Attachment

Response to Request for Additional Information
Regarding NEI 12-16, *Guidance for Performing Criticality Analyses of Fuel Storage at Light-Water Reactor Power Plants*

NRC Questions and Responses:

1. *On page 36, Section 9.5.1.b of its letter dated April 18, 2014, the guidance document states that basic testing is appropriate when previous testing and operating experience of the material indicates that no degradation mechanism would result in loss of Boron-10. The staff understands this to mean that tests for neutron-absorbing capacity may be discontinued in the program because basic testing does not include testing for neutron attenuation. Please discuss whether neutron attenuation testing will be performed in addition to basic testing and whether it will be performed at intervals not exceeding 10 years.*

Response:

The guidance provided in NEI 12-16 is not intended to imply a discontinuation of the neutron absorber monitoring program. Rather, the intent is to define a program that is reflective of the condition and operating experience of the specific type of material used in the spent fuel storage rack. Utilities that have coupon monitoring programs in use for many years, if not decades, have continued to remove coupons for off-site testing in accordance with their neutron absorber monitoring program approved by the NRC. The original coupon tree was typically designed to have a sufficient number of coupons to allow for periodic removal for testing within the licensed term of the reactor. However, the number of coupons was not necessarily sufficient for extended operations due to license renewal (and possibly second license renewal), or if additional coupons were removed for further investigation of corrosion or corrosion precursors. As fewer coupons become available it has become apparent that removing coupons from the coupon tree for destructive examination was short-sighted for neutron absorbers that do not show any indication of degradation that would affect the functionality or effectiveness of the neutron absorber. Therefore, the implementation of basic testing is intended to rectify this issue by providing an initial evaluation of a coupon through visual and dimensional testing that would identify any precursors or advance indication of degradation that would lead to loss of ^{10}B. If no such indication is observed through basic testing of the coupon, then that coupon could be returned to the spent fuel pool for additional in-pool exposure, thereby extending the life of the coupon tree and the coupon monitoring program. One of the key features of basic testing is to ensure that the coupon is not exposed to conditions that are non-representative of the spent fuel pool environment (such as by drying or desiccation) that would no longer make that coupon representative of in-service material.

If basic testing indicates that there are degradation mechanisms present indicating a loss of ^{10}B that would affect the functionality and effectiveness of the neutron absorber, then that coupon would be more extensively examined in accordance with the requirements for full testing to determine the extent and ramifications of those visually observed degradation mechanisms from basic testing. Such indications would be loss of weight, large amounts of pitting holes combined with visually observed loss of the neutron absorbing element in the material, observed brittleness, crumbling of the material, etc. A sensitivity study to determine the size and extent of blistering or pitting that would result in a loss of neutron absorber efficacy is currently in progress. The results of this sensitivity study will be made available to the NRC once completed. Basic testing would be performed no less than every ten years, based upon the experience and history of the specific material. Therefore, neutron attenuation testing would be performed at an interval dependent upon the operating experience of visual and dimensional testing performed during basic testing and will be reserved for those situations where degradation would actually be observed.

The usefulness of employing a graded testing program for coupons can best be illustrated through an example of applying this program to Boral. For many years, if not decades, coupon testing of Boral has not shown any indications of degradation that impacts the functionality or effectiveness of the neutron absorber. Some surface discoloration, small pits, and slight dimensional changes have been observed. With a graded approach in place, these coupons can be returned to the spent fuel pool for additional exposure and subsequently removed in later years for additional observation. An added advantage of a graded testing approach is that subsequent measuring of the same coupon will allow for trending of results. Under this approach, Boral coupons that begin to show blistering or pitting of the aluminum cladding can be observed on a regular basis. Any such observation will be entered into the licensee's corrective action program and will trigger the use of full testing to determine whether the blistering results in a loss of the functionality and effectiveness of the neutron absorber. After the full testing and evaluation of the results, a licensee can then make a determination as to whether to institute full testing on a continual basis or to continue to implement basic testing on the original frequency or a more frequent basis.

