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JAFP-16-0165
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U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Response to Generic Letter 2016-01 - Monitoring of Neutron Absorbing Materials in Spent Fuel Pools

James A. FitzPatrick Nuclear Power Plant
Docket No. 50-333
License No. DPR-059

Reference: NRC letter, Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools, Generic Letter 2016-01, dated April 7, 2016

Dear Sir or Madam:

On April 7, 2016, the NRC issued Generic Letter 2016-01 to all power reactor licensees except those that have permanently ceased operation with all power reactor fuel removed from on-site spent fuel pool storage.

The purpose of this letter is to provide a response for James A. FitzPatrick Nuclear Power Plant (JAF). JAF has been determined to be a Category 4 licensee in accordance with the Reference. As a Category 4 licensee, information on the neutron absorber material, criticality analysis of record and neutron absorber monitoring program is requested depending on the type of neutron absorber material present and credited in the spent fuel pool. The JAF spent fuel pool credits Boral and therefore is required to provide information in the following Areas: 1, 2, and 4. The Attachment contains responses to the requested information.

This letter contains no new regulatory commitments. If you have any questions regarding this submittal, please contact William C. Drews at 315-349-6562.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 3rd day of November, 2016.

Respectfully,

Brian R. Sullivan
Site Vice President
BRS/WCD/mh

Attachment: Response to Requested Information in Generic Letter 2016-01

cc: Director, Office of Nuclear Reactor Regulation
NRC Region I Administrator
NRC Resident Inspector
NRC Project Manager
NYSPSC
President NYSERDA

JAFP-16-0165

ATTACHMENT

Response to Requested Information in Generic Letter 2016-01

(14 Pages)

Response to Requested Information in Generic Letter 2016-01

A. Background

On April 7, 2016, the U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools" (GL-2016-01) [1]. The following information provides the James A. FitzPatrick Nuclear Power Plant (JAF) response to the GL 2016-01, including the applicable Areas of Requested Information (ARI) in Appendix A. This response has been developed based on a reasonable search of the plant's records, including docketed information.

B. Category 4 Licensee - GL 2016-01, Appendix A Response

ARI 1

Describe the neutron-absorbing material credited in the spent fuel pool (SFP) nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP, including the following:

a) manufacturers, dates of manufacture, and dates of material installation in the SFP

Response

High density spent fuel racks have been installed at JAF in three phases:

1. Program and Remote Systems (PaR) made 26 racks comprising 2244 spaces in 1978. These are made of aluminum with sealed Brooks and Perkins Boral plates. Installed in 1981 under License Amendment #55.
2. Holtec made 5 racks comprising 553 spaces in 1990. These are made of stainless steel with AAR Brooks and Perkins Boral plates fixed by a stainless steel cover. Boral is open to the spent fuel pool water. Installed in 1994 under License Amendment #175.
3. Holtec made 3 more racks comprising 264 spaces in about 1995. These are nearly identical in design to the previously installed Holtec racks. Installed in 1999 under License Amendment #256.

b) neutron-absorbing material specifications:

i. materials of construction, including the certified content of the neutron absorbing component expressed as weight percent

Response

- The PaR racks are of bolted anodized aluminum with Boral plates. The Boral plates are sealed within concentric square aluminum tubes and do not contact the pool water. Boral is a sandwich of thin 1100 aluminum plates covering an aluminum matrix mixed with boron carbide (B_4C). The Boral was manufactured by Brooks and Perkins.
- The Holtec racks are made of 304L stainless steel with Boral plates held in place by a stainless steel plate that allows contact between the Boral plate and the spent fuel pool water. The Boral was manufactured by AAR Brooks and Perkins.
- The Boral in all racks is not specified on a weight percent basis of the neutron absorbing component. See response to 1 b) ii for the certified areal density.

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ii. minimum certified, minimum as-built, maximum as-built and nominal as-built areal density of the neutron-absorbing component

Response

- The aluminum PaR racks have a certified minimum content of boron in the PaR Boral plates is 0.129 gm B-10/cm^2. This converts to 0.0232 gm B-10/cm^2 using the natural abundance of B-10.
- The stainless steel Holtec racks were approved and installed in two phases: License Amendment 175 and License Amendment 256.

