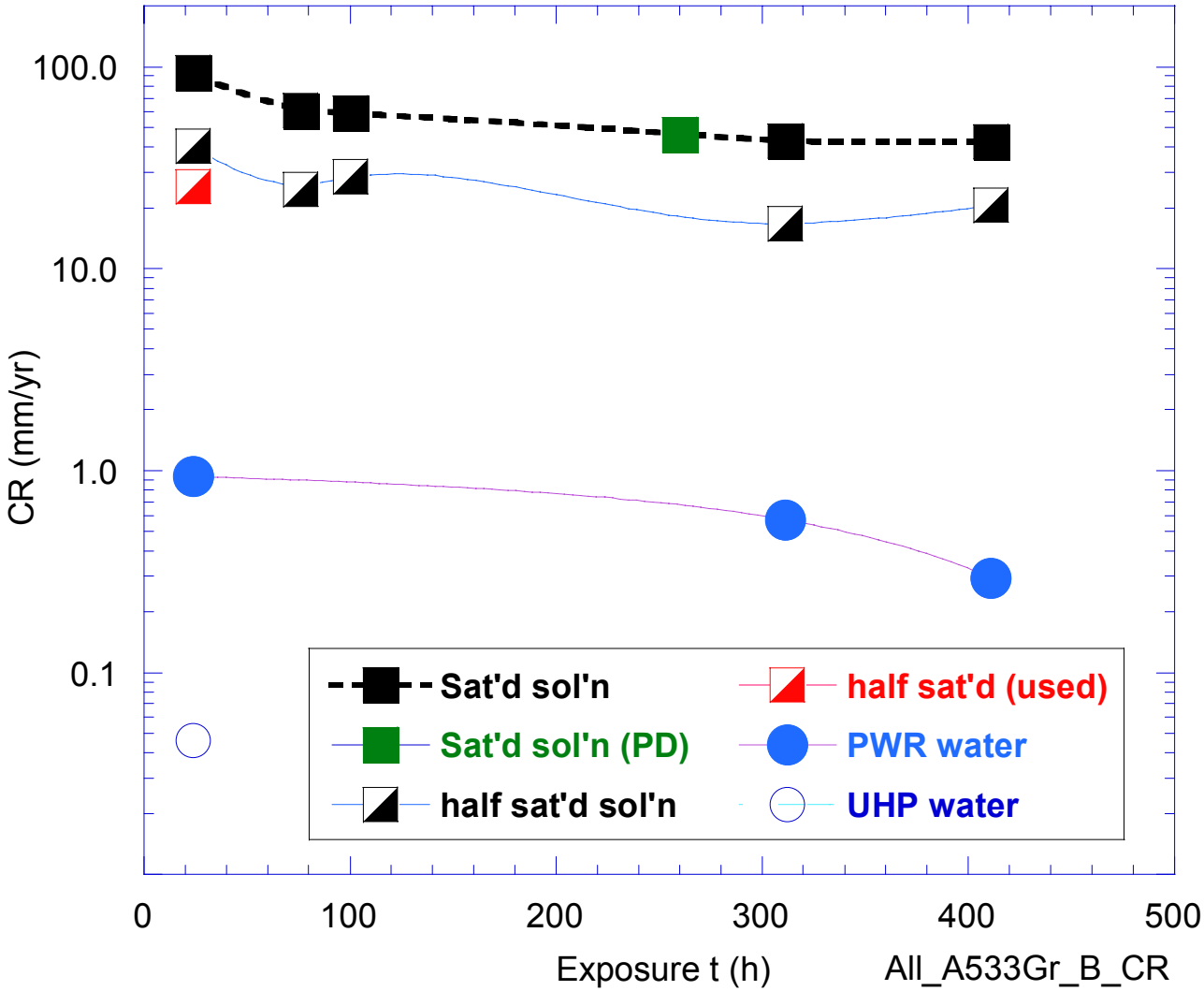
B: A600 (30%CW), C: A600-1, E: SS308 clad weld

