November 3, 2016

L-2016-188
10 CFR 50.54(f)

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

Florida Power & Light Company
St. Lucie Units 1 and 2
Docket Nos. 50-335, 50-389

Florida Power & Light Company
Turkey Point Units 3 and 4
Docket Nos. 50-250, 50-251

NextEra Energy Seabrook, LLC
Seabrook Station
Docket No. 50-443

NextEra Energy Duane Arnold, LLC
Duane Arnold Energy Center
Docket No. 50-331

NextEra Energy Point Beach, LLC
Point Beach Units 1 and 2
Docket Nos. 50-266, 50-301

Subject: **Response to Generic Letter 2016-01, "Monitoring of Neutron Absorbing Materials in Spent Fuel Pools," Response to NRC Request for Information Pursuant to Title 10 of the Code of Federal Regulations 50.54(f).**

References: 1. Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools," dated April 7, 2016. [ML16097A169]

On April 7, 2016, the NRC issued Reference 1 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 Florida Power & Light Company, the licensee for St. Lucie Nuclear Plant (St. Lucie) Units 1 and 2 and Turkey Point Nuclear Plant (Turkey Point) Units 3 and 4, and on behalf of NextEra Energy Seabrook, LLC, the licensee for Seabrook Station (Seabrook) Unit 1; NextEra Energy Duane Arnold, LLC, the licensee for Duane Arnold Energy Center (Duane Arnold) Unit 1; and NextEra Energy Point Beach, LLC, the licensee for Point Beach Nuclear Plant (Point Beach) Units 1 and 2 (collectively referred to as NextEra Energy).

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NRR

Point Beach Units 1 and 2 have been determined to be a Category 1 licensee in accordance with Reference 1. As a Category 1 licensee, this letter confirms that no neutron absorbing materials are currently credited to meet NRC requirements in 10 CFR 50.68, "Criticality Accident Requirements."

St. Lucie Units 1 and 2, Turkey Point Units 3 and 4, Seabrook Unit 1, and Duane Arnold Unit 1 have been determined to be Category 4 licensees in accordance with Reference 1. 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. St. Lucie Units 1 and 2, Turkey Point Units 3 and 4, Seabrook Unit 1, and Duane Arnold Unit 1 credit Boral in their respective spent fuel pools and therefore are required to provide information in the following areas: 1, 2, and 4. Attachments 1, 2, 3, and 4 contain responses to the requested information for Category 4 licensees for the aforementioned plants, respectively.

St. Lucie Units 1 and 2 and Turkey Point Units 3 and 4 credit Metamic. For St. Lucie Units 1 and 2, the Metamic Surveillance Program has not been incorporated into the licensing basis via an NRC-approved Technical Specification (TS) change or as a license condition. For Turkey Point Units 3 and 4, the Metamic Surveillance Program has been incorporated into the licensing basis via an NRC-approved TS change; therefore, Turkey Point has been determined to be a Category 3 licensee, with respect to Metamic, in accordance with Reference 1. Details are provided in Attachment 2.

This letter contains no new or revised regulatory commitments.

If you have any questions regarding this submittal, please contact Emilio Fuentes at 561-304-6249.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on the 3rd day of November, 2016.

Respectfully,

Larry Nicholson
Director, Nuclear Licensing and Regulatory Compliance

Attachments

1. GL 2016-01 Response - St. Lucie Units 1 and 2
2. GL 2016-01 Response - Turkey Point Units 3 and 4
3. GL 2016-01 Response - Seabrook Unit 1
4. GL 2016-01 Response - Duane Arnold Unit 1

cc: NRC Project Manager - St. Lucie
NRC Project Manager - Turkey Point
NRC Project Manager - Seabrook
NRC Project Manager - Duane Arnold
NRC Project Manager - Point Beach
Regional Administrator - NRC Region 1
Regional Administrator - NRC Region 2
Regional Administrator - NRC Region 3
NRC Resident Inspector - St. Lucie
NRC Resident Inspector - Turkey Point
NRC Resident Inspector - Seabrook
NRC Resident Inspector - Duane Arnold
NRC Resident Inspector - Point Beach

Attachment 1
GL 2016-01 Response - St. Lucie Units 1 and 2

AREA OF REQUESTED INFORMATION - 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:

ST. LUCIE'S RESPONSE:
See the specific responses below.

