Entergy Operations, Inc.
17265 River Road
Killona, LA 70057-3093
Tel 504 739 6660
mchisum@entergy.com

Michael R. Chisum
Site Vice President
Waterford 3

10 CFR 50.54(f)

W3F1-2016-0065

November 2, 2016

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Waterford 3 Response to Generic Letter 2016-01
Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools
Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

References: NRC letter to Entergy, "Generic Letter 2016-01: Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools," dated April 7, 2016 (0CNA041601) (ML16097A169)

Dear Sir or Madam:

On April 7, 2016, the U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2016-01 to all nuclear power reactors, except those that have permanently ceased operations with all reactor fuel removed from onsite spent fuel pool storage and all holders of operating license for a non-power reactor who have fuel storage.

Pursuant to 10 CFR 50.54(f), this letter provides the Entergy Operations, Inc. (Entergy) response to GL 2016-01 for Waterford 3, including the applicable Areas of Requested Information (ARI). Per the descriptions provided in GL 2016-01, page 7-8 of 15, Waterford 3 has been determined to be a response Category 4 licensee. This response has been developed based on a reasonable search of the plant's records, including docketed information.

This letter contains no new commitments. Please contact John P. Jarrell, Regulatory Assurance Manager, at (504) 739-6685 if you have questions regarding this information.

I declare under penalty of perjury that the foregoing is true and correct. Executed on November 2, 2016.

Sincerely,

MRC/JPJ/mmz

Attachment: Waterford Steam Electric Station, Unit 3 Response to Generic Letter 2016-01

cc: Mr. Kriss Kennedy, Regional Administrator
U.S. NRC, Region IV
RidsRgn4MailCenter@nrc.gov

U.S. NRC Project Manager for Waterford 3
April.Pulvirenti@nrc.gov

U.S. NRC Senior Resident Inspector for Waterford 3
Frances.Ramirez@nrc.gov
Chris.Speer@nrc.gov

Attachment

to

W3F1-2016-0065

Waterford Steam Electric Station, Unit 3

Response to Generic Letter 2016-01

Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools

(15 pages)

Waterford Steam Electric Station, Unit 3
Response to Generic Letter 2016-01
Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools

NRC Request

Nuclear Regulatory Commission (NRC), Generic Letter (GL) 2016-01, requested each licensee submit a written response in accordance with 10 CFR 50.54(f) within 210 days of the date of the GL to provide the requested information summarized below:

(1) a description of 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;

(2) a description of 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;

(3) a description of the technical basis for determining the interval of surveillance or monitoring for the credited neutron-absorbing material;

(4) a description of 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; and

(5) a description of 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.

The NRC provided four areas of categorization from which they would accept a response.

Category 1: Power reactor addressees that do not credit neutron-absorbing materials other than soluble boron in the AOR.

Category 2: Power reactor addressees that have an approved license amendment to remove credit for existing neutron-absorbing materials and that intend to complete full implementation no later than 24 months after the issuance of this GL.

Category 3: Power reactor addressees that have incorporated their neutron absorbing material monitoring programs into their licensing basis through an NRC-approved Technical Specification (TS) change or license condition.

Category 4: All other power reactor addressees.

Waterford 3 does not fall under Categories 1-3; therefore, Waterford 3 has been determined to be a Category 4 licensee. For Category 4 licensees, the GL states that the NRC seeks information in five areas depending upon the type of neutron absorber material used by the licensee in the SFP. The requested information (in italics) along with the Waterford 3 responses are provided below.

GL 2016-01, 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;*

Waterford 3 Response

Twenty five racks were designed and manufactured for wet storage of spent and new fuel by Holtec International Inc. Sixteen of those racks were placed in the spent fuel pool (Region 2), four racks were placed in the cask storage pit (Region 1), and five racks will be placed in the refueling canal (Reference 2, Section 2.4.1).

All currently installed racks contain Boral inserts, a patented product of AAR Manufacturing, Inc. (Reference 3, Section 2.0).

