UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

September 15, 2014

Mr. Mark A. Satorius
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: GENERIC LETTER 20XX-XX, "MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS"

Dear Mr. Satorius:

During the 617th meeting of the Advisory Committee on Reactor Safeguards, September 4-6, 2014, we reviewed draft Generic Letter 20XX-XX, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools." Our Metallurgy and Reactor Fuels Subcommittee also reviewed this matter during a meeting on August 21, 2014. During these meetings, we had the benefit of discussions with representatives of the NRC staff and the Nuclear Energy Institute. We also had the benefit of the documents referenced.

RECOMMENDATIONS

1. The Generic Letter will provide valuable information related to the current status of spent fuel pool absorber systems. It should be issued after consideration of Recommendation 2.

2. Additional clarity should be provided regarding the level of response required, based on a tiered approach depending on the type of neutron absorber being used and the degree to which the absorber is being credited in the pool criticality analysis.

BACKGROUND

Neutron absorber materials have been used in spent fuel pools for more than 30 years to allow an increased number of spent fuel assemblies to be accommodated in the pool and still maintain margins against criticality. Plates or sheets of these materials are used in spent fuel pool racks and are comprised of a compound, alloy, or a composite material that serves as a matrix to contain a neutron absorber nuclide, primarily ^{10}Boron. Several types have been deployed and include the following:

- Boraflex - boron carbide (B_4C) in a silicone polymer
- Carborundum - B_4C in a phenol formaldehyde resin matrix
- Boral® - B_4C in an aluminum matrix with aluminum cladding
- Borated Stainless Steel - natural boron in a stainless steel matrix
- Metamic™ - B_4C in an aluminum metal matrix composite
- BORALCAN - B_4C in an aluminum metal matrix composite

Operating experience includes several instances of degradation and deformation of neutron absorbing materials in spent fuel pools, as described in NRC Information Notice 09-26, "Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool," and other earlier communications. While there have been no criticality incidents, degradation of the absorber system has resulted in licensees being cited for violation of their licensing bases. This experience has raised concerns that current monitoring of absorber systems may not be adequate.

DISCUSSION

The primary function of the neutron absorber system is to prevent criticality in the spent fuel pool. This function requires that the spent fuel storage configuration, the neutron absorber system, and any boron dissolved in the pool water provide adequate margin against criticality, as defined by the spent fuel pool nuclear criticality safety analysis of record. Pressurized water reactor pools employ a combination of dissolved boron and solid absorbers while boiling water reactor pools use only solid absorbers. As higher density fuel racks have been installed, the required boron content has also increased. Degradation of the absorber via general or localized corrosion is a source of boron loss and thus must be avoided or appropriately monitored. Licensees must demonstrate adequate margin below criticality as required by the regulations.

The most common absorber materials in use in the US are Boraflex, Carborundum, and Boral®. Recent applications use more robust materials such as Metamic™, BORALCAN, or borated stainless steel. The water environment combined with the gamma dose in spent fuel pools causes severe degradation of Boraflex and Carborundum and has resulted in violations of licensing bases. For these absorber types, this has been an issue since their initial use. Extensive efforts to understand the degradation phenomena, characterize the degree of degradation, and mitigate the effects on criticality margins continue. For example, licensees have implemented absorber monitoring programs with test coupons, in-situ measurements with tools such as the BADGER scanning system, and predictive computational tools such as RACKLIFE for predicting Boraflex degradation. As a result of monitoring uncertainties and observed degradation, licensees have resorted to alternate options, such as lower density storage configurations, conservative analysis assumptions, removal of credit for the absorber in criticality analyses, and replacement of susceptible materials.

Observed degradation of Boral® absorber material is different than Boraflex or Carborundum. In this case, water access to the interface between the pure aluminum cladding and the boron-containing material results in the development of blisters that impact the local surface. Little corrosion and loss of boron have been observed. Corrosion coupons or other programs have been implemented to monitor progression of the blistering.

The remaining absorber materials, borated stainless steel, Metamic™, and BORALCAN, have thus far not exhibited degradation issues that have plagued the polymer-based materials.

The performance of the neutron absorber materials can thus be divided into three groups:

- Group I: Boraflex and Carborundum are highly susceptible to degradation-related boron loss.
- Group II: Boral® has experienced some degradation but little observed boron loss.
- Group III: Borated stainless steel, Metamic™, and BORALCAN have neither seen, nor are expected to see, significant degradation or boron loss.

The issues related to Group I materials are being addressed through a combination of replacement, programmatic changes to eliminate the need to credit absorbers, or absorber monitoring. Group II material is being monitored using corrosion coupons or an improved BADGER system. The Group III materials are also being monitored using corrosion coupons.

