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May 12, 2014

Ms. Cindy K. Bladey
Chief, Rules, Announcements and Directives Branch (RADB)
Office of Administration
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Industry Comments on NRC Draft Generic Letter 201X-XX, "Monitoring of Neutron Absorbing Materials in Spent Fuel Pools" (Docket ID: NRC-2014-0040)

Project Number: 689

Dear Ms. Bladey:

On behalf of the nuclear energy industry, the Nuclear Energy Institute (NEI)[1] appreciates the opportunity to provide comments on the draft Generic Letter 201X-XX that was published in the *Federal Register* on March 11, 2014 (79 FR 13685). This generic letter requests every licensee with a spent fuel pool to provide a broad range of extensive information on in-use neutron absorbers, neutron absorber monitoring programs and justification of the technical basis for the use of neutron absorbers.

The industry agrees that it is important that licensees take appropriate measures to assure that neutron-absorbing materials are able to perform their intended function over time. However, we do not agree that this topic warrants issuance of a generic letter at this time for the following three reasons:

1. The NRC has not established a safety concern sufficient to warrant a generic letter.
2. The proposed generic letter is too broad and would require the industry to unnecessarily expend significant resources.
3. The proposed generic letter is premature and should be reconsidered following NRC review of ongoing R&D in this area.

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all utilities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

These reasons are further extrapolated and justified in the attachment to this letter.

If you have any questions or require additional information, please contact me.

Sincerely,

Kristopher W. Cummings

Attachment

c: Mr. Eric J. Leeds, NRR, NRC
Ms. Jennifer Uhle, NRR, NRC
Mr. Daniel H. Dorman, NRR, NRC
Mr. Timothy McGinty, NRR/DSS, NRC
Mr. David Pelton, NRR/DPR/PGCB, NRC
Mr. Christopher Jackson, NRR/DSS/SRXB, NRC

Industry Comments on NRC Draft Generic Letter 201X-XX, "Monitoring of Neutron Absorbing Materials in Spent Fuel Pools" (Docket ID: NRC-2014-0040)

Background

The material properties and aging behaviors exhibited by neutron absorbers in the spent fuel pool has been an ongoing area of study and monitoring since industry began using high-density spent fuel storage racks that necessitated the inclusion of neutron absorbers. The NRC has previously issued several generic communications as additional operational experience has been observed that could pose an unresolved safety issue. Licensees have responded to this information through industry sponsored research by the Electric Power Research Institute, adoption of coupon monitoring programs, additional in-situ testing of the fixed neutron absorbers and creation of the EPRI Neutron Absorber Users Group (NAUG) to proactively investigate the phenomena and collaboratively share information on developing solutions to this issue.

The changes in the material properties and aging effects observed is a slow process that develops over decades and is inherently dependent upon the specific material of interest. Early neutron absorbers that were based on polymers or phenolic resins have been observed to lose neutron absorption capability as a result of irradiation, pool chemistry and thermally driven water flow. Specifically, Boraflex neutron absorber properties degrade over time given sufficient irradiation and this phenomena is exacerbated in the presence of flowing water. Carborundum has also exhibited evidence of loss of neutron absorbing capability, which has been observed through weight loss in coupons. Most licensees that have these materials installed in their spent fuel pools have modified their spent fuel pool criticality analysis to account for any potential degradation or eliminated credit for neutron absorbers known to experience significant degradation. Those licensees that continue to credit or partially credit these materials have instituted monitoring programs to periodically evaluate whether and how much degradation is occurring.

Based on this experience with early neutron absorber materials, more robust neutron absorbers were developed with Aluminum as the primary base material. The most prevalent of these absorbers, Boral, is a mixture of aluminum and B_4C powder sandwiched and rolled between two thin aluminum sheets. Because of an underlying porosity of the core material, small amounts of water have, in some instances, ingressed into the core material where an Al-H_2O reaction occurs and generates a localized amount of gas inside the material. This results in small blisters (approximately 1-2" in diameter and 0.25" high) to form between the thin aluminum clad and the core material, however there has been no observed loss of neutron absorbing capability. These blisters are small and localized and generally occur near the edges of the material where the core material is exposed and can allow the water ingress to occur. Because of the localized effect of the blisters, these have a negligible effect on the neutron absorption properties and resulting reactivity of the spent fuel storage racks. To date, the industry has over 35 years of experience with Boral as a neutron absorber, with no degradation mechanisms identified that would result in a safety issue in the spent fuel pool.