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

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

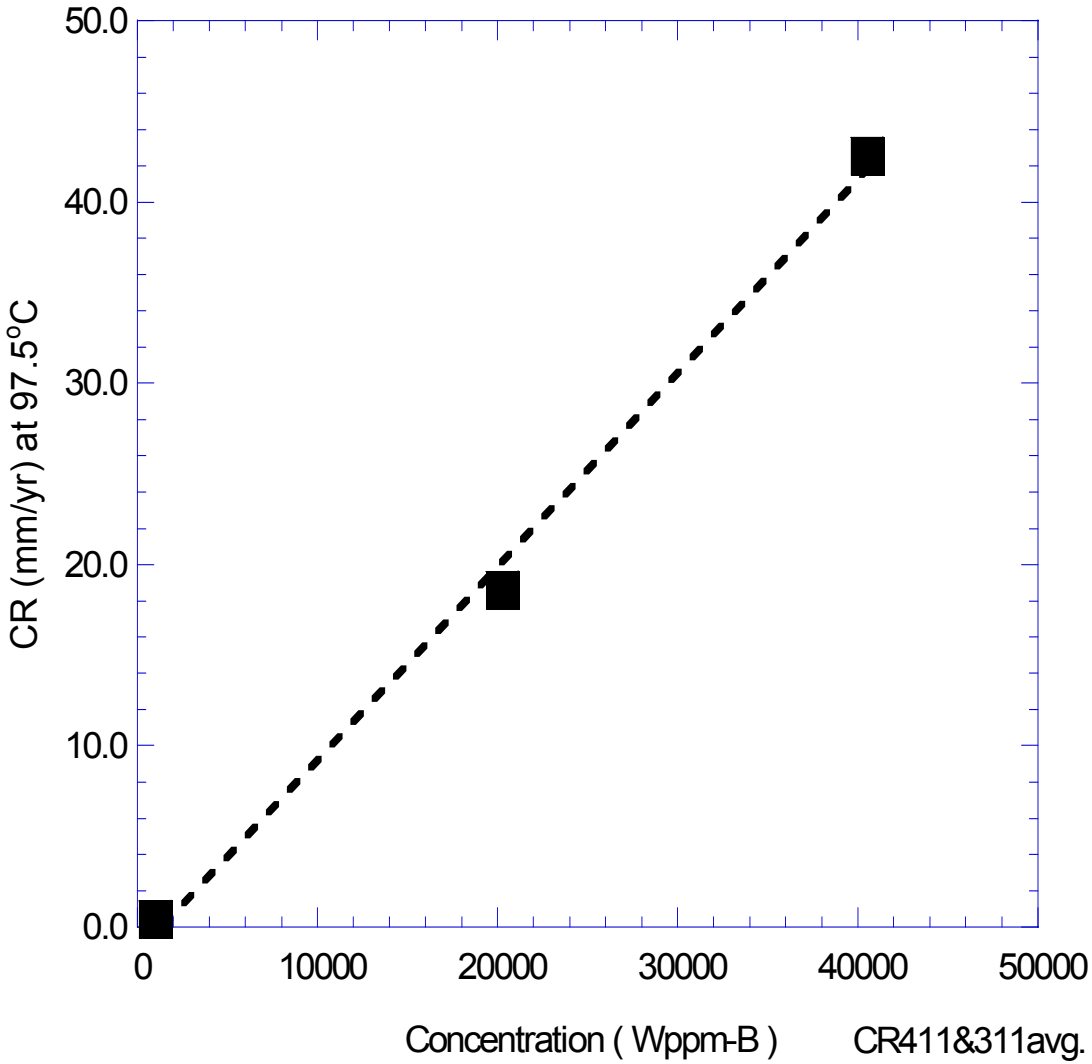
N & O: Alumina (N, in the sol'n & O, interface solution/vapor)