  Under License Amendment 175, the certified minimum loading in the Holtec racks was 0.0135 gm B-10/cm^2. However, material certification supplied by the Boral manufacturer show that the actual loading is higher than 0.0162 gm B-10/cm^2.

  Under License Amendment 256, Boral certification records from the first set of Holtec racks were compiled for use by Holtec in preparing the criticality analysis for the second set of Holtec racks. Holtec used the results of the calculation to state that the criticality analysis for both sets of Holtec racks could be combined. The Critical Safety Analysis utilized the 0.0162 gm B-10/cm^2 as the nominal value (+/-0.0012).
- After a reasonable search of the plants records, including docketed information, JAF determined that the characterization of the as-built areal densities for the PaR and second set of Holtec racks was not part of the original licensing basis or previously requested by the NRC as part of the licensing action that approved the neutron absorber monitoring program and is not available.

iii. material characteristics, including porosity, density and dimensions

Response

- The core of Boral is somewhat less than maximum theoretical density and can contain varying amounts of porosity (1 to 8%). This porosity can have varying degrees of interconnectivity potentially allowing water ingress into the core.
- The Boral plates used in the PaR racks are 152 inches long by 5.25 inch wide by 0.115 inch thick.
- The Boral plates used in the Holtec racks are of two lengths. The first set of Holtec racks use 144 inch plates and the second set use 150 inch plates. The Holtec plates are 5.00 inch wide and 0.075 inch thick. These are nominal dimensions.

c) qualification testing approach for compatibility with the SFP environment and results from the testing

Response

Boral, which was the patented product of AAR Brooks and Perkins, is a poison material used in spent fuel storage racks as a neutron absorber material. Around 1990, Holtec International undertook an assessment of the use of Boral, compiling information from in-plant operating experience, laboratory tests and coupon data.

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Boron carbide is considered a strong neutron absorbing material known to be both physically stable and chemically inert in the radiation, thermal, and aqueous environment of the spent fuel pools. Boral was originally manufactured by AAR Brooks and Perkins under a computer-aided/Quality Control program in conformance with requirements found in 10CFR50, Appendix B. The core of a Boral plate is made from a composite of finely divided B_4C powder with Type 1100 aluminum powder. Construction of a specific Boral plate is dependent upon the Boron-10 loading requirement.

AAR and its predecessor, Brooks & Perkins, conducted extensive qualification testing to demonstrate the suitability of Boral for spent fuel storage and transportation applications. Radiation qualification testing consisted of subjecting a series of Boral samples to gamma, thermal neutron and fast neutron radiation in water at the reactor core face at the University of Michigan 2 MW_{th} Ford Nuclear Reactor. The tests ran for a period of nine years and periodically three samples were removed for inspection and testing. Test results are reported up to 7×10^{11} rads gamma. At this gamma exposure, the samples had also received fast and thermal neutron exposures of 3.6×10^{18} nvt and 2.7×10^{19} nvt, respectively. The test specimens were severely oxidized having been in the pool water for nine years. The oxidation could be removed by brushing with a wire brush. Aside from the corrosion, the samples showed no other signs of physical deterioration. Neutron attenuation testing and neutron radiography showed no loss of boron carbide. This was confirmed by chemical analysis. Tensile test results indicate no change in the ultimate strength. It is noted that the test conditions in the pool of the Ford Nuclear Reactor are far more severe in terms of radiation damage than conditions in spent fuel storage applications.

The use of Boral in the spent fuel pool environment is extensive and this provides a basis for the knowledge of Boral in such environments. This helps to provide confidence in the acceptability of Boral in the spent fuel racks as a neutron absorber. Available surveillance coupon data in the evaluation of the acceptability for Boral in the racks, confirmed that there was no loss of boron content during in-service operation under the radiation, thermal and chemical environments.

Corrosion of Boral is related to general corrosion and localized pitting. This was not deemed as a cause for concern, as no significant loss of the B_4C would occur. In general, corrosion of Boral appeared to be essentially that of the aluminum used in manufacture with no contribution from the inert B_4C.