The latest materials being implemented, such as Metamic and Boralcan, are characterized as metal-matrix materials and are a mix of Aluminum and B_4C that produce a homogeneous material with very low porosity

and no potential for blistering (because there is no Aluminum cladding). These materials were developed to eliminate the blistering issues observed in Boral and there have been no observed degradation mechanisms for these materials to date.

Assessment of Generic Letter

1. NEI believes that the generic letter has not established a safety concern for neutron absorber materials or neutron absorber monitoring programs to sufficiently warrant issuing a generic letter that would place this burden on licensees to provide the requested information:

- There is no identified safety issue associated with metallic neutron absorbers. With 35 years of in-service performance history with Boral, there have been no instances of operational experience that has shown any gross loss of material like that observed by the non-metallic absorbers. It is recognized that blistering can have a localized effect of displacing water that could theoretically have an effect on reactivity (~0.01 Δk); however, when modelled accurately, blistering has a negligible effect (~0.001 Δk) that is easily addressed through the margin and conservatism in the licensing basis spent fuel pool criticality analysis. For non-metallic absorbers (Boraflex and Carborundum), the majority of licensees have discontinued credit for the absorber material. The remaining licensees that continue to credit these materials have existing monitoring programs in place (either coupons or in-situ testing) that were reviewed and approved by the NRC and found to be acceptable.
- Spent fuel pools maintain a large amount of excess reactivity margin that would have to be overcome before a safety issue would occur.
  - PWR spent fuel pools maintain excess reactivity margin through the use of soluble boron which is controlled by a Technical Specification (TS) Limiting Condition of Operation (LCO) and associated Surveillance Requirements (SR). The soluble boron provides additional reactivity margin of at least 0.15 Δk before a safety issue would occur.
  - BWR spent fuel pools are supported by a spent fuel pool criticality analysis that is performed in a very conservative manner, which assumes that all fuel assemblies are at their maximum reactivity at any point during their irradiation in the core. This maximum reactivity occurs at a relatively low burnup of 15-20 GWD/MTU. The additional burnup of fully irradiated BWR fuel assemblies to ~55 GWD/MTU would provide excess reactivity margin of at least 0.10 Δk in reactivity. Additionally, since soluble boron is not present in the spent fuel pool, the analysis maintains an additional large safety margin (0.05 Δk) that would need to be overcome before a criticality event could occur.
- The NRC's studies[1] demonstrate that a significant level of degradation must occur (50-60% loss of absorbing material along the entire length of every absorber panel) before a large enough reactivity effect is produced to overcome the large amount of reactivity margin identified above (0.05 Δk).
- Neutron absorber material aging effects, including degradation, deformation, corrosion, and/or pitting take long timeframes to occur. For non-metallic absorbers these effects were seen after

[1] NRC Presentation at 2013 RIC, "Evolving Nuclear Fuel Pool Storage Criticality Regulations and Guidance," March 13, 2013.

approximately a decade of in-service exposure. For metallic based absorbers, there exists over 35 years of operational experience without any degradation or deformation that would impact the reactivity of the storage racks to pose a safety issue. The aging effects observed, such as blistering, pitting and general corrosion have taken several decades to develop and do not show any evidence of accelerating. These effects are appropriately monitored and addressed through the existing licensee programs such as the corrective action program, aging management programs, etc. Additionally, during license renewal, licensees are required to adopt neutron absorber monitoring programs as part of the aging management program.

- Newer metallic absorbers, such as Metamic and Boralcan, have less than a decade of in-service operational experience and have more detailed coupon measurement programs in place. Given the long timeframes associated with observation of deformation or corrosion there is no safety issue associated with these materials. Additionally, the generic letter provides no evidence of any associated material aging issues with these more modern materials.
- There is considerable margin to criticality in spent fuel pools due to conservative analytical methodologies, design and construction techniques, and plant operations that provide multiple layers of defense-in-depth protection in addition to the protection provided by the neutron absorber. As such, there is sufficient protection against an inadvertent criticality event in commercial reactor spent fuel pools.
- A portion of the information requested in Appendix A of the Generic letter concerning the Analysis of Record (AOR) and monitoring program would already be available to the NRC through review of the applicable license renewal applications or license amendment requests, and related requests for additional information and the associated safety evaluations. Some licensees have provided this information in the last five years and should be readily available to the NRC. The licensees should not be burdened by reformulating and verifying the information that has already been provided to the NRC.

