Research Activities Addressing the Materials and Monitoring of Spent Fuel Pool Neutron Absorbing Materials

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Degradation of Neutron Absorbing Materials in the Spent Fuel Pool
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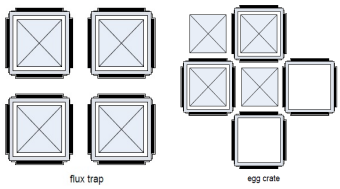
Overview

- Research Products
- Materials
  - Phenolic Resins
  - Boraflex
- Monitoring
  - RACKLIFE
  - BADGER
- Knowledge Management
- Research Path Forward



Rack configurations
T.C. Haley, 2012

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Research Products

- Monitoring Degradation of Phenolic Resin-Based Neutron Absorbers in Spent Nuclear Fuel Pools, ML13141A182
- "Boraflex, RACKLIFE, and BADGER, Description and Uncertainties (T.C. Haley), ML12216A304
- "Initial Assessment of the Uncertainties Associated with the BADGER Methodology" (ORNL), ML12254A064
- Spent Fuel Pool Criticality Management Database, ML14024A142 and ML113550241
- Spent Fuel Wet Storage Public Webpage: http://www.nrc.gov/waste/spent-fuel-storage/pools.html

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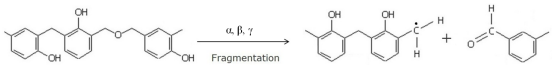
Materials: Phenolic Resins

- B_4C plates, Carborundum, Tetrabor
- B_4C particles encased in a phenolic resin matrix
- Polymer backbone degraded by irradiation and the pool environment, releasing B_4C particles

Phenolic resin degradation by direct radiation:



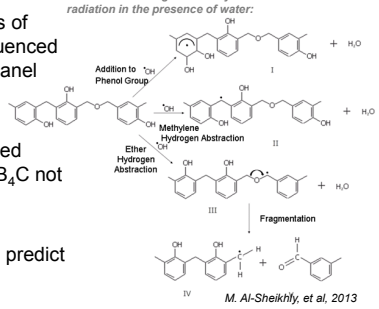
M. Al-Sheikhly, et al, 2013

Materials: Phenolic Resins

Findings:

- Modes and rates of degradation influenced by the specific panel environment
- Ability of degraded matrix to retain B_4C not well known
- Limited ability to predict the loss of B_4C

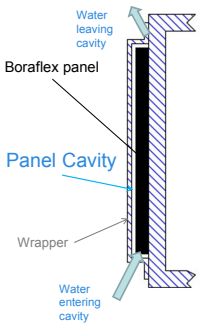
Phenolic resin degradation by radiation in the presence of water:



M. Al-Sheikhly, et al, 2013

Materials: Boraflex

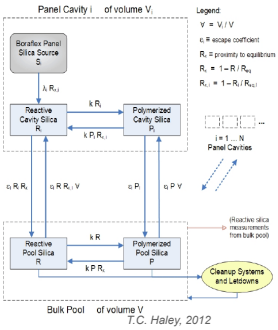
- B_4C particles encased in a silicone matrix
- Degraded by a well-established multi-step mechanism
- Findings:
  - Degradation is non-uniform
  - Rate of degradation dependent on the specific flow rate through the panel cavity



Monitoring: RACKLIFE

- Predictive modeling program developed in the mid 1990's
- Uses pool silica content and accumulated gamma exposure as inputs
- Predicts matrix degradation and loss of B_4C particles from each individual panel
- Specific to Boraflex degradation

Silica transport model

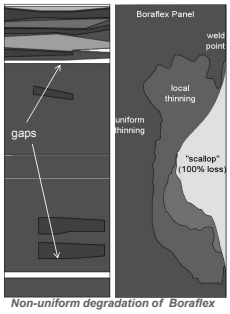


T.C. Haley, 2012

Monitoring: RACKLIFE

Findings:

- Does not account for non-uniform degradation
- Incorrect tuning of the model introduces uncertainties into the results
- At higher levels of matrix degradation, the dissolution is not well represented by the silica transport model



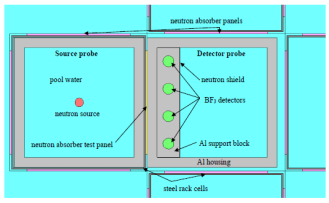
Non-uniform degradation of Boraflex

T.C. Haley, 2012

Monitoring: BADGER

- Boron Areal Density Gauge for Evaluating Racks
- Measures ^{10}B areal density in units of g $^{10}B/cm^2$

BADGER source and detector heads



Scaglione et al, 2012

- Independent of neutron absorbing material

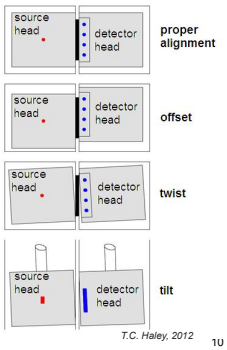
Monitoring: BADGER

Findings:

Uncertainties in results:

- Gamma interference during data processing
- Calibration procedure
- Head misalignment
- Extrapolating measurements from a small number of panels to an entire pool

Head misalignment in BADGER



T.C. Haley, 2012

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Knowledge Management

Spent Fuel Pool Criticality Management Spreadsheet

- Lists how each pool meets the subcriticality requirements
- References the applicable licensing document
- Accompanied by an explanatory Technical Letter Report: ML113550241
- Latest Update: March 2014: ML14024A142

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Knowledge Management

Public website: http://www.nrc.gov/waste/spent-fuel-storage/pools.html

- Short overview of wet pool storage
  - Neutron Absorbing Materials
  - NRC Actions
  - Links to key NRC documents
    - Generic Communications
    - Information Notices
    - Guidance
    - Technical reports
    - Public Meeting Materials

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Knowledge Management

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Future Work

- Investigation of cermets such as Boral
  - Effect of porosity on degradation
  - Effect of batch to batch variability
  - Initiation of corrosion of Al-B_4C core and Al cladding
  - Effect of matrix degradation on B_4C content and distribution
- Similar research may be conducted on other neutron absorber materials
- Effects of a design basis event on the materials and their mechanisms of degradation

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