Coupons from two plants (Susquehanna and Cooper Station) showed some blistering on the coupons. However, analysis of the Boron-10 content by neutron attention and wet chemical technique confirmed that there was no loss of boron.

Available information in the evaluation of the acceptability for Boral in the racks, demonstrated that the performance of Boral in environments representative of spent fuel storage pools showed that Boral is fully capable of maintaining its effectiveness as a control poison over an anticipated 40 or 50 year lifetime. Cladding and the core aluminum of Type 1100 aluminum alloy exhibits good corrosion resistance. When exposed to water, the aluminum reacts to form a tightly adhering layer of hydrated oxide, which provided a protective later that affords good corrosion resistance to Boral.

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d) configuration in the SFP

i. method of integrating neutron-absorbing material into racks (e.g., inserts, welded in place, spot welded in place, rodlets)

Response

The JAF spent fuel pool storage racks consist of two separate designs:

- Aluminum High Density (PaR) Racks:

  The spent fuel storage racks are made up of double-walled aluminum containers. These are approximately 14 feet long and have a square cross section with an inner dimension of 6.16 inches. A Boral plate (B_4C in a matrix of aluminum) is seal welded into the cavity between adjacent cells.

- Stainless Steel (Holtec) High Density Racks:

  The rack structure is a folded metal plate assemblage welded to a base plate and supported on four legs. The principal parts are (1) the storage box subassembly, (2) the baseplate, (3) the neutron absorber material, (4) picture frame sheathing and (5) support legs. The “boxes” are fabricated from two precision formed channels (austenitic stainless steel ASTM 240-304L) by seam welding them together in a seam welding machine. “Picture frame sheathing” is attached to each side of the box with poison material installed in the sheathing cavity. The box with the integrally connected sheathing is referred to as the “composite box.” Both sets of Holtec racks are of the same basic design differing only in the height of the Boral plates.

ii. ***sheathing and degree of physical exposure of neutron absorbing materials to the spent fuel pool environment***

Response

- PaR Racks:

  Boral is seal welded in the cavity between adjacent fuel assemblies. The Boral is not exposed to pool water.

- Holtec Racks

  These racks use a picture frame sheathing attached to the side of the box with the Boral poison material installed in the sheathing cavity. The sheathing is welded to the box at the top and bottom and at staggered positions along the longitudinal length. The sheathing is not seal welded to the box. Pool water is free to enter the cavity, and hydrogen gas produced by the water–aluminum reaction to exposure of the Boral aluminum cladding to pool water is free to escape.

e) current condition of the credited neutron-absorbing material in the SFP

i. estimated current minimum areal density

Response

Based on results of boron loading by chemistry, neutron attenuation measurements of coupons, and review of the literature, there are no known mechanisms by which B-10 is lost from plates in service. Therefore, the estimated current minimum areal density is the

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same as when the material was fabricated and installed in the SFP, which is provided in the response to 1 b) ii.

ii. current credited areal density of the neutron-absorbing material in the NCS AOR

Response

The current credited areal density in the AOR for the PaR racks is the minimum certified areal density of 0.0232 gmB-10/cm^2. The current credited areal density in the AOR for the Holtec racks is a nominal areal density of 0.0162 gmB-10/cm^2 with an areal density tolerance of +/- 0.0012 gmB-10/cm^2 included as an uncertainty.

iii. recorded degradation and deformations of the neutron-absorbing material in the SFP (e.g., blisters, swelling, gaps, cracks, loss of material, loss of neutron-attenuation capability)

Response

Almost all coupons examined that were exposed to spent fuel pool water exhibit some amount of blistering beginning with the first set of coupons examined in 1987. There is no obvious trend, qualitatively speaking, to the blistering behavior. Blisters appear predominantly near the cut edges of the coupons. There have been no observations of any interference to fuel movements within any of the racks. Radiographs have been performed of blistered coupons and there have been no indications linking blisters with loss of boron loading in the Boral.

Many coupons show evidence of pitting corrosion in the aluminum sheets covering the Boral core. The pits appear to extend through the thickness of sheet. Pitting corrosion is highly localized affecting a small fraction of a coupon when present. In the most recent coupon inspection, a radiograph of a pitted coupon shows no adverse effect on B-10 areal density.