2. The response timeframe and estimated level of effort to provide the information requested on Page 7 and Appendix A of the draft Generic letter are significantly underestimated:

- The estimated level of effort (120 hours for most licensees, 200 hours for licensees with multiple absorbers) is underestimated by an order of magnitude. This level of effort may be appropriate for spent fuel storage racks that never had a fixed neutron absorber or has discontinued credit for the neutron absorber. However, the extensive information requested in Appendix A is estimated to require approximately 1000 – 2000 hours per spent fuel pool to appropriately collect, review and verify. The work will require engineers familiar with the spent fuel storage rack system, design and licensing and will require expertise in multiple disciplines including criticality, material fabrication, seismic and structural.
- The response time of 90 days does not account for the collection of the subset of information requested in Appendix A of the Generic letter that will need to be acquired from the spent fuel storage rack or neutron absorber vendor. This will likely create multiple requests from several utilities to the same small subset of vendors that will be needed to provide this information, significantly taxing the resources necessary to respond to all requests in a timely manner. While some of the information may be generic in nature and applicable to multiple sites, the generic letter

requests all licensees to provide this same information. A more reasonable estimate to accommodate the necessary time to compile, review and submit this information would be 360 days.

- NRC generic letter 96-04 previously requested information with regard to Boraflex degradation in 1996. This generic letter requested the following information:

  > *"All licensees of power reactors with installed spent fuel pool storage racks containing the neutron absorber Boraflex are requested to provide an assessment of the physical condition of the Boraflex, including any deterioration, on the basis of current accumulated gamma exposure and possible water ingress to the Boraflex and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response. All licensees are further requested to submit to the NRC a description of any proposed actions to monitor or confirm that this 5-percent subcriticality margin can be maintained for the lifetime of the storage racks and describe what corrective actions could be taken in the event it cannot be maintained. Licensees should describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed. Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."*

  At the time, the NRC estimated that the effort to respond to this information request in GL 96-04 would require 150 hours. The draft generic letter requests a similar amount of information on page 7, but then requests an additional 5 pages of detailed information contained in Appendix A.
- The draft generic letter requests information in accordance with 10 CFR 50.54(f), which requires licensees to provide information under oath and affirmation of accuracy. However, some of the information may be impossible to be absolutely established, such as the current minimum areal density of neutron-absorbing in the spent fuel pool (see comments on Appendix A). Absent an evaluation of 100% of the neutron absorber in the spent fuel pool, a licensee cannot provide this information with absolute certainty. The information request should be reviewed to ensure that the requested information is available at the necessary level of certainty. Further, the time estimate for responding to the generic letter must consider the significant time required to validate the information to the standards required for a 50.54(f) response.
- The evaluation against cumulative effects of regulation needs to be reexamined based on the significantly higher time and cost necessary for licensees to respond to the generic letter information request.
- The generic letter (page 9 and page 11) states that there are two power reactors with several neutron absorbing materials. This statement is incorrect, as the Exelon fleet alone has six power reactors with multiple neutron absorbers. This inaccuracy indicates that the NRC has drastically underestimated the total cumulative effort needed by the industry to address the generic letter.

3. It is premature for the NRC to request licensees who have metallic absorbers to provide the information requested in the generic letter as research is being conducted that will provide valuable additional information:
   - The Electric Power Research Institute (EPRI) has research and benchmarking activities underway to investigate the aging effects of Boral. The first project, the Boral Accelerated Corrosion test is performing accelerated corrosion testing for a wide range of Boral coupons that cover different manufacturing methods, various forms of encapsulation in both borated and non-borated water. This program is currently in the second year of a five year program to simulate approximately 90 years of in-service exposure to spent fuel pool water. It will provide information on the long-term behavior of Boral in a spent fuel pool environment. Secondly, EPRI has a project to perform in-situ testing of Boral panels from the Zion nuclear plant, remove those panels from the storage rack and take sample material to be tested in a lab using conventional neutron transmission testing. This program will provide information about the relationship between in-situ testing results and actual in-lab areal density measurements. It will also allow for a comparison between the behaviors exhibited by coupons compared to in-service Boral panels.