The racks were installed between October 3, 1998 and November 9, 1998 (Reference 4, page 51).

The four racks located in the Cask Storage Area (Region 1) of the spent fuel pool were removed in 2011 (Reference 5, pages 3-4).

With regard to the request for date of manufacture of the neutron absorbing material, after a reasonable search of plant records, including docketed information, Waterford 3 has determined that the requested information was not part of the original licensing basis nor previously requested by the NRC as part of the licensing action that approved the neutron absorber monitoring program.

b) *neutron-absorbing material specifications, such as:*

i) *materials of construction, including the certified content of the neutron-absorbing component expressed as weight percent;*

Waterford 3 Response

Boral is a cermet composite material made of Type 1100 aluminum and boron. The composite panel consists of boron carbide particles embedded in a Type 1100 aluminum matrix clad in Type 1100 aluminum sheets (Reference 2, Section 2.5.2).

The Boral in Region 2 of the SFP contains 69.59% Al and 30.41% B4C as an input into the AOR (Reference 6, page B-2).

With regard to the request for certified content of the neutron absorbing component of the Boral inserts, after a reasonable search of plant records, including docketed information, Waterford 3 determined that the requested information was not part of the original licensing basis nor previously requested by the NRC as part of the licensing action that approved the neutron absorber monitoring program.

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

Waterford 3 Response
For the ten Region 2 Boral Coupons installed in the pool, the average initial areal density for the coupons was 0.02371 g B-10/cm^2 (Reference 7).

With regard to the as-built areal densities of the Boral panels, after a reasonable search of plant records, including docketed information, Waterford 3 determined that the requested information was not part of the original licensing basis nor previously requested by the NRC as part of the licensing action that approved the neutron absorber monitoring program.

iii) *material characteristics, including porosity, density, and dimensions;*

Waterford 3 Response
Dimension of the Boral poison sheets are nominally 0.075 inches thick by 7.25 inches wide by 155 inches long (Reference 8, Item 6).

The density of the Boral inserts assumed in the AOR is 2.646 g/cc (Reference 6, page B-2).

For the ten Region 2 Boral coupons installed in the pool, the average initial density for the coupons was 2.6161 g/cc (Reference 7).

With regard to the porosity of the Boral inserts, after a reasonable search of plant records, including docketed information, Waterford 3 determined that the requested information was not part of the original licensing basis nor previously requested by the NRC as part of the licensing action that approved the neutron absorber monitoring program.

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

Waterford 3 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.

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 10 CFR 50, Appendix B. The core of a Boral plate is made from a composite of finely divided B4C 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 MWth Ford Nuclear Reactor. The tests ran for a period of nine years and three samples were removed periodically for inspection and testing. Test results are reported up to 7 x 10^{11} rads gamma. At this gamma exposure, the samples had also received fast and thermal neutron exposures of 3.6 x 10^{18} nvt and 2.7 x 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 at the time 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 B4C would occur. In general, corrosion of Boral appeared to be essentially that of the aluminum used in manufacture with no contribution from the inert B4C.

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

Available information at the time 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.

d) configuration in the SFP, such as:

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

Waterford 3 Response
The Boral inserts are sheets placed in stainless steel sheathes on each side of the stainless steel box that makes up a cell (Reference 6, Section 5.5.2).

The stainless steel boxes are welded together such that every cell has a Boral insert over the entire length of the active fuel on all 4 sides of the box. In addition, there is at least one Boral panel between adjacent assemblies at interfacing sides of Region 2 racks (Reference 6, Section 7.3.2).