Corrosion Rates of A533Gr-B in various BA solutions at 97.5ºC



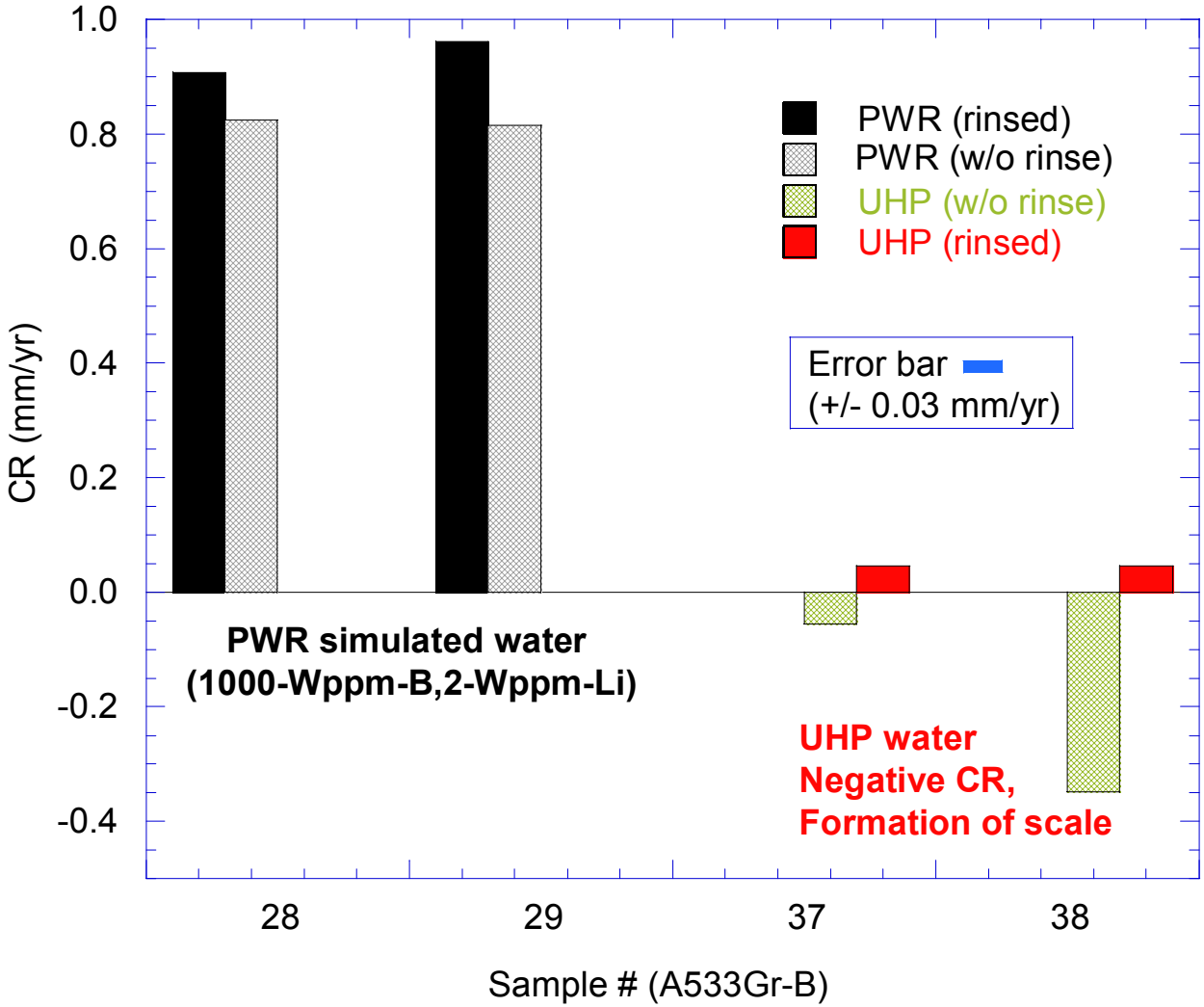
Note:
CR determined times between 24 and 411 h.