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

ST. LUCIE'S RESPONSE:

Boral

The manufacturer for the Boral in the SFPs at St. Lucie is AAR Manufacturing Group (AAR). The date of manufacture for the Boral in both units is 2001. The date of material installation in the SFP is 9/1/04 for Unit 1 and 10/5/06 for Unit 2.

Metamic

The manufacturer of the Metamic DREAM inserts is Nanotec Metals and the date of manufacture is 2012. The Metamic inserts were installed in the Unit 1 SFP in May 2012 and in the Unit 2 SFP from June-July 2012.

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

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

ST. LUCIE'S RESPONSE:

Boral

Boral is composed of 1100 alloy aluminum with boron carbide. The boron carbide is a minimum of 70% Boron with a nominal 18 wt% of Boron-10.

Metamic

The nominal weight percent of boron carbide in the Metamic is described in Section 2.1.12 of ML12181A019 and ML12235A463 (Extended Power Uprates for Unit 1 and 2, respectively). The nominal weight percent of boron in the boron carbide is 77.59% boron, and the minimum weight percent of the Boron-10 isotope is 18.5%.

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

ST. LUCIE'S RESPONSE:

Boral

The minimum areal density of Boron-10 in Boral credited in the AOR is 0.028 g/cm^2, and the nominal as-built areal density of Boron-10 in Boral is 0.030 g/cm^2. A review of the manufacturing documentation for the Boral used in the cask pit rack (CPR) indicates an areal density range of 0.0287-0.0378 g/cm^2.

Metamic

The minimum certified, minimum as-built, maximum as-built, and nominal as-built areal density of the neutron-absorbing component in the Metamic can be found in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Boral

Porosity data is not available. The density and dimensions of the Boral inserts are shown in the table below.

Material Characteristics of Boral

Mass density [g/cc]	2.713
Length [in]	140
Width [in]	7.25
Thickness [in]	0.098

Metamic

Porosity data is not available. The density of the Metamic inserts is 2.662 g/cc. The nominal geometrical dimensions are described in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Boral

The material used in the Boral panels and coupons used for testing from each lot of Boral were tested for material compatibility in SFP-like environments. Each lot of boron carbide was tested for water soluble boron content by AAR Manufacturing, Inc. in an approved test laboratory. The water soluble boron content acceptance criterion is 0.2-1.0 wt% boron. Coupons from each Boral lot were immersed in demineralized water at 170°F for at least 45 days. The coupons were examined for evidence of swelling or core degradation by comparing pre-test and post-test thickness and weight measurements. Swelling in excess of 5% of the thickness and/or visible signs of core degradation are causes for rejecting the entire Boral lot. The results from testing are shown in the table below.

Boral Qualification Testing Results

Serial Number	Weight before soak (g)	Weight after soak (g)	Weight after dry (g)	Average thickness before soak (in)	Average thickness after soak (in)	Percent change in thickness	Percent weight gain	Percent weight change after dry
CF110005-2	431.3	439.1	438.6	0.1019	0.1026	0.73	1.81	1.69
CF110006-1	438.7	445.8	445.4	0.1029	0.1038	0.89	1.62	1.53

Metamic

The qualification report for the Metamic inserts is included in ML12181A019 and ML12235A463.

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*

ST. LUCIE'S RESPONSE:

Boral

The Boral is inside stainless steel sheathing that is mounted on the external side of each fuel box, except the boxes on the rack periphery, which only have Boral on the interior sides. The Boral is attached tightly on the box surface by die forming the internal and external box sheathings. The flanges of the sheathing are attached to the box using skip welds and spot welds.