Summary

10 CFR 50.54(f) allows the NRC to demand information in order to determine whether licenses should be suspended, modified, or revoked. The NRC has not demonstrated adequate rationale that the extensive demand for information in the draft generic letter is justified under 10 CFR 50.54(f):

1. There is not a safety issue given previous and ongoing actions by licensees and industry to address potential neutron absorbing material degradation; and,
2. There is no reason to believe that all licensees are in a state of non-compliance with their licensing basis with respect to spent fuel pool neutron absorbers credited for the spent fuel pool criticality analyses and technical specifications.

Detailed Comments on Specific Sections of the Generic Letter

In addition to the comments provided above, the industry has concerns with the specific information requested in Appendix A of the generic letter that need to be clarified or corrected prior to final issuance.

General comment: The terminology "not limited to" is used in multiple places throughout Appendix A. Licensees should not be expected to interpret what other conditions should be postulated to satisfy this request. It is recommended that the terminology "not limited to" be removed as it is open ended, open to interpretation by each licensee and does not clearly state what information the NRC is requesting.

General comment: The draft generic letter treats all neutron absorbers equally and applies the term "degradation" to cover all aspects of observed aging behaviors, including general corrosion, blistering and deformation, without regard to how the mechanism may or may not affect neutron absorption properties. The generic letter needs to discuss how each mechanism could lead to loss of absorption properties if not surveyed and monitored. The generic letter should also discuss the fact that industry has monitoring

programs in place to ensure that such degradation does not progress to the point that margin to criticality is impacted.

Item 1.b.i: Not all neutron absorbers are specified based on defining the neutron absorbing material as a weight percent. For instance, purchase of Boral was typically specified on the basis on a certified minimum areal density. Providing the weight percent of absorbing material is redundant to providing the areal density and thickness. Recommend eliminating this request as it is redundant and provides no additional value to the information requested in Item 1.b.ii

Item 1.b.ii: NRC should provide the basis for requesting the "minimum certified, minimum as-built, maximum as-built and nominal as-built areal density" of the neutron absorber. It is not readily apparent that each of these parameters is known or required for all neutron absorbers in order to provide assurance that the margins to criticality are maintained for the neutron absorbers of interest. For example, the maximum as-built areal density would have little relevance in a spent fuel pool criticality analysis. Recommend changing this item to requesting the minimum certified and nominal areal density.

Item 1.b.iii: The most important characteristic of the neutron absorber material is the areal density. The material characteristics, such as porosity and density have a negligible effect of reactivity and therefore no impact on safety. Additionally, porosity was not necessarily a controlled or measured parameter and is only applicable to metallic absorbers. Recommend eliminating this item from the request as it provides little additional information relevant to the safety issue around neutron absorbers. Neutron absorber dimensions would be available in the licensing documents provided to the NRC when the spent fuel storage racks were submitted for approval. Licensees should not be burdened with providing information already available to the NRC.

Item 1.c: The qualification testing approach for neutron absorber materials are typically provided and approved by the NRC during the first application for use of a new neutron absorber. All licensees may not have this information, because they relied on the previous precedence of NRC approval of a specific neutron absorber material. It is a redundant activity to ask each licensee to provide this material individually. Recommend eliminating this request.

Item 1.d.ii: The term "exposure of neutron-absorbing materials" is not clear. It is requested that the NRC clarify whether this means radiation exposure or pool water exposure (i.e., years of presence in the spent fuel pool water) or other types of exposure. Radiation exposure for each neutron absorber panel in the spent fuel pool cannot be determined without additional analysis for most licensees and would further increase the estimates already provided above. If this is simply time in the spent fuel pool, this information can be determined from the information provided in Item 1.a.

Item 1.e and Item 1.e.i: The request for the "current condition of the credited neutron absorbing material" is too broad and open to interpretation. Is this intended to mean "What is the current areal density of every absorber panel in the spent fuel pool?" If so, this information is not available and was not necessary to be provided as part of the review and approval of the spent fuel storage racks. This is because the neutron absorber is typically defined based on a minimum areal density that is certified by the manufacturer and

verified by taking samples from each neutron absorber batch with neutron transmission tests in the lab. However, each panel is not tested individually. Therefore it would not be possible to provide the "current minimal areal density". Additionally, please clarify how this differs from the "minimum as-built areal density" requested in Item 1.b.ii.

Item 1.e.iii: Clarify whether this is intended to be the recorded deformation and degradation observed from coupon monitoring programs. This request, in conjunction with the "current condition" implies a request for the operational experience associated with actual panels in-service. The common approved practice is to monitor coupons, but not the actual in-service material.

It is recommended that Item 1.e be eliminated in its entirety. It is too broad and not clearly specified what information the NRC is requesting or that it is actually available.

Item 2.a and 2.b: The information requested goes well beyond what has been requested by the NRC during review and approval of new spent fuel storage racks submittals. If this information was not requested or required for the purposes of making a safety determination and completing the Safety Evaluation Report (SER), the NRC should justify that this information meets the criteria in 50.54 (f) that "the NRC must prepare the reason or reasons for each information request prior to issuance to ensure that the burden to be imposed on the respondents is justified in view of the *potential safety significance* of the issue to be addressed" (emphasis added). It appears that the NRC is requesting this information so that they can re-judge the adequacy of the neutron absorber monitoring program that was previously reviewed and approved by the NRC. This is not an appropriate use of the generic letter or 50.54(f) process.

Item 2.b.iv.3: It is not appropriate to require licensees to make use of the results from the NRC Technical Letter Report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology" as it is not a part of their current licensing basis. The bases for this report are outdated and inaccurate. It is apparent that the NRC created this document with no input from the manufacturers or users of the BADGER system. In many places, the NRC makes conservative assumptions based on a lack of agency information that drive it to a conclusion that is not correct. Satisfying this requirement would inherently require licensees to go back and have to perform calculations. This request should be removed in its entirety.

Item 3: For most licensees, the technical basis for the type and frequency of coupon testing or in-situ testing was based on discussions with the NRC staff during the licensing of the spent fuel storage racks. The technical basis was previous experience with the material, observation of recent results and expectations of future behavior. It was also recognized, that any issues that would arise would be addressed with the current processes that exist for all licensees, namely, the corrective action process, operability determination and the Part 21 process, if necessary. For many licensees that use Boral, they do not have a coupon testing program. The basis for acceptability was multiple NRC positions provided to the industry[2].

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[2] NRC letter from Laurence I. Kopp to Dr. Krishna P. Singh, dated February 16, 1995 (NRC Accession # 9502230383) and NRC letter from Anthony C. Attard to Korea Hydro & Nuclear Power Company, dated October 2, 2003 (provided upon request).

Item 4.a: New spent fuel storage rack applications have always considered the neutron absorber to be in its as-installed condition. As issues have arisen, whether it is degradation or deformation, these issues have been addressed in the licensees corrective action program and evaluated under 50.59 (if appropriate), evaluated as a degraded or non-conforming condition, or led to a submittal of a new License Amendment Request to address the change in material properties. Applications that included partial credit of Boraflex have addressed the issue of modelling the neutron absorber in a degraded condition, and in these cases, the licensees either have a monitoring program in place to evaluate the performance of their neutron absorber material or are pursuing options for removing partial credit for Boraflex.

Item 4.c: The NRC has not previously required the bias and uncertainty of the monitoring program to be propagated in the spent fuel pool criticality analysis. This is because for the most part, the monitoring program is verifying that there has not been a loss of neutron absorbing material. Therefore, the monitoring program is a verification of the as-manufactured neutron absorber density, which has been addressed in the spent fuel pool criticality analysis. NEI 12-16, Revision 1, which has been submitted to the NRC for endorsement, provides a detailed explanation of an acceptable monitoring program and how to use the results of the monitoring program in verifying the assumptions made in the spent fuel pool criticality analysis.

Item 5: The NRC has not defined what it means by "design basis events". Please clarify the specific design basis events for which a technical basis needs to be provided. This should be limited to those design basis events that would have an impact on the neutron absorber.

Item 5.b: It is not the intent of the monitoring program to "ensure that the current material condition of the neutron absorbing material will withstand the effects during a design-basis event and remain within the assumptions". The purpose of the monitoring program is to determine the behavior of the in-service neutron absorbers. If any adverse conditions are observed, current licensee processes are in place to ensure that the neutron absorber can continue to perform its intended function.