The potential safety importance of the degradation issue warrants the issuance of a Generic Letter. However, clarification of the required response to the Generic Letter is needed to reduce unnecessary burden to licensees. A tiered approach to the response should be implemented in the final version of the Generic Letter. For those licensees that do not incorporate neutron absorber materials in their spent fuel pool or have eliminated the need to credit neutron absorbers in meeting the regulatory requirements, a minimal response to the Generic Letter should be sufficient. For licensees that credit neutron absorbers in their criticality analyses, there should be a differentiation between those using Boraflex or Carborundum (Group I) and those using the more robust materials (Group II, III) that reflects the level of susceptibility associated with the different materials.

The Generic Letter will provide valuable information related to the current status of spent fuel pool absorber systems. It should be issued after clarification of the required response.

Sincerely,

/RA/

John W. Stetkar
Chairman

REFERENCES

1. Memorandum from Timothy J. McGinty to E. Hackett, “Generic Letter 20XX-XX:Monitoring of Neutron-Absorbing Materials In Spent Fuel Pools,” July 22, 2014 (ML14191A190)

2. Information Notice 93-70, “Degradation of Boraflex Neutron Absorber Coupons,” September 10, 1993, (ML031070107)

3. Information Notice 95-38, “Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks,” September 8, 1995, (ML031060277)

4. Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks," June 26, 1996, (ML031110008)

5. Information Notice 12-13, "Boraflex Degradation Surveillance Programs and Corrective Actions in the Spent Fuel Pool," August 10, 2012, (ML121660156)

6. Information Notice 83-29, "Fuel Binding Caused by Fuel Rack Deformation," May 6, 1983, (ML14043A291)

7. Information Notice 09-26, "Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool," October 28, 2009, (ML092440545)

8. Technical Letter Report, "Boraflex, RACKLIFE and BADGER: Description and Uncertainties," September 30, 2012, (ML12216A307)

9. Technical Letter Report, "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012, (ML12254A064)

10. Technical Letter Report, "Monitoring Degradation of Phenolic Resin-Based Neutron Absorbers in Spent Nuclear Fuel Pools," June 5, 2013, (ML13141A182)

11. 10 CFR 50.68, "Criticality Accident Requirements"

12. NEI-12-16, "Guidance for Performing Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants", Revision 1, April 2014.

13. Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications (2009 Edition), EPRI Technical Report 1019110, November 2009.

14. Letter from Kristopher W. Cummings to Tim McGinty, "Proposed Approach to Address Monitoring of Neutron Absorbing Materials in Spent Fuel Pools," April 19, 2014

15. LR-ISG-2009-01, Aging Management of Spent Fuel Pool Neutron-Absorbing Materials Other than Boraflex, April 27, 2010, (ML100621321)

16. NRC NUREG-1801, Revision 2, "Generic Aging Lessons Learned Report," December 2010, (ML103409041)

4. Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks," June 26, 1996, (ML031110008)

5. Information Notice 12-13, "Boraflex Degradation Surveillance Programs and Corrective Actions in the Spent Fuel Pool," August 10, 2012, (ML121660156)

6. Information Notice 83-29, "Fuel Binding Caused by Fuel Rack Deformation," May 6, 1983, (ML14043A291)

7. Information Notice 09-26, "Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool," October 28, 2009, (ML092440545)

8. Technical Letter Report, "Boraflex, RACKLIFE and BADGER: Description and Uncertainties," September 30, 2012, (ML12216A307)

9. Technical Letter Report, "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012, (ML12254A064)

10. Technical Letter Report, "Monitoring Degradation of Phenolic Resin-Based Neutron Absorbers in Spent Nuclear Fuel Pools," June 5, 2013, (ML13141A182)

11. 10 CFR 50.68, "Criticality Accident Requirements"

12. NEI-12-16, "Guidance for Performing Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants", Revision 1, April 2014.

13. Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications (2009 Edition), EPRI Technical Report 1019110, November 2009.

14. Letter from Kristopher W. Cummings to Tim McGinty, "Proposed Approach to Address Monitoring of Neutron Absorbing Materials in Spent Fuel Pools," April 19, 2014

15. LR-ISG-2009-01, Aging Management of Spent Fuel Pool Neutron-Absorbing Materials Other than Boraflex, April 27, 2010, (ML100621321)

16. NRC NUREG-1801, Revision 2, "Generic Aging Lessons Learned Report," December 2010, (ML103409041)

Accession No: **ML14252A299** **Publicly Available** Y **Sensitive** N
Viewing Rights: ☒ NRC Users or ☐ ACRS Only or ☐ See Restricted distribution

OFFICE	ACRS	SUNSI Review	ACRS	ACRS	ACRS
NAME	CBrown	CBrown	CSantos	EMHackett	EMH for JWS
DATE	09/15/14	09/15/14	09/15/14	09/15/14	09/15/14

OFFICIAL RECORD COPY