All welds in the construction of the racks conform to the requirements of Section II of the ASME Boiler and Pressure Vessel Code (Reference 9, page 220).

ii) sheathing and degree of physical exposure of neutron-absorbing materials to the SFP environment;

Waterford 3 Response
The racks have vented Boral sheathings that expose the Boral sheets to the spent fuel pool water (Reference 2, Section 2.5.2).

e) current condition of the credited neutron-absorbing material in the SFP, such as:

i) estimated current minimum areal density;

Waterford 3 Response
There is no evidence of loss of boron areal density based on the analysis of the tested Boral coupons detailed in the response to ARI 2(a)iv. Therefore, it is estimated that the current minimum installed areal density for the Region 2 racks is equivalent to the initial minimum areal density.

ii) current credited areal density of the neutron-absorbing material in the NCS AOR; and

Waterford 3 Response
In the analysis of record, the credited areal density of B-10 in the Boral inserts in the Region 2 racks is 0.02160 g B-10/cm^2. To account for manufacturing tolerances, the reactivity effect of the minimum B-10 areal density (0.0200 g B-10/cm^2) is included in the statistical combination of manufacturing tolerances and uncertainties (Reference 6 Page B-2).

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).*

<u>Waterford 3 Response</u>
A full summary of all tested coupons can be found in the response to ARI 2(a)iv. Results from all tested coupons indicate no gross degradation or loss of B-10 areal density.

<u>GL 2016-01, ARI (2)</u>
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:*

<u>Waterford 3 Response</u>
The Boral surveillance program at Waterford 3 consists of a coupon surveillance program. The coupons were taken from the same lots of material used in construction of the racks. They were placed in a location in the SFP and surrounded by freshly discharged fuel for four cycles in order to ensure they experienced higher than average gamma and neutron irradiation and water temperatures. After the first four cycles, the fuel surrounding the coupons was unchanged. 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;*

<u>Waterford 3 Response</u>
The coupon test frequency is provided in the response to ARI 2(b)ii(4), and the sample size is one coupon per test interval with a total of 10 Region 2 coupons initially placed on the coupon tree. These intervals and amounts 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 experienced cases where loss of neutron absorbing capability has occurred when following industry standard monitoring programs.

The coupon test frequency was based on refueling outages and was planned to exceed 10 years between intervals after the next planned coupon test. Revision 5 of the site procedure (Reference 11) was issued on October 18, 2016 to correct this frequency to fall into compliance with the testing interval described in NUREG-1801, Section XI.M40, of not to exceed 10 years. The new testing schedule, provided in the response to ARI 2(b)ii(4), specifies coupon testing every 10 years. Note that all previously tested coupons did not exceed a 10 year interval.

ii) parameters to be inspected and data collected;

Waterford 3 Response
Only certain coupons at Waterford required testing, while others only required a visual inspection. See the table in the Response to ARI 2(b)ii(4) for details on which coupons required testing. Note that all coupons removed in the future require testing. The Boral Surveillance Program states that for coupons requiring testing, the examinations consist of the following minimal requirements:

- visual observation
- neutron attenuation
- dimensional measurements
- determination of weight and specific gravity

For coupons that do not require testing, a visual inspection is to be performed and the performer of the inspection is to document any anomalies including blisters, pitting, etc. Such documentation is to be noted on a Surveillance Coupon Visual Inspection report. Where a visual inspection has revealed degradation, such as excessive blistering or pitting, the coupon must be subjected to testing.

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;

Waterford 3 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 with ample time to take such corrective actions as may be necessary.

The acceptance criteria for the Waterford 3 monitoring program are as follows:

- A coupon test result indicating a decrease of less than 5% Boron-10 content as compared to the initial measured B-10 content.
- A test result indicating an increase of less than 10% in thickness at any point from the initial thickness.

If either of these acceptance criteria is failed, then an engineering evaluation must be performed to support the continued use of the Spent Fuel Storage Racks for fuel storage. Note that the areal density corresponding to a 5% loss is still greater than that assumed in the NCS AOR, so any degradation of neutron absorbing capability will be caught and entered in the corrective action program prior to challenging the analysis limits.

iv) monitoring and trending of the surveillance or monitoring program data; and

Waterford 3 Response
Waterford 3 has performed monitoring of Boral surveillance coupons as described above. Tests were conducted in 2001, 2005, and 2010. In addition, visual inspections were conducted in 2002 and in 2003. No Region 2 coupons have failed the acceptance criteria, and the visual inspection performed in 2003 noted no anomalies. The visual inspection report from 2002 is unavailable, but it is expected that no anomalies were noted since no testing was subsequently performed on that coupon. The Region 1 rack and coupon tree is no longer in the pool, so any results from those coupons were not included in this response.