The details of the most recent coupon reports are provided in the response to ARI 2 a) iv.

Through all Boral coupon surveillances for both PaR and Holtec racks, there has not been any significant change in areal B-10 density. To date, the poison density and overall structural integrity of the Boral and contained poison appears unaffected by the blistering and pitting. Surveillance as planned will continue to provide data to judge long-term integrity of the Boral panels.

ARI 2

Describe the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used.

a) Provide the technical basis for the surveillance or monitoring method, including a description of how the method can detect degradation mechanisms that affect the material's ability to perform its safety function. Also, include a description and technical basis for the technique(s) and method(s) used in the surveillance or monitoring program, including:

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Response

The Boral surveillance program at JAF consists of a coupon surveillance program for both the PaR and Holtec rack designs. The coupons were taken from the same lots of material used in construction of the racks, and encased in a similar manner as the in-service material. The coupons are thus able to detect aging/degradation mechanisms that the in-service materials experience.

i. approach used to determine frequency, calculations and sample size

Response

The coupon test frequency and sample size were based on operating experience with Boral and not based on an analytic determination. Based on accelerated test programs and years of operating experience, Boral is considered a satisfactory material for reactivity control. Ongoing programs at various spent fuel pools have not demonstrated cases where loss of neutron absorbing capability has occurred when utilizing industry standard monitoring programs.

The frequency of Boral inspection and testing activities is consistent with the guidance in NUREG-1801, Section XI.M40, which states that the frequency is “not to exceed 10 years”. The site’s monitoring program procedure for the Holtec racks outlines an initial test frequency of three years, followed by a five year frequency of occurrence, as given in the response to ARI 2 b) ii (4).

The site’s monitoring program frequency for the PaR racks is outlined in the response to ARI 2 b) ii (4). The remaining coupons from Coupon No. 6 forward are scheduled at a 10 year frequency of occurrence.

The total coupon amount was twelve Boral test coupons for the Holtec racks and eight test coupon assemblies, with two containers of four test coupons each for the PaR racks (for a total of 64 PaR coupons). An additional eight test coupon assemblies were provided as spares to be used as replacements or held for archive purposes, which brings the total to 128 PaR coupons. These amounts were based on the rack manufacturers’ recommendations.

ii. parameters to be inspected and data collected

Response

The JAF Boral monitoring program consists of coupon measurements in the following areas:

- Visual Examination
- Photograph (each side of coupon)
- Coupon weights
- Neutron Transmission/Attenuation

iii. acceptance criteria of the program and how they ensure that the material’s structure and safety function are maintained within the assumptions of the NCS AOR

Response

The purpose of the surveillance program is to characterize certain properties of the Boral with the objective of providing data necessary to assess the capability of the Boral panels in the racks to continue to perform their intended function. The surveillance program is not designed to confirm the safety function of the in-service material, but it is capable of detecting the onset of any significant degradation. In the event that an acceptance criterion is not met, the corrective action program will be used confirm the safety function of the in-service material.

The acceptance criteria for the JAF monitoring program are as follows:

- The neutron attenuation of the Boral has to be greater than or equal to the areal density assumed in the AOR (0.0232 gm B-10/cm^2) for the Aluminum High Density Racks (PaR fuel storage racks).
- The neutron attenuation of the Boral has to be greater than or equal to the areal density assumed in the AOR (0.0162 gm B-10/cm^2) for the Stainless Steel High Density Racks (Holtec fuel storage racks).

iv. monitoring and trending of the surveillance or monitoring program data

Response

JAF has performed monitoring of the Boral surveillance coupons as described above. Tests were conducted on coupons from the JAF SFP. The most recent tests were conducted in the years 2000, 2005, 2011 and 2016. The 2016 test results are not yet processed and therefore have not been described. As part of the JAF testing program, the areal densities are measured to ensure that these remain above the areal density assumed in the AOR: 0.0232 gm B-10/cm^2 for the Aluminum High Density Racks (PaR fuel storage racks) and 0.0162 gm B-10/cm^2 for the Stainless Steel High Density Racks (Holtec fuel storage racks). Furthermore, the measured areal densities are compared to as-manufactured values to ensure that that no significant loss of Boron is ongoing. The following information was summarized the surveillance reports.