2. *On page 36, Section 9.5.2, first bullet, of its letter dated' April 18, 2014, the guidance document states that in-situ measurement of Boron-10 areal density should be performed on an appropriate statistical sample. Please discuss the methodology used in determining an appropriate/acceptable statistical sample.*

Response:

This statement in the guidance document will be modified and expanded to provide two possible options for defining the number of panels to be measured via in-situ examination.

The first option would define a statistically significant sample based upon the methodology contained in NUREG/CR-6698. In the discussion on non-parametric statistical treatment (p.14), it concludes that a sample size of 59 measurements will "…attain a 95% degree of confidence that 95% of the population is above the smallest observed value". This is a conservative approach to defining the minimum number of panels as it applies nonparametric statistics, versus applying a statistical approach to the expected normal distribution of installed panels in the spent fuel pool.

The second option takes credit for the operational experience that many types of neutron absorbers have material degradation processes that are known to be dependent upon radiation, temperature and time. A licensee may selectively choose in-service panels to be tested that have experienced the greatest level of exposure to those variables that influence degradation. These are typically panels that are adjacent to storage locations where freshly discharged spent fuel is placed, especially if this has occurred on a repeating basis. For completeness, the licensee could also choose to select additional panels for testing that are not at leading locations to gain a more representative sample of the spent fuel pool. However, provided that leading neutron absorbers are selected for examination by in-situ measurements, it is recommended that 1% of the panels be selected for in-situ measurement, at a minimum.

In both of these options, consideration should be made to accommodate the availability of equipment to reach storage locations, minimization of spent fuel transfers and separation of the measured storage cells from other spent fuel to minimize signal noise and eliminate corruption of the results by background radiation.

To provide for these options, the first and second bullet of Section 9.5.2 of NEI 12-16 will be replaced with:

- In-situ measurement campaigns should be performed on an adequate number of panels and at an acceptable interval. Two options are available for determining an adequate number of panels:

    - Option 1: Take a measurement of a minimum of 59 panels, based on the methodology of NUREG-6698 to provide a 95% degree of confidence that 95% of the population is above the smallest observed value.
    - Option 2: Selectively choose panels to be tested that have experienced the greatest exposure (within the top 5%) to those parameters that influence degradation (i.e., radiation fluence, temperature, time). The number of panels selected should be no less than 1% of the total number of panels in the spent fuel pool. Additional panels can be selected from other areas of the spent fuel pool to gain a more representative sampling of the spent fuel pool.

- In-situ measurement campaigns should consider the availability of equipment to reach storage locations, minimization of spent fuel transfers and separation of the measured storage cells from other spent fuel to minimize signal noise and eliminate corruption of the results by background radiation.

3. *U.S. Nuclear Regulatory Commission guidance (i.e., Generic Aging Lessons Learned Report 1801) recommends basing the frequency for inspection and testing of neutron-absorbing material capacity on the condition of the material and operating experience, not to exceed 10 years. In the Nuclear Energy Institute letter dated April 18, 2014, the guidance document provides little guidance for maximum test intervals for materials that are known to degrade and the rate of degradation is not fully understood. Please discuss whether guidance will be provided on maximum test intervals for materials that are known to experience significant degradation and rate of degradation is not fully understood.*

Response:

Industry agrees with the guidance provided in NUREG-1801, "Generic Aging Lessons Learned", which recommends basing the frequency for inspection and testing of neutron absorbing material capacity on the condition of the material and operating experience, not to exceed ten years. Any material that begins to show degradation that affects the function and efficacy of the neutron absorber would need to be evaluated in more detail, with conservative degradation rates determined. Observations and measurements obtained from the neutron absorber monitoring program (either coupons or in-situ) will help to determine the appropriate degradation rate. Any further inspection frequency would need to be based on these future evaluations, therefore it is not possible to specify a numerical value as to the maximum test intervals for materials that are known to experience significant degradation, but for which the rate of degradation is not fully understood.

Any licensee that observes degradation in a material whether expected or not, would rely on the corrective action program and 10CFR21 reporting requirements in accordance with their 10CFR 50, Appendix B Quality Assurance Program. Through this process, the licensee would develop the appropriate test intervals to ensure that the spent fuel pool complies with 10CFR 50.68.