As part of the Waterford 3 testing program, the areal densities recorded during the test being conducted are compared to as-manufactured values to ensure that the acceptance criteria are met. The following information was summarized in the surveillance reports.

A. Coupon 2-1 (Year 2001)

The coupon was determined to be in good condition. There were no corrosion pits and no blisters. Furthermore, no blisters developed during elevated temperature drying. The thickness was compared to the pre-irradiation value for the coupon, which showed a reduction in the thickness of 1.53%. Therefore, the coupon met the thickness acceptance criteria, as the thickness changed less than 10%, and is deemed satisfactory.

The Boron-10 areal density was measured via neutron attenuation testing conducted at five locations on the coupon. The average areal density was 0.02372 g B-10/cm^2, which is above the pre-exposure areal density of 0.0233 g B-10/cm^2 for that coupon, as well as above the areal density assumed in the criticality AOR for Region 2 (0.02 g B-10/cm^2). Thus, the coupon met the areal density acceptance criterion.

B. Coupon 2-4 (Year 2005)

The visual inspection of R2-4 also showed no blisters or pitting. The as-built thickness of the Boral coupon is 0.076 inches. The thickness was measured at five locations on the coupon, which showed an average reduction in the thickness of 2.5%. Therefore, the coupon met the thickness acceptance criteria, as the thickness changed less than 10%, and is deemed satisfactory.

The Boron-10 areal density was measured via neutron attenuation testing conducted at five locations on the coupon. The average areal density was 0.02386 g B-10/ cm^2, which is above the pre-exposure areal density of 0.0233 g B-10/ cm^2 for that coupon, as well as above the areal density assumed in the criticality AOR for Region 2 (0.02 g B-10/ cm^2). Thus, the coupon met the areal density acceptance criterion.

C. Coupon 2-5 (Year 2010)

The coupon was in good overall condition. A few corrosion pits were noted on each coupon, and a small blister was noted near the right edge of the back side prior to

drying. The as-built thickness of the coupon was 0.076 in. The thickness was measured at five locations on the coupon, which showed an average reduction in the thickness of 6.63%. Therefore, the coupon met the thickness acceptance criteria, as the thickness changed less than 10%, and is deemed satisfactory.

The Boron-10 areal density of the coupon was measured via neutron attenuation testing conducted at five locations on the coupon. The average areal density from five test locations of R2-5 was 0.0238 g B-10/ cm^2, which is above the pre-exposure areal density of 0.0236 g B-10/ cm^2 for that coupon, as well as above the areal density assumed in the criticality analysis (0.02 g B-10/ cm^2). Thus, the coupon met the areal density acceptance criterion.

Conclusive Statement

In conclusion, no trends have been identified, and the three coupon test reports show a uniform result of coupons remaining intact through the monitoring periods, with no apparent areas of missing Boral. The coupon performance has been excellent to date.

v) industry standards used.

<u>Waterford 3 Response</u>
Waterford 3 License Amendment 144 does not specify any codes or standards that pertain directly to the coupon surveillance program; however, the Waterford Boral surveillance program is consistent with the guidance provided in NUREG-1801, Section XI.M40.

As recommended in NUREG-1801, Section XI.M40, paragraph 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, Waterford 3 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 coupons (see ARI 2(a)ii)
- boron areal density (see ARI 2(a)ii).

Waterford also follows the recommendation in NUREG-1801, Section XI.M40, paragraph 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 response to ARI 2(a)i, which indicates testing will not exceed a timeframe of 10 years.