A. Year 2000

Testing consisted of eight coupons from the PaR fuel storage racks (i.e., aluminum high density racks) and two coupons from the Holtec fuel storage racks (i.e., stainless steel high density racks). Visual inspection of the coupons conducted concluded that the eight PaR coupons in a sealed capsule were in as-fabricated condition with no blisters in the aluminum skin. Two of the PaR coupons (8-3010-3-6 and 8-3010-3-5) showed a series of small blisters along the edges only.

One of the Holtec coupons (CA031198-1-5) had blisters present on the edges and in the central region on both sides. The second coupon (DA031338-2-4) exhibited blisters only on the edges.

Each coupon was subjected to neutron attenuation measurement for Boron-10 areal density determination. The measurement showed that the lowest average areal density measured for the PaR coupons was 0.02398 gm B-10/cm^2. This is higher than the certified areal density of 0.0232 gm B-10/cm^2 for the PaR racks, and above the Boral areal density used in the NCS AOR (0.0232 gm B-10/cm^2).

Furthermore, the measurement showed that the lowest average areal density measured for Holtec coupons was 0.02066 gm B-10/cm^2. This is higher than the pre-exposure areal density of 0.0202 gm B-10/cm^2 for that coupon, and above the Boral areal density used in the NCS AOR (0.0162 gm B-10/cm^2). Therefore, all coupons met the areal density acceptance criterion.

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B. Year 2005

Testing consisted of eight coupons from the PaR fuel storage racks (i.e., aluminum high density racks) and one coupon from the Holtec fuel storage racks (i.e., stainless steel high density racks). Visual inspection of the coupons conducted saw that the eight PaR coupons in the sealed capsule were in the as-fabricated conditions with no blisters in the aluminum skin. All of the vented PaR coupons as well as the Holtec coupon had a more or less uniform oxide film on all surfaces.

Each of the PaR coupons had a series of small blisters that appear to have initiated within an inch of an edge of the coupons. The blisters range in size from approximately ¼ in. to ¾ in. in diameter. In addition, all of the PaR vented coupons had a few corrosion pits. The Holtec coupon (DA032046-2-2) had seven small blisters on the front side and five small blisters on the back side.

Each coupon was subjected to neutron attenuation measurement for Boron-10 areal density determination. The measurement showed that the lowest average areal density measured for the PaR coupons was 0.02504 gm B-10/cm^2. This is higher than the certified areal density of 0.0232 gm B-10/cm^2 for the PaR racks, and above the Boral areal density used in the NCS AOR (0.0232 gm B-10/cm^2).

Furthermore, the measurement showed that the lowest average areal density measured for Holtec coupon was 0.02236 gm B-10/cm^2. This is higher than the pre-exposure areal density of 0.0223 gm B-10/cm^2 for that coupon , and above the Boral areal density used in the NCS AOR (0.0162 gm B-10/cm^2). Therefore, all coupons met the areal density acceptance criterion.

C. Year 2011

Testing consisted of one Boral coupon from the Holtec fuel storage racks (i.e., stainless steel high density racks). The coupon (CA031198-1-7) was found in good condition, with no significant deterioration or degradation. Though there were numerous clad blisters on both sides of the coupon, it does not affect the neutron absorbing function of the material. All blisters on the front side range in area from 0.0064 in.^{2} to 0.9309 in.^{2}, except for one blister that measured 2.4988 in.^{2}. On the back side of the coupon, the blisters ranged from a minimum 0.0336 in.^{2} to a maximum of 1.1245 in.^{2} It was concluded that the blisters did not affect the functionality of the neutron absorbing material.

The coupon was subjected to neutron attenuation measurement for Boron-10 areal density determination. The measurement showed that the lowest average areal density measured for Holtec coupon CA031198-1-7 was 0.0221 gm B-10/cm^2. This is higher than the pre-exposure areal density of 0.0210 gm B-10/cm^2 for that coupon, and above the Boral areal density used in the NCS AOR (0.0162 gm B-10/cm^2). Therefore, the coupons met the areal density acceptance criteria.