Corrosion Rates vs. Wppm-B for A533Gr-B in BA solutions at 97.5ºC

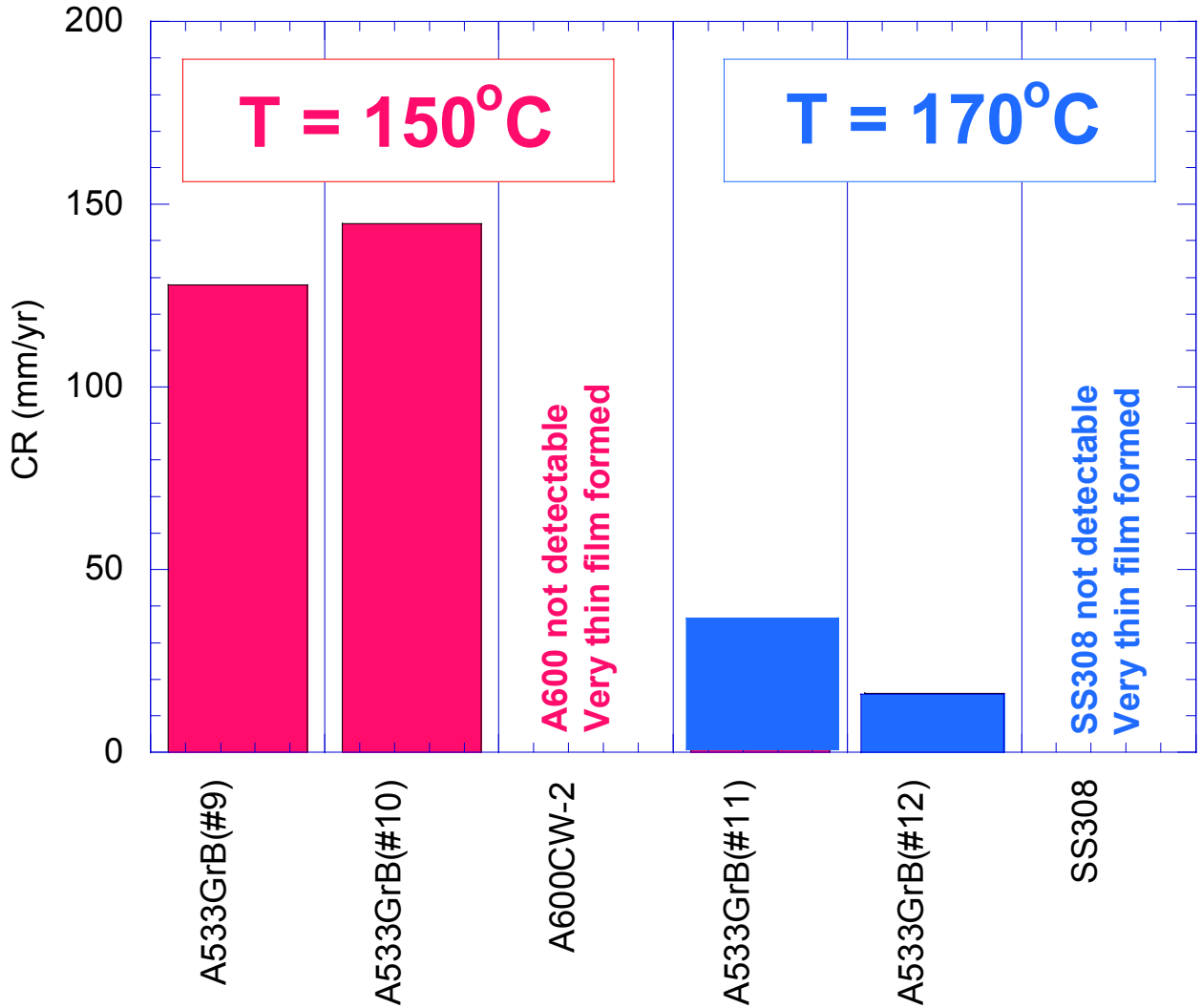


Note:
Corrosion rates based on 311 & 411 h exposure

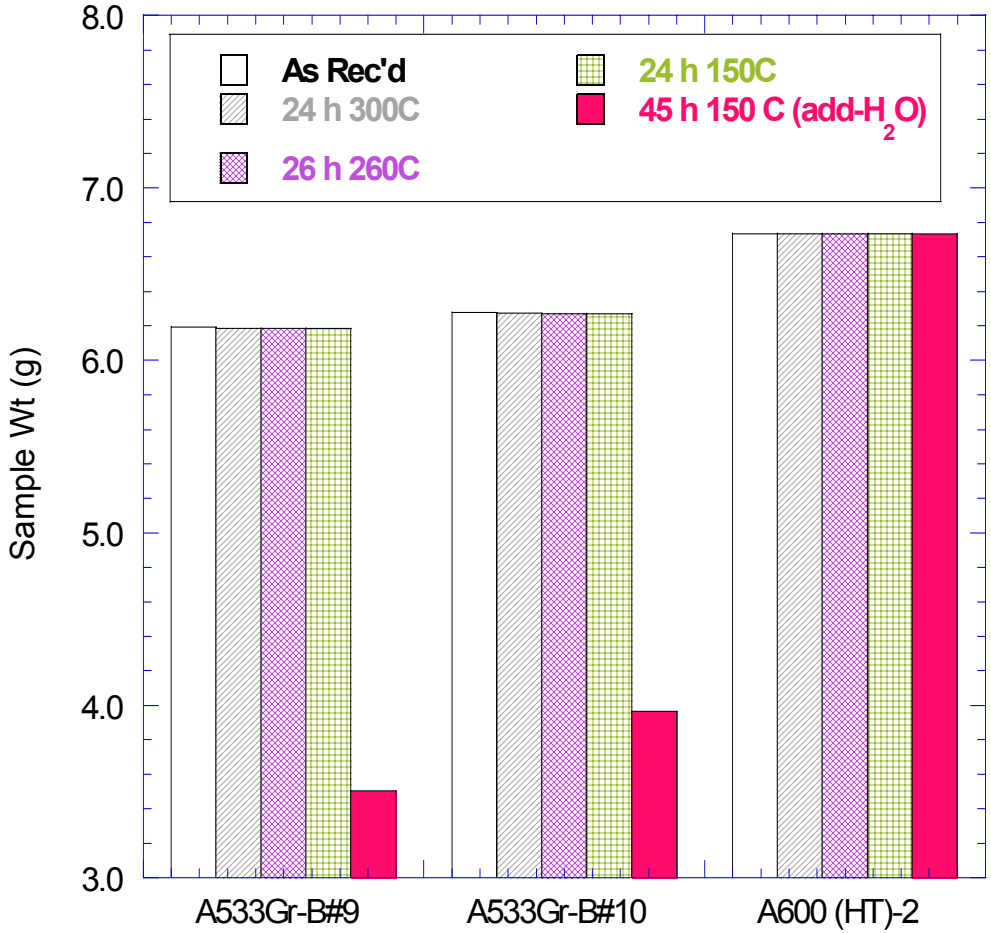
CRs of A533Gr-B in PWR & UHP-waters @97.5ºC