Lastly, Waterford 3 also compares coupon results to as-manufactured data for each coupon (see ARI 2(a)iv). This is consistent with guidance of paragraph 5 in section

XI.M40 of NUREG-1801, which states “measurements from periodic inspections and analysis are compared to baseline information or prior measurements and analysis for trend analysis.”

Conclusive Statement

The responses provided in subparts i, ii, and iv of ARI 2(a) provide satisfactory conclusions that the Waterford 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 inservice material:*

(1) *describe the visual inspection performed on each sample; and*

<u>Waterford 3 Response</u>
This request is not applicable. In-service inspections are not performed at Waterford 3.

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

<u>Waterford 3 Response</u>
This request is not applicable. In-service inspections are not performed at Waterford 3.

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;*

<u>Waterford 3 Response</u>
The surveillance program at Waterford 3 is modeled after the program provided by the rack vendor, Holtec International Inc., in Reference 3. As stated in Section 1.0 of Reference 3, the purpose of the surveillance program is to “characterize certain properties of the Boral with the objective of providing data necessary to assure the capability of the Boral panels in the racks to continue to perform their intended function.”

To ensure that the Boral coupons are representative of the Boral inserts installed in the racks, Holtec specified that the Boral used for the coupons was “from the same production run as the panels in the racks and dimensions of the coupon and mounting shall conform to the reference drawing” (Reference 3, Section 6.1.1). The Boral coupons are hung on hooks on a “tree,” both made of

stainless steel (Reference 12), that is then placed in a cell in the racks. There is no additional sheathing over the coupons, and pool water is free to flow around the coupons.

According to the Holtec Boral Surveillance procedure, the “accumulated dose to the Boral over a 40 year storage period is estimated to be about 3 to $7x10^{10}$ rads depending on how the racks are used and the number of full-core off-loads that may be necessary” (Reference 3, Section 4.0).

In order to ensure that the Boral inserts in the racks would continue to perform their function, a testing approach was designed that subjected the removable Boral coupons to the highest possible radiation fields to demonstrate the corrosion and irradiation effects that would be the worst anywhere in the racks. This approach included surrounding the Boral coupon tree with freshly discharged fuel assemblies for the first four cycles after rack installation (Reference 11, Attachment 13.1). After that point requiring that “any cell scheduled to receive a Coupon Tree should have fuel located in all adjacent cells prior to Coupon Tree insertion. This includes Region 1 if spent fuel is planned to be stored there” (Reference 11, Section 6.3).

Each of the Region 2 coupons measured nominally 8 inches by 4 inches by 0.075 inches before being placed into the Region 2 racks (Reference 12). The coupons were tested before insertion in the pool to determine their starting B-10 areal densities for comparison after irradiation and exposure to the pool environment (Reference 7). The coupons are removed one by one before designated time periods and sent to a vendor for testing if required (Reference 11, Attachment 13.1).

(2) *provide the dates of coupon installation for each set of coupons;*

<u>Waterford 3 Response</u>
The coupon tree containing all coupons for Region 2 racks was installed on March 17, 1999 (Reference 4, page 52).

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

<u>Waterford 3 Response</u>
The site procedure (Reference 11, Section 10.10.2) does allow for coupons evaluated with non-destructive methods to be returned to the pool and reused. However, no coupons pulled have been returned to the pool. According to ARI 2(b)ii(4), the remaining untested Region 2 coupons cover the expected operating life of the plant, so at this time Waterford 3 has no plans to reuse coupons.

(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.*

Waterford 3 Response
Four Boral coupons remain in Region 2 of the spent fuel pool. All remaining coupons are scheduled to be removed and tested in accordance with the schedule detailed in Reference 11, Attachment 13.1, which is reproduced below:

Region 2 Coupon Tree			
Pull Coupon Prior to Refuel*	Remove Coupon #	Install w/ Freshly Discharged Fuel Assemblies**†	Testing Required
10	1 (bottom, WO#50095297)	Yes	Yes
11	2 (WO#00013918)	Yes	No
12	3 (WO#00020593)	Yes	No
13	4 (WO#50989059)	Yes	Yes
16	5 (WO#00189825)	No	Yes
19	6 (WO#52491030)	No	Yes
Pull Coupon in Year			
2024	7	No	Yes
2034	8	No	Yes
2044	9	No	Yes
2054	10	No	Yes

* Remove shortly before indicated refueling.