<u>Conclusive Statement</u>

The three separate surveillance testing periods show a uniform result of coupons remaining intact through the surveillance period, with some blistering and no apparent areas of missing Boral, resulting in acceptable coupon performance.

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v. industry standards used

Response

License Amendments 55, 175, and 256 do not specify any codes or standards that pertain directly to the coupon surveillance program; however, the JAF program is consistent with the recommendations outlined in NUREG-1801, Section XI.M40. As recommended in NUREG-1801, Section XI.M40, para. 3, parameters that should be monitored “include the physical condition of the neutron-absorbing materials, such as in-situ gap formation, geometric changes in the material (formation of blisters, pits, and bulges) as observed from coupons or in situ, and decreased boron areal density, etc.” In accordance with the above guidance, JAF monitors the following parameters:

- physical condition of the neutron absorbing materials (see ARI 2 a ii.)
- geometric changes in the material (e.g., formation of blisters, pits, and bulges) as observed from the coupons (see ARI 2 a ii.)
- boron areal density (see ARI 2 a ii.)

JAF also follows the recommendation in NUREG-1801, Section XI.M40, para.4, which states that the “frequency of the inspection and testing depends on the condition of the neutron-absorbing material and is determined and justified with plant-specific operating experience by the licensee, not to exceed 10 years.” This is demonstrated in the ARI 2 a i, that indicates testing will not exceed a timeframe of 10 years.

Conclusive Statement

The responses provided in in sub-parts *i, ii, and iv* of ARI 2 a) provide satisfactory conclusions that the JAF Boral Surveillance Program meets the regulatory guidelines.

b) For the following monitoring methods, include these additional discussion items:

i. If there is visual inspection of in-service material:

(1) Describe the visual inspection performed on each sample.

(2) Describe the scope of the inspection (i.e., number of panels or inspection points per inspection period).

Response

JAF does not perform visual inspections of their in-service material in the spent fuel pool storage racks

ii. If there is a coupon monitoring program:

(1) Provide a description and technical basis for how the coupons are representative of the material in the racks. Include in the discussion, the material radiation exposure levels, SFP environment conditions, exposure to the SFP water, location of the coupons, configuration of the coupons (e.g., jacketing or sheathing, venting bolted on, glued on, or free in the jacket, water flow past the material, bends, shapes, galvanic considerations, and stress-relaxation considerations), and dimensions of the coupons.

Response

JAF utilizes a Boral coupon monitoring program. Some of the coupons are surrogate material from the same manufacturing lot as installed material. Since the fuel in the spent fuel pool racks (both new and used) undergoes reconfigurations, the Boral coupons are situated in the spent fuel pool per vendor recommendations to represent exposure histories, the same water conditions, and provide exposure to gamma and neutron irradiation. The coupons are able to detect aging/degradation mechanisms that the in-service neutron absorber materials experience.

The PaR coupons are 5-inch by 10-inch nominal Boral slabs. Each coupon holder contains eight coupons: 4 are sealed in the same manner as in the racks and not exposed to water, and four are vented and exposed to pool water. The coupon holders house the Boral coupons and are hung from the side of a spent fuel rack. There is no bolting used to seal the coupons in the holders.

The Holtec coupons are nominally 4 inch by 15 inch. They are placed in a vented stainless steel jacket and stainless steel bolts hold it in position on the coupon assembly to simulate any galvanic issues during the time in the spent fuel pool. The Holtec coupons are all placed on a coupon tree that is inserted into a rack cell surrounded by other rack cells.

The Holtec coupons were installed with the first set of Holtec racks. The second set of Holtec racks were installed during the timeframe in which the NRC was not requiring a monitoring program for Boral, so no coupons were installed into those racks. It is expected that the coupons from the first set of Holtec racks are representative of the second set of racks, since their designs are identical except for the Boral plate height and areal density. They have also undergone longer exposure to the SFP environment than the second set of racks.

(2) Provide the dates of coupon installation for each set of coupons.