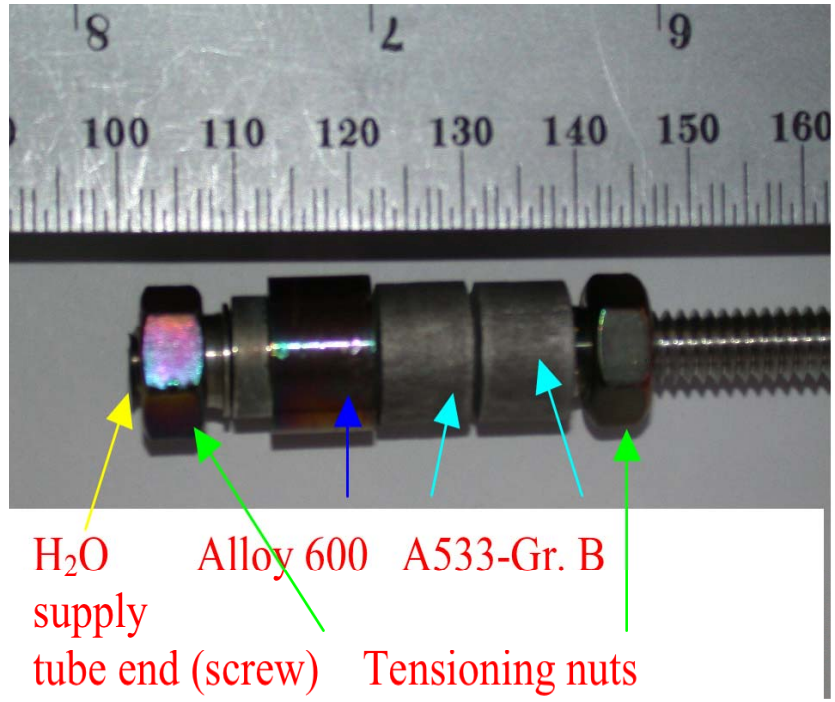


CR: A533-Gr. B, A 600, and SS 308 at 150°C &170ºC with H_2O additions in molten H-B-O.

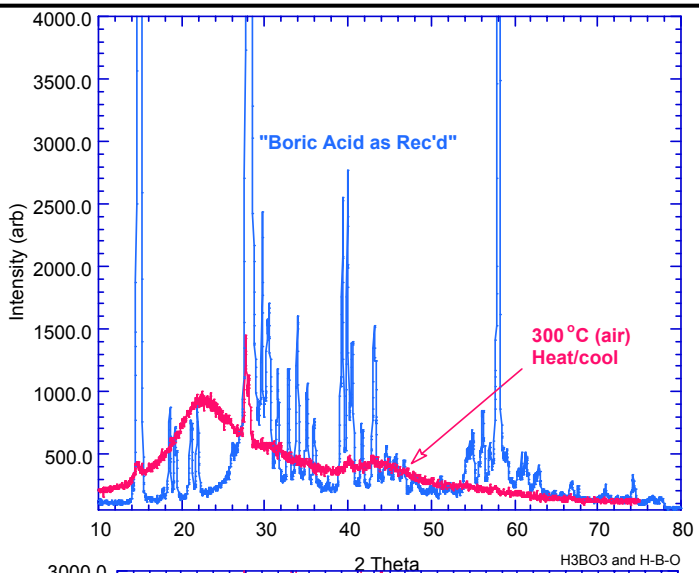


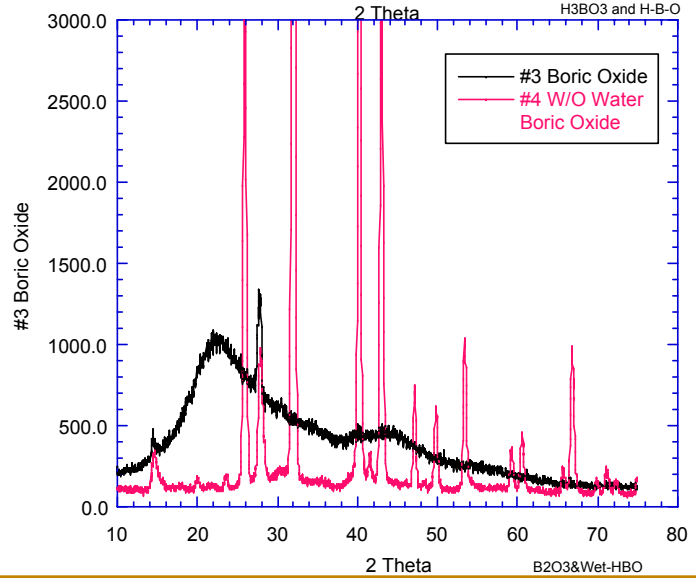
Molten H-B-O wastage tests: A600 and A533-Gr. B with and without H_2O additions

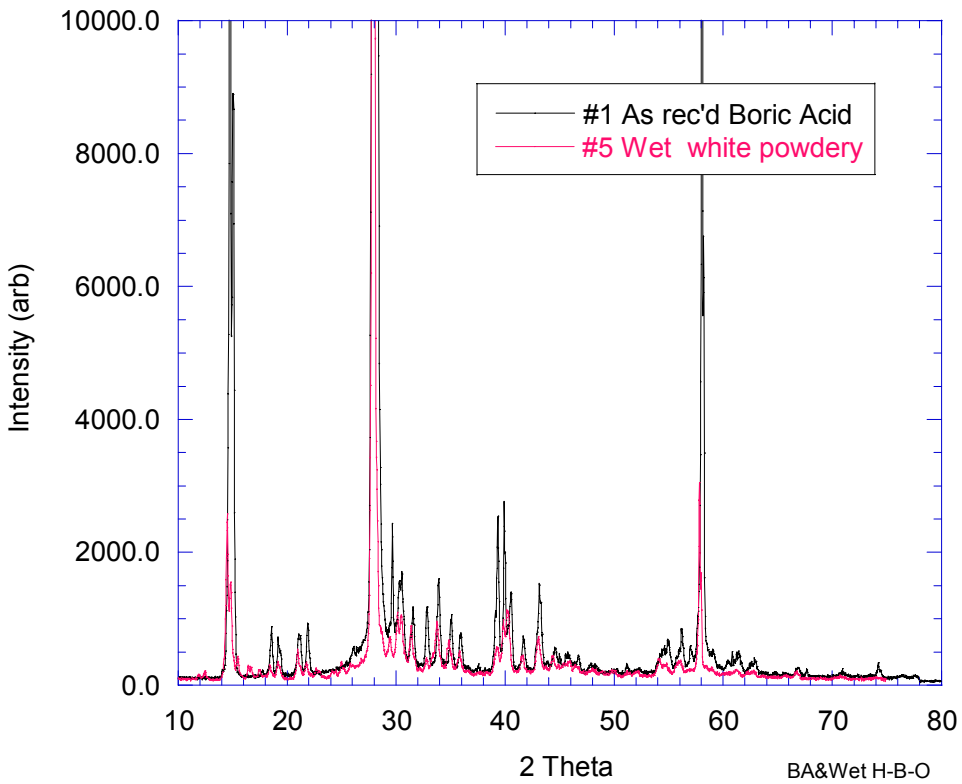




X-ray spectrum for $B(OH)_3 \leftrightarrow HBO_2 \leftrightarrow B_2O_3$







Transformed by T & H_2O

$B(OH)_3 \leftrightarrow HBO_2 \leftrightarrow B_2O_3$

Summary *(TASK #3)*

- **Wastage tests for the A533Gr B in the BA solution at 97.5ºC were completed.**

  -CR value of 2-in/yr in the saturated solution was highest
  -CRs were shown 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 150-290ºC 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 150ºC showed the highest CR value, and higher the T the lower the CR.

- **Wastage tests in the Hi-T & P conditions to be conducted based on the scoping work from the Task#4**