** If Yes, following coupon removal, return tree to its previous location and then, following refueling, move tree into cell location that is surrounded by freshly discharged fuel assemblies. If No, return coupon tree to previous location.

† Region 2 Coupon Tree must be stored in Region 2 of the SFSR.

This schedule was implemented beginning with Revision 5 of the procedure (effective October 18, 2016).

As shown by the schedule, the remaining coupons to be tested will last until the year 2054. This covers the current expected operating life of the plant.

iii) *If RACKLIFE is used:*

Waterford 3 Response
This request is not applicable. RACKLIFE is not used at Waterford 3.

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

Waterford 3 Response
This request is not applicable. In-situ testing is not performed at Waterford 3.

<u>GL 2016-01, ARI (3)</u>

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.

<u>Waterford 3 Response</u>

This request is not applicable. Waterford 3 racks only contain Boral inserts.

<u>GL 2016-01, ARI (4)</u>

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.

<u>Waterford 3 Response</u>

For an overview of the technical basis for modeling neutron absorber material for Region 2 of the spent fuel pool, see Sections 5.5.2 and 7.2.7 of the previously submitted NCS AOR Licensing Report (Reference 13, Attachment 3).

According to the SFP NCS AOR, no specific modeling considerations were given to potential degradation of Boral inserts, or localized effects that would potentially prevent the Boral inserts from performing their function. Industry and Waterford 3 experience (Reference 14 page 5-37) has shown that Boral does not lose neutron absorbing capability, so modeling the material in this manner is appropriate.

b) 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.

<u>Waterford 3 Response</u>

The Boral coupon surveillance program is described in the response to ARI 2(b)ii. The acceptance criteria for tested Boral coupon samples are provided in the response to ARI 2(a)iii. Observations of changes and corrosion of coupons are provided in the response to ARI 2(a)iv. The response to ARI 1(b)ii details the average of the measured areal densities of the Boral coupons in Region 2 of the spent fuel. It is apparent through simple calculations that a decrease in 5% of the B-10 areal density for any of the Boral coupons would still result in an areal density of the Boral coupon that is greater than the minimum areal density assumed in the SFP NCS AOR (see response to ARI 1(e)ii for credited values). Therefore, the acceptance criteria for the Boral coupon surveillance program bounds the acceptable B-10 areal density to greater than is required by the SFP NCS AOR.

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

Waterford 3 Response
The Boral coupon monitoring program is not mentioned in the AOR. Industry and Waterford 3 experience indicates that Boral does not lose neutron absorbing capability (Reference 14 page 5-37), 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.*

Waterford 3 Response
The AOR does not account for the degradation of adjacent panels. Industry experience indicates that Boral does not lose neutron absorbing capability (Reference 14, page 5-37), so this modeling approach is appropriate.

GL 2016-01, 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).

Waterford 3 Response
This request is not applicable. Waterford 3 racks only contain Boral inserts.

References

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4. Work Authorization 99003465, “Increase Spent Fuel Storage Capacity,” 1998-99.

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8. Drawing 5817-12063, “Rack Construction – Region II Spent Fuel Storage Racks,” Sheet 1, Revision 0, February 17, 1998.

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12. Drawing 5817-12068, “Poison Test Coupon and Poison Tree Spent Fuel Storage Racks,” Revision 0, February 17, 1998.

13. Entergy Letter WF3-2008-0052, “License Amendment Request NPF-38-277,” dated September 17, 2008 (ADAMS Accession Number ML082660649).

14. EPRI 1019110, “Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications,” Electric Power Research Institute, 2009 Edition.

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