<u>Response</u>

Two styles of Boral coupons were installed in the JAF spent fuel pool to represent the conditions of the Boral contained in the spent fuel pool storage racks. The first of these, representing the PaR racks, were installed in July 1984. The second style of coupons, representing the Holtec racks, were installed on November 19, 1994.

(3) If the coupons are returned to the SFP for further evaluation, provide the technical justification of why the reinserted coupons would remain representative of the materials in the rack.

<u>Response</u>

The Boral sample coupons are <u>not</u> returned to the spent fuel pool rack for further evaluation. However, some spare coupon holders replaced those withdrawn early in the program.

(4) Provide the number of coupons remaining to be tested and whether there are enough coupons for testing for the life of the SFP. Also provide the schedule for coupon removal and testing.

<u>Response</u>

Seven sets of PaR coupons assemblies have been withdrawn and examined to date. Of the original PaR coupon assemblies, a single coupon assembly remains in the pool and is scheduled for removal in 2024. There are 5 additional coupon assemblies in the pool that replaced withdrawn assemblies early in the program. There are no dates fixed for withdrawal of those replacement assemblies but are available for analysis if the spent fuel pool operation conditions warrant further analysis beyond JAF's current renewed Operating License in 2034.

Eight Holtec Boral coupons have been withdrawn and examined to date. Four Holtec coupons remain in the pool. They are scheduled to be withdrawn at five year intervals with the next coupon scheduled for 2019.

JAF has committed to a coupon analysis program in accordance with License Amendments 55, 175 and 256. JAF coupon analysis schedule was originally based on vendor recommendations. To ensure coupon analysis is in accordance with industry standards, JAF has since committed to maintaining a Boral coupon program that follows a Technical Specifications schedule for removal and analysis of the coupons.

iii. If RACKLIFE is used:

(1) Note the version of RACKLIFE being used (e.g., 1.10, 2.1).

(2) Note the frequency at which the RACKLIFE code is run.

(3) Describe the confirmatory testing (e.g., in-situ testing) being performed and how the results confirm that RACKLIFE is conservative or representative with respect to neutron attenuation.

(4) Provide the current minimum RACKLIFE predicted areal density of the neutron-absorbing material in the SFP. Discuss how this areal density is calculated in RACKLIFE. Include in the discussion whether the areal densities calculated in RACKLIFE are based on the actual as-manufactured areal density of each panel, the nominal areal density of all of the panels, the minimum certified areal density, the minimum as-manufactured areal density, or the areal density credited by the NCS AOR. Also discuss the use of the escape coefficient and the total silica rate of Boraflex degradation in the SFP.

Response

RACKLIFE is only applicable for Boraflex, and therefore is not applicable to JAF, since Boral is used.

iv. If in-situ testing with a neutron source and detector is used (e.g., BADGER testing, blackness testing):

(1) Describe the method and criteria for choosing panels to be tested and include whether the most susceptible panels are chosen to be tested. Provide the statistical sampling plan that accounts for both sampling and measurement error and consideration of potential correlation in sample results. State whether it is statistically significant enough that the result can be extrapolated to the state of the entire pool.

(2) State if the results of the in-situ testing are trended and whether there is repeat panel testing from campaign to campaign.

(3) Describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (Agency wide Access and Management Systems Accession No. ML12254A064). Discuss the effect of rack cell deformation and detector or head misalignment, such as tilt,

twist, offset, or other misalignments of the heads and how they are managed and accounted for in the analysis.

(4) Describe the calibration of the in-situ testing device, including the following:

(a) Describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results.

(b) Describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results.

(c) If the calibration includes the in-situ measurement of an SFP rack "reference panel", explain the following:

(i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements,

(ii) whether all surveillance campaigns use the same reference panel(s)

(iii) If the same reference panels are not used for each measurement surveillance, describe how the use of different reference panels affects the ability to make comparisons from one campaign to the next.

Response

In-situ testing is not part of the Boral monitoring program at JAF.

ARI 3

For any Boraflex, Carborundum, or Tetrabor being credited, describe the technical basis for determining the interval of surveillance or monitoring for the credited neutron-absorbing material. Include a justification of why the material properties of the neutron-absorbing material will continue to be consistent with the assumptions in the SFP NCS AOR between surveillances or monitoring intervals.

Response

The JAF plant does not utilize Boraflex, Carborundum or Tetrabor in its spent fuel pool.

ARI 4

For any Boraflex, Carborundum, Tetrabor, or Boral being credited, describe how the credited neutron-absorbing material is modeled in the SFP NCS AOR, and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR:

a) Describe the technical basis for the method of modeling the neutron-absorbing material in the NCS AOR. Discuss whether the modeling addresses degraded neutron-absorbing material, including loss of material, deformation of material (such as blisters, gaps, cracks, and shrinkage), and localized effects, such as non-uniform degradation.

Response

The Boral in the NCS AOR for both rack types is modeled at, or below (for Holtec), the minimum certified areal density with no consideration of deformation (i.e. blisters and

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pits). Industry and JAF experience has shown that Boral deformations (blisters and pits) do not cause a loss in neutron absorbing capability, so modeling the material in this manner is appropriate. There is also no identified long term boron loss mechanism for Boral that would require a reduction in the areal density used in the rack criticality analysis.

b) Describe how the results of the monitoring or surveillance program are used to ensure that the actual condition of the neutron absorbing material is bounded by the SFP NCS AOR. If a coupon monitoring program is used, provide a description and technical basis for the coupon tests and acceptance criteria used to ensure the material properties of the neutron-absorbing material are maintained within the assumptions of the NCS AOR. Include a discussion on the measured dimensional changes, visual inspection, observed surface corrosion, observed degradation or deformation of the material (e.g., blistering, bulging, pitting, or warping), and neutron-attenuation measurements of the coupons.

Response

The technical basis and acceptance criteria of the coupon monitoring program are provided in the responses to ARI 2 a). The details on the coupon results are provided in the response to ARI 2 a) iv.

In order to ensure that the spent fuel storage racks are meeting their intended function the vendor analysis of the Boral coupons is reviewed. The review of the analysis will document any adverse trends to see if the data supports continued operation/operability of the spent fuel pool racks. If there are any questions with regards to operability of the spent fuel storage racks, JAF employs the use of the "Defense in Depth Strategy" as outlined in the 2012 EPRI Technical Report "Strategy for Managing the Long Term Use of Boral in Spent Fuel Storage Pools."

c) Describe how the bias and uncertainty of the monitoring or surveillance program are used in the SFP NCS AOR.

Response

The bias and uncertainty of the monitoring program is not used in the NCS AOR for either rack design. Industry and JAF experience indicates that Boral does not lose neutron absorbing capability, so not including any bias or uncertainty from the monitoring program is appropriate. For Boral, the monitoring program is used as a confirmation that no loss of neutron absorbing capability has occurred.

d) Describe how the degradation in adjacent panels is correlated and accounted for in the NCS AOR.

Response

As described in the response to ARI 4(a) above, the NCS AORs do not account for degradation in adjacent panels. Based on coupon surveillance results, there are no degraded conditions affecting criticality analyses.

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ARI 5

For any Boraflex, Carborundum, or Tetrabor being credited, describe the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events (e.g., seismic events, loss of SFP cooling, fuel assembly drop accidents, and any other plant-specific design-basis events that may affect the neutron-absorbing material).

a) ***For each design-basis event that would have an effect on the neutron-absorbing material, describe the technical basis for determining the effects of the design-basis event on the material condition of the neutron-absorbing material during the design-basis event, including:***
   i. ***shifting or settling relative to the active fuel***
   ii. ***increased dissolution or corrosion***
   iii. ***changes of state or loss of material properties that hinder the neutron-absorbing material's ability to perform its safety function***

b) ***Describe how the monitoring program ensures that the current material condition of the neutron-absorbing material will accommodate the stressors during a design-basis event and remain within the assumptions of the NCS AOR, including:***
   i. **monitoring methodology**
   ii. ***parameters monitored***
   iii. ***acceptance criteria***
   iv. ***intervals of monitoring***

   Response

   The JAF plant does not utilize Boraflex, Carborundum or Tetrabor in its spent fuel pool.

References:

[1] Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools," ML16097A169