Metamic

Physical and geometric configurations are described in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Boral

Stainless steel sheathings act to position the poison sheet correctly and to preclude its movement under seismic conditions. The sheathing is attached to each side of the box with the poison material installed in the sheathing cavity. The stainless steel sheathing is skip and spot welded, thus allowing SFP water to contact the Boral panels.

Metamic

The Metamic inserts are not sheathed, and are exposed directly to the SFP environment.

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

i) estimated current minimum areal density;

ST. LUCIE'S RESPONSE:

Boral

There is no expected change in the minimum areal density.

Metamic

Based on the coupon areal density testing performed this year (4 years after installation), the minimum areal density is unchanged from the manufactured areal density. Coupon testing results were recently obtained for the first campaign, with no deviation noted from as-manufactured condition.

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

ST. LUCIE'S RESPONSE:

Boral

The minimum credited areal density used in the NCS AOR for the Unit 1 and Unit 2 SFP CPR is 0.028 g/cm^2 (i.e., nominal 0.030 g/cm^2 - 0.002 g/cm^2).

Metamic

The areal density used in the criticality analysis is discussed in section 2.8.6.2.3 of ML12181A019 and ML12235A463.

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).*

ST. LUCIE'S RESPONSE:

Boral

There are no recorded deformations or degradation of the Boral in the SFPs at St. Lucie.

Metamic

The four-year surveillance test results were received and showed no evidence of blisters, swelling, gaps, cracks, loss of material, or loss of neutron-attenuation capability.

AREA OF REQUESTED INFORMATION - 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.

ST. LUCIE'S RESPONSE:

Boral

There is currently no Boral surveillance or monitoring program in place, as none has been required. Since St. Lucie does not have a surveillance or monitoring program, the remaining discussion items in this section are not applicable to Boral.

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:*

i) *approach used to determine frequency, calculations, and sample size;*

ST. LUCIE'S RESPONSE:

Metamic

The Metamic coupons used for monitoring the health of the Metamic in the SFP are a surrogate material from the same manufacturing lot as the as-installed material. This enables any aging/degradation mechanisms the in-service neutron absorber materials' experience to be detected. The coupon tree is intended to be placed in a location in the SFP near freshly discharged fuel during refueling as well as fresh permanently discharged fuel, which provides exposure to gamma and neutron radiation and higher than average water temperatures. The technical basis is further described in Section 2.1.12 of ML12181A019 and ML12235A463. The coupon measurement program discussed in ML12181A019 and ML12235A463 is based on recommendations from the manufacturing contractor, Holtec International. The recommendations are given in the table below.

Suggested Sample Surveillance Coupon Schedule from Holtec International

Refueling Number (after Rerack)	Remove(1) Coupon No.	Install Fresh Fuel Assemblies(2)
1	1	Yes
2	2	Yes
3	3	Yes
5	4	Yes
10	5	No
20	6	No
30	7	No
40	8	No

(1) Remove coupon shortly before the indicated refueling and return the tree to the same location.

(2) If yes, remove 8 surrounding assemblies and surround coupon tree with 8 freshly unloaded assemblies at refueling.

ii) *parameters to be inspected and data collected;*

ST. LUCIE'S RESPONSE:

Metamic

The parameters measured for the Metamic coupon testing program are described in Section 2.1.12 of ML12181A019 and ML12235A463, as are the parameters measured during visual inspections of Metamic inserts.

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;*

ST. LUCIE'S RESPONSE:

Metamic

The acceptance criteria for the program are described in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Metamic

There is no trending of the surveillance program thus far because only one surveillance has been performed.

v) *industry standards used.*

ST. LUCIE'S RESPONSE:

Metamic

The standards referenced for the Metamic coupon monitoring program are as follows: ASTM E2971-14 "Standard Test Method for Determination of Effective Boron-10 Areal Density in Aluminum Neutron Absorbers using Neutron Attenuation Measurements" and ASTM C1187-15, "Standard Guide for Establishing Surveillance Test Program for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Fuel Storage Racks In a Pool Environment."

