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Boraflex, Carborundum and BORAL® Degradation Impact on Criticality

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Overview

- Boraflex, Carborundum & BORAL®
  - Degradation
  - Impact on criticality

- Future use of these poison materials

Boraflex – Degradation Background

- Boraflex is a silicon rubber polymer with boron carbide filler
- Degradation effects
  - Initial irradiation degradation
    - Hardening, shrinkage, loss of elasticity
  - Continued irradiation degradation (>10^{10} Rads)
    - Amorphous silica
  - Exposed to aqueous environment
    - Subject to dissolution
    - Amount of degradation dependent on:
      - Accumulated dose
      - Temperature
      - Rate of water exchange

Boraflex – Degradation Impact on Criticality

- Shrinkage
  - Small reactivity effect
    - < .005 Δk for end effects
    - ~0.02-0.04 Δk for worst case gaps
  - Accounted for in criticality analysis
- Dissolution
  - Large reactivity effect
    - Can significantly alter storage configuration patterns
  - Modeled by reduced B-10 density

Carborundum – Degradation Background

- Carborundum is a resin containing boron carbide
  - 2 types: plate and sheet
- Degradation effects
  - Very little research done on Carborundum by EPRI
    - Qualification testing
      - Mechanical strength decreases with irradiation and immersion
      - Weight loss and change in volume
        - Indicates formation of porosity
    - In-service
      - Mechanisms not well understood

Carborundum – Degradation Impact on Criticality

- Plate
  - 1 plant observed large B-10 loss
  - Revised criticality analysis for no poison credit
- Sheet
  - Monitor weight loss (corresponds to B-10 loss)
    - Assumed B-10 loss accounted for in criticality analysis

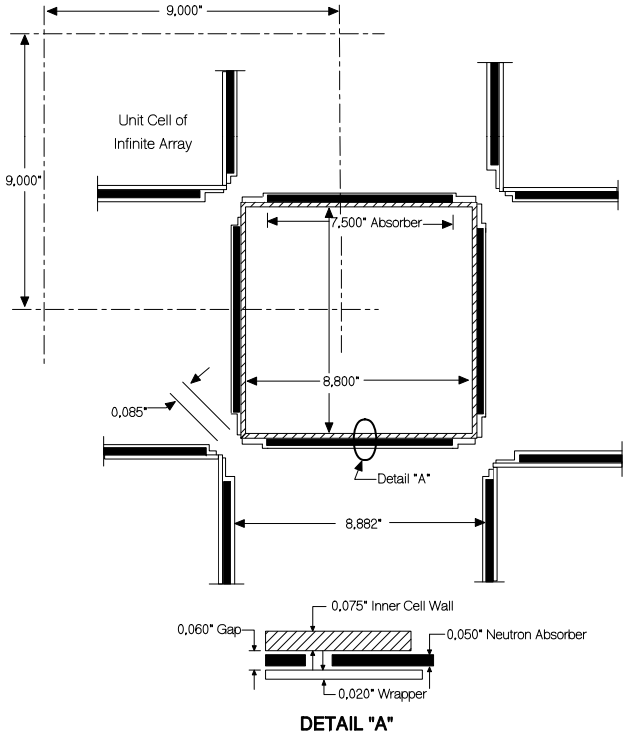
BORAL® – Degradation Background

- BORAL® is a boron carbide cermet
  - Porous inner core
  - Al clad
- Degradation effects
  - General and pitting corrosion
  - Blistering of Al clad

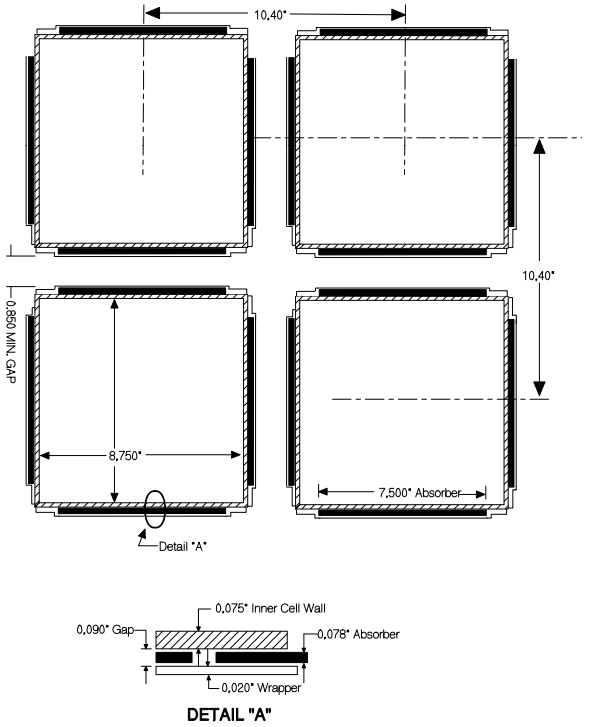
BORAL® – Degradation Background

- BORAL® blistering

BWR/Region 2 Rack



PWR Region 1 Rack



BORAL® – Degradation Impact on Criticality

- Corrosion
  - No significant loss of material
- Blisters
  - Only effects flux trap designs (PWR Region 1 type)
  - Effect is very small
  - Can include in criticality analysis

Continued strategy for neutron absorber credit

- Boraflex
  - Most plants eliminated credit for Boraflex
  - Few plants continue to rely on monitoring
- Carborundum
  - Very few plants
  - Most plants monitoring weight loss
  - 1 plant eliminated credit for Carborundum
- BORAL®
  - Continued use with full credit

Reference List – EPRI Reports

- 1025204, “Strategy for Managing the Long Term Use of BORAL(R) in Spent Fuel Storage Pools,” July 2012
- 1021053, “Reaction-path and Capillary-effects Models of BORAL™ Blistering,” December 2010
- 1021052, “Overview of BORAL® Performance Based Upon Surveillance Coupon Measurements,” December 2010
- 1021051, “Experimental Characterization of BORAL® Pore Size and Volume Distributions,” December 2010
- 1019110, “Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications,” November 2009
- 1013723, “Qualification Testing for Metal Matrix Neutron Absorber Materials for Wet and Dry Storage Applications,” November 2006
- TR-108761, “A Synopsis of the Technology Developed to Address the Boraflex Degradation Issue”, December 1997
- TR-101986, “Boraflex Test Results and Evaluation,” February 1993
- NP-6159, “An Assessment of Boraflex Performance in Spent-Nuclear-Fuel Storage Racks”, December 1988

Reference List – Previous NRC Meetings

- May 6, 2010, “Public Meeting to Discuss Neutron Absorber Material Degradation Issues”
- May 1, 2009, “Public Meeting to Discuss Concerns With Spent Fuel Pool Criticality Submittals”
- February 27, 2009, “Public Meeting to Discuss Materials Currently In Spent Fuel Pools”

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