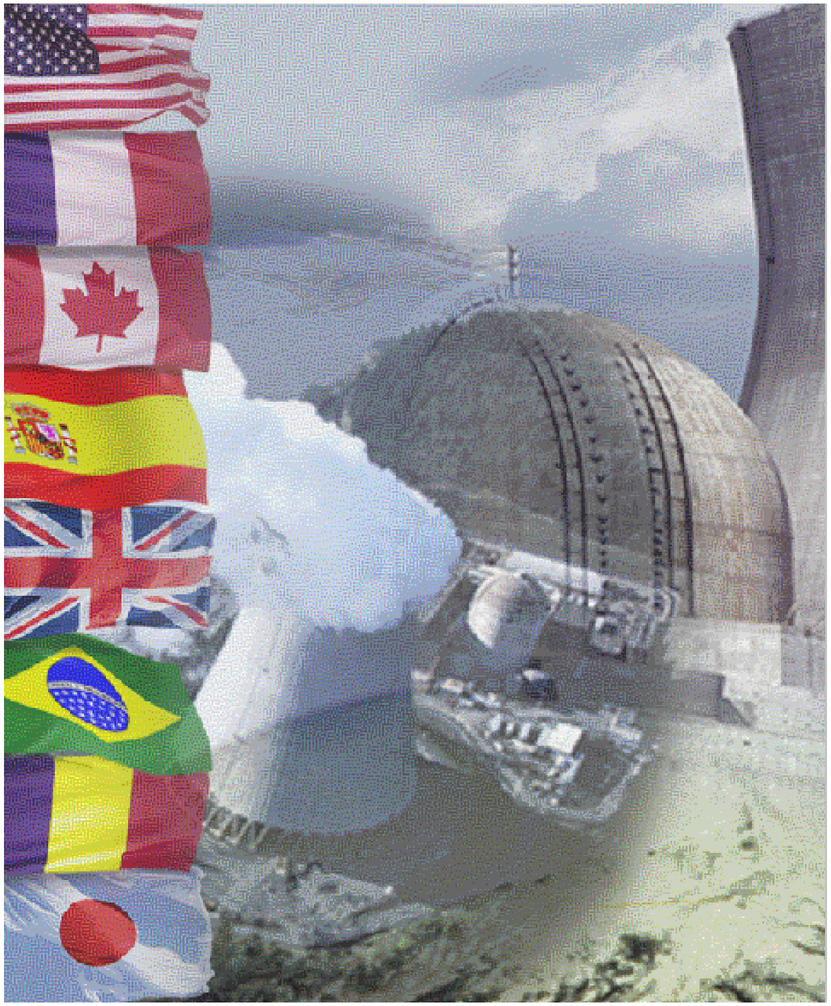

EPRI MRP Boric Acid Corrosion (BAC) Program

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Introduction to BAC Testing

- Assessments done to date implicate boric acid as a major factor in the corrosion but point to a dichotomy of involved mechanisms.
  - An assessment of the chemistry developed in an annulus at low leak rates, i.e. MRP 55, suggests an alkaline pH, while that provided in MRP 75 with regard to extensive wastage, i.e. a “top-down” mechanism, assumes an acid pH. Test data is needed to quantify the relative effects of the pH regime.
  - BAC wastage mechanism may vary with time following initiation of a leak into the CRDM annulus. Data is needed to quantify duration and the rate of corrosion during various phases of wastage.
- Existing data in the EPRI *Boric Acid Corrosion Guidebook, Revision 1* provides some test data necessary to understand the progression of boric acid corrosion at Davis-Besse.
  - However, the previous BAC testing did not consider factors such as:
    - the key transition from a leak into a tight annulus to a more substantial leak into a larger cavity
    - corrosion rates for hydrated molten boric acid.

BAC Review Panel

- Convened an independent panel to review the wastage model documented in MRP-75.
- Key Comments from Panel
  - Visual inspection is the most efficient method of detecting boric acid and therefore leaks around the primary pressure boundary;
  - Leak rate is governed by crack characteristics but the paucity of data makes the numerical dependence somewhat dubious;
  - The situation of cavities developing from adjacent cracked nozzles, approaching each other and possibly merging, should be addressed;
  - The methodology of MRP-75 is reasonable; however, further testing to resolve several uncertainties is recommended.

BAC Review Panel (cont'd)

- Key Comments from panel (cont'd)
  - The potentially erosive nature of a steam-water leak could induce bottom-up cavity formation
  - Flow-assisted/erosion corrosion is likely to have played a major role in the wastage at Davis Besse
  - The methodology of the probability analysis in MRP-75 seems sound; however, it is recommended that more conservative wastage rate be evaluated to study flow effects at given leak rates.

Significant Technical Areas Lacking Data

- Chemistry of the leaking annulus environment including the rate of dehydration, pH, ECP, and conductivity as a function of temperature, pressure, and the concentrations of boron and lithium in the flow entering the annulus
- Properties and corrosivity of molten boric acid with a range of moisture contents
- Galvanic and crevice corrosion behavior of low alloy steel (anode) coupled to Alloy 600 (cathode) in a concentrated boric acid environment—these mechanisms could lead to significant corrosion in deaerated (low oxygen) annulus environments
- Role of galvanic corrosion, crevice corrosion, extent of cooling, and liquid location in development of large cavity
  - Contribution of flow-assisted and/or impingement corrosion

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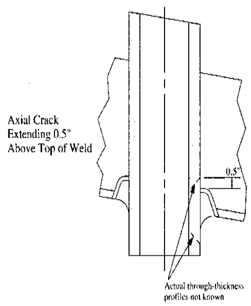
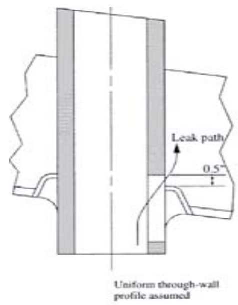
BAC TASKS



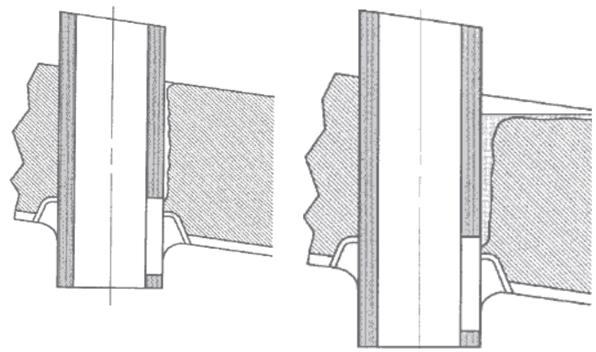
Task1

Stagnant/Low Flow



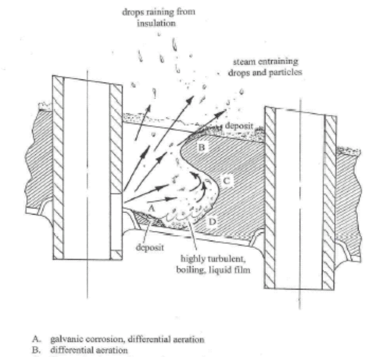
Task 2

Flowing/Impingment



Task 3

Single Effects Tests



Task 4

Full-Scale Mockup

•Task 1: Perform corrosion test in stagnant and low flowing (<0.005 gpm) primary water simulating early stages of CRDM penetration degradation

•Task 2: Perform corrosion test in flowing primary water and measure the real time corrosion rate and ECP under laminar and impact flow.

•Task 3: Testing should focus on a matrix of laboratory immersion corrosion, autoclave chemistry, and electrochemical polarization curve tests for concentrated boric acid and wetted molten boric acid environments.

•Task 4: Testing will involve a matrix of full-scale mockup tests for CRDM nozzles. The main purpose of this phase of testing will be to understand the synergies of the separate effects tested in Phases 1, 2, and 3.

Summary of Proposals

- 12 RFP’s Sent out
- 8 Proposals Submitted
  - 4 proposals addressed Task 1 Low Flow Corrosion
  - 4 proposals addressed Task 2 High Flow Corrosion
  - 6 proposals addressed Task 3 Single Affects Testing
  - 5 proposals addressed Task 4 Mock up Testing: 4 were physical testing and 1 was computer modeling. Most proposal utilized input from previous tasks in design of mockup tests.

Task 1 Low Flow Corrosion

Corrosion Studies Using A Crevice Device

- BOL & EOL chemistry
- Real-time Monitoring of ECP, pH, and ECN.
- W/WO galvanic corrosion
- 100, 150, 250, and 330 C
- 25 cc/kg H and air sat.
- 1 year

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Task 2 High Flow

- Loop Tests
- Perpendicular jet impacting
- Rectangular coupons
- 18 runs; each 1 wk
- pH 6.9, 7.15 and 7.4 primary water
- Electrical Resistivity and ECP monitoring
- Profile, metallography, SEM, EDX, and Auger characterization

Task 3 Single Effects

- Autoclave Corrosion Tests
  - Monitoring of pH, conductivity, and ECP
  - Bare metal, crevices, and galvanic couples
  - 0 – 100% boric acid
  - Wt. loss and microscopic evaluations
  - 1 year of testing

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Task 4 Full-Scale Mockup Testing

- Full size CRDM
- Design team collaboration
- HIP'd EDM slit .25, .75. And 1.23" long
- 550-600 F
- Use Existing BAC test facility
- A range of fits
- Leak rates from .0001 to .3 gpm
- UT monitoring of wastage during test
- Leak rate vs Crack Geometry
- Extent of cooling
- Sensitivity of visual inspection

Schedule of BAC Test Program

- Proposal received at EPRI April 23, 2003
- Initiate contracting: June 15, 2003.
- Tasks 1-3: scheduled for 1 year to 18 months
- Task 4: scheduled for 30 months