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*

ST. LUCIE'S RESPONSE:

Metamic

A description of the visual inspections, their frequency, and the criteria for examination are described in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Metamic

The scope of the inspections, including the number of Metamic absorbers inspected, is described in Section 2.1.12 of ML12181A019 and ML12235A463.

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;*

ST. LUCIE'S RESPONSE:

Metamic

A comparison of the coupons to in-service panels is described in Section 2.1.12 of ML12181A019 and ML12235A463. In addition, the physical dimensions of the coupons and the coupon location and configuration are described in Section 2.1.12 of ML12181A019 and ML12235A463.

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

ST. LUCIE'S RESPONSE:

Metamic

The Metamic coupon tree for Unit 1 was installed on 5/4/12 and was installed for Unit 2 on 6/22/12.

(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*

ST. LUCIE'S RESPONSE:

Metamic

The Metamic coupons were not returned to the SFP following testing.

(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.*

ST. LUCIE'S RESPONSE:

Metamic

There are eight Metamic coupons remaining in both the Unit 1 and Unit 2 SFPs. The schedule for Metamic coupon removal and testing is described in Section 2.1.12 of ML12181A019 and ML12235A463. There are 26 years remaining of the coupon surveillance program, as described in Section 2.1.12 of ML12181A019 and ML12235A463. The current Unit 1 license expires 03/01/36, and the current Unit 2 license expires 04/06/43.

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

ST. LUCIE'S RESPONSE:

Metamic

In-situ testing of complete Metamic panels is not performed. Instead, predetermined coupons that act as samples of the Metamic panels are tested following removal from the SFP. According to the aforementioned coupon tree configuration in the pool, the coupon tree is placed in a location in the SFP near freshly discharged fuel during refueling as well as fresh permanently discharged fuel, which provides exposure to gamma and neutron radiation and higher than average water temperatures. This makes the coupons the most susceptible samples since they are exposed to the most highly radioactive configuration achievable. The technical basis is further described in Section 2.1.12 of ML12181A019 and ML12235A463. Neutron attenuation measurements use a beam of thermalized neutrons and a neutron counter, and these measurements are performed with a counting interval that allows for a minimum of 80,000 counts. This achieves the desired statistical confidence limits.

The remaining discussion items in this section are not applicable.

AREA OF REQUESTED INFORMATION - 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.*

ST. LUCIE'S RESPONSE:

Unit 1

The vendor report included in the criticality License Amendment Request, HI-2104714, Revision 2 (safety evaluation - ML12181A019), describes the method of modeling the neutron absorbing material. For the Boral panels, the minimum Boron-10 loading was used.

Unit 2

The vendor report included in the criticality License Amendment Request, HI-2104753, Revision 4 (safety evaluation - ML12263A224), describes the method of modeling the neutron absorbing material. For the Boral panels, the minimum Boron-10 loading was used.

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.*

ST. LUCIE'S RESPONSE:

Units 1 and 2

For the Boral panels in the cask area rack, there is no monitoring program. Those racks are primarily used during refueling outages; in between outages, the racks are left nearly empty in the SFP. Any issue related to Boral racks should be discovered well before it affects these racks that are seldom used.

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

ST. LUCIE'S RESPONSE:

Unit 1

The vendor report included in the criticality License Amendment Request, HI-2104714, Revision 2 (safety evaluation - ML12181A019) states:

> "...the use of the minimum B-10 areal density in the design basis calculations bounds those [measurement] uncertainties, so no additional uncertainties need to be considered for the surveillance measurements." (page 30)

Unit 2

The vendor report included in the criticality License Amendment Request, HI-2104753, Revision 4 (safety evaluation - ML12263A224), does not include the bias or uncertainty of the monitoring or surveillance program.

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

ST. LUCIE'S RESPONSE:

Units 1 and 2

All panels are expected to meet the conditions of the NCS AOR. The analysis does not provide any allowances for degraded panels.

Attachment 2
GL 2016-01 Response - Turkey Point Units 3 and 4

AREA OF REQUESTED INFORMATION - 1

The Metamic Surveillance Program has been incorporated into the licensing basis for Turkey Point Units 3 and 4 through License Amendments 234 and 229 (ML092440802). Technical Specification Surveillance Requirement 4.9.14.2 requires Metamic insert inspection in accordance with the Metamic Surveillance Program as described in UFSAR Section 16.2. No changes have been made to this program. Reports of surveillances performed are required to be submitted to the NRC.

This attachment provides responses for Boral in the cask pit area racks only.

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:

TURKEY POINT'S RESPONSE:
See the specific responses below.

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

TURKEY POINT'S RESPONSE:

The Boral panels were manufactured in 2003 by AAR Manufacturing Group (AAR) and supplied to Holtec International for incorporation into the removable cask pit area racks. The cask pit area racks were designed and built by Holtec in 2004. The Unit 3 and Unit 4 racks were originally installed in late 2004.

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

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

TURKEY POINT'S RESPONSE:

Boral is a hot-rolled composite plate material composed of 1100 alloy aluminum as the two outer layers with a boron carbide/aluminum cermet in between. The certified content of the neutron absorbing material (Boron-10) is 18.54 weight percent.

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

TURKEY POINT'S RESPONSE:

Minimum certified Boron-10 areal density: 0.0204 gm/cm^2
Minimum as-built: 0.0223 gm/cm^2
Maximum as-built: 0.0282 gm/cm^2
Nominal: none specified

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

TURKEY POINT'S RESPONSE:
Porosity: none specified
Density: ranges from 2.4315 to 3.2701 gm/cm^3
Dimensions: 147.0 inches +0.25 inch length x 7.5 inches +0.0625 inch width x 0.075 inches ±0.005 inch thick

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

TURKEY POINT'S RESPONSE:

Two Boral coupons were soak tested for 45 days at a temperature of 170±2 °F. The rejection criteria were thickness change in excess of 5% and any visible sign of core degradation. The results are tabulated below:

Boral Qualification Testing Results

Serial Number		ZK310002-1					
Weight before soak (g)	Weight after soak (g)	Weight after dry (g)	Average thickness before soak (in.)	Average thickness after soak (in.)	Percent change in thickness	Percent weight gain	Percent weight change after dry
345.8	364.4	356.7	0.0777	0.0780	0.40	5.38	3.15
Serial Number		ZK310003-1					
Weight before soak (g)	Weight after soak (g)	Weight after dry (g)	Average thickness before soak (in.)	Average thickness after soak (in.)	Percent change in thickness	Percent weight gain	Percent weight change after dry
347.9	362.6	354.5	0.0778	0.0780	0.17	4.23	1.90

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*

TURKEY POINT'S RESPONSE:

Boral panels are stitch welded into stainless sheathes, the flanges of which are attached to the box using skip welds and spot welds.

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

TURKEY POINT'S RESPONSE:

The stainless steel sheathing is skip and spot welded, thus allowing SFP water to contact the Boral panels.

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

i) *estimated current minimum areal density;*

TURKEY POINT'S RESPONSE:

There is no expected change in the minimum areal density.

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

TURKEY POINT'S RESPONSE:

The vendor report included in the criticality License Amendment Request, WCAP-17094, Revision 3 (safety evaluation - ML14184A795), requires a Boral areal density of 0.0204 g B-10/cm^2 for the cask area rack in Section 6.3; that is the areal density credited in the NCS AOR.

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).*

TURKEY POINT'S RESPONSE:

No degradation has been recorded.

AREA OF REQUESTED INFORMATION - 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.

TURKEY POINT'S RESPONSE:

The Boral containing SFP rack was not licensed to include surveillance or monitoring; therefore, no monitoring is performed on Boral. The remaining discussion items in this section are not applicable.

AREA OF REQUESTED INFORMATION - 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.*

TURKEY POINT'S RESPONSE:

The vendor report included in the criticality License Amendment Request, WCAP-17094, Revision 3 (safety evaluation - ML14184A795), describes the method of modeling the neutron absorbing material.

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.*

TURKEY POINT'S RESPONSE:

For the Boral panels in the cask area rack, there is no monitoring program. Those racks are primarily used during refueling outages; in between outages, the racks are left nearly empty in the spent fuel pool. Any issue related to Boral racks should be discovered well before it affects these racks that are seldom used.

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

TURKEY POINT'S RESPONSE:

For the Boral panels in the cask area rack, there is no monitoring program.

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

TURKEY POINT'S RESPONSE:

All panels are expected to meet the conditions of the NCS AOR. The analysis does not provide any allowances for degraded panels.

Attachment 3

GL 2016-01 Response - Seabrook Unit 1

AREA OF REQUESTED INFORMATION - 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:

SEABROOK'S RESPONSE:
See the specific responses below.

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

SEABROOK'S RESPONSE:

Seabrook's Boral panels and coupons were manufactured within the period of 1996 to 1997 and shipped from the AAR Manufacturing Group (AAR) facility to Westinghouse on 2/2/1997. The 6 Boral SFP rack modules were installed in the Seabrook SFP in August 1998.

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

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

SEABROOK'S RESPONSE:

Boral is a hot-rolled composite plate material composed of 1100 alloy aluminum as the two outer layers with a boron carbide/aluminum cermet in between. The certified content of the neutron absorbing material (Boron-10) is 18.6 weight percent.

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

SEABROOK'S RESPONSE:

Minimum certified Boron-10 areal density: 0.020 gm/cm^2
Minimum as-built: 0.0212 gm/cm^2
Maximum as-built: 0.0242 gm/cm^2
Nominal: none specified

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

SEABROOK'S RESPONSE:

Porosity: none specified
Density: none specified
Dimensions: 141.00 inches ± 0.12 inch length x 7.5 inches ± 0.06 inch width x 0.075 inch ± 0.005 inch thick

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

SEABROOK'S RESPONSE:

The Boral material represented and supplied under this certification was inspected and tested in accordance with AAR procedures dated 1/6/1995. Quantitative test results specific to the Seabrook material were not located.

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*

SEABROOK'S RESPONSE:

Boral panels are fixed to the four outside surfaces of each rack cell by a 20-mil stainless wrapper plate. Vertical flanges on each side of the wrapper plate are spot welded to the cell to form a pocket with approximately 90-mil clearance to accommodate the Boral panel.

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

SEABROOK'S RESPONSE:

The coupon jackets and coupon tree mimic the encapsulated Boral panels within the racks. In the racks the top and bottom ends of the 20-mil stainless wrapper plate are folded inward toward, but not touching, the cell wall to loosely capture the Boral panel and allow some SFP water to enter into, and egress from, the pocket containing the Boral panel. Pool water also flows under the wrapper plate flange between the spot welds and also through a 1/2-inch "verification" through-hole on the vertical mid-line of the wrapper plate near the top of the Boral panel.

The stainless steel coupon jackets and Boral coupons are constructed from materials that approximate the same chemical composition, thickness, clearance, including the "verification" through-hole, to reproduce the chemical, gamma heating, galvanic, radiolytic, thermal and mechanical forces and conditions experienced within the actual SFP racks.

The coupon tree is surrounded by the 24 highest burnup discharge fuel assemblies at each refueling to expose the coupons to the maximum irradiation and thermal conditions in the SFP. Observed oxide patterns on the exposed coupons clearly indicate thermal convective flow through the coupon jackets which, as stated, are designed to mimic the encapsulated Boral panels within the racks.

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

i) *estimated current minimum areal density;*

SEABROOK'S RESPONSE:

Based on the results of the Boral Monitoring Program the current estimated minimum Boron-10 areal density remains above the minimum as-built value of 0.0212 gm/cm^2 of the Boral panels within the SFP racks.

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

SEABROOK'S RESPONSE:

The vendor report included in the criticality License Amendment Request, HI-2114996, Revision 3 (safety evaluation - ML14184A795), Section 4.5.4.1 notes:

> "The analyses are performed for Boron-10 loading of 0.015 g/cm^2. Note that the value is minimum value that is assumed in the analyses without any additional consideration for uncertainty."

The same value is noted in Table 4.5.6 for the Region 1 fuel rack specifications. That value is the areal density credited in the NCS AOR for the Region 1 racks. No neutron absorber is credited for the Region 2 racks.

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).*

SEABROOK'S RESPONSE:

The current Boral conditions, listed below from Cycle 17, satisfy the Boral Monitoring Program acceptance criteria and conform well to the predictions from the previous examinations.

Blister Volume Criterion A Evaluation

The maximum coupon blister displacement measured in Cycle 17 was found to be 0.933 in^3 on the A112 limiting coupon. This volume represents 1.58 in^3/ ft^2 and a uniform void of 11.04 mils. This limiting uniform void of 11.04 mils is 24.53% of the 45-mil limit. The conservative blister volume growth and the proportionate change in uniform void were calculated using a logarithmic extrapolation of the A112 limiting coupon data for the last 7 examinations performed at each cycle. The limiting blister volume at the next Boral examination was projected to be 1.08 in^3. The uniform void was projected to be 12.78 mils or 28.4% of the 45-mil limit; therefore, the margin to the coupon blister displacement limit of 45 mils is expected to be 71.6% at the end of Cycle 18.

Boron-10 Areal Density Criterion B Evaluation

The minimum Boral Boron-10 areal density measured by thermal neutron beam attenuation was found to be 0.0231 gm/cm^2 on coupon A111, which is within the expected range 0.022 to 0.025 gm/cm^2. The Technical Specification limit on minimum Boron-10 areal density was changed from 0.020 gm/cm^2 to the new value of 0.015 gm/cm^2 when License Amendment Request (LAR) 11-04, "Changes to the Technical Specifications for New and Spent Fuel Storage," (ML12038A036) was granted. (See Note below.) Consequently, the margin to the areal density limit has increased to 0.0081 gm/cm^2, or 54% for the Cycle 17 measurement to limit; however, visual indications of aluminum corrosion on surveillance coupons indicate Boron-10 areal density reduction over very small areas on the coupon edges and corners. These boron carbide losses from the coupon edge and corner, as indicated by neutron radiography, are less than the 60-mil dimensional tolerance for the Boral panel width; therefore, the indicated loss in Boron-10 areal density is within design limits.

Neutron Radiography Criterion C Evaluation

Neutron radiography indicated acceptable boron carbide distribution within the test coupons. Several areas were observed by Thermal Neutron Radiography during the Cycle 16 and 17 coupon examinations and indicated incipient Boron-10 areal density reduction over very small areas on the coupon edges and corners. These areas of Boron-10 areal density loss were smaller than the dimensional tolerance values of the Boral panels within the SFP racks and are therefore acceptable. A very small "internal void" has also been recognized in the radiographic image of coupon A112 as shown in Section 3.3, "Neutron Radiography". This "void" was too small to be discerned by neutron beam attenuation which indicated greater than 0.023 gm/cm^2, which is well above the 0.015 gm/cm^2. The "void" was evaluated by gray scale comparison on the A112 neutron radiograph which indicated an equivalent Boron-10 areal density of 0.0212 gm/cm^2 which is above the 0.015 gm/cm^2 minimum acceptance criterion and represents a 9.6% local reduction in areal density.

NOTE: The results of previous Boral monitoring evaluations are considered in the SFP Criticality Analysis of record. This Criticality Analysis provides for Boral monitoring acceptance criteria A and B of 45 mils uniform void and 0.020 gm/cm^2 Boron-10 areal density, respectively. A new SFP Criticality Analysis that redefines the required Boral Boron-10 areal density to 0.015 gm/cm^2 has been granted under LAR 11-04.

AREA OF REQUESTED INFORMATION - 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:*

SEABROOK'S RESPONSE:

The Boral Monitoring Program is described in ML12136A126 and addresses the remaining discussion items in this section.

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

i) *If there is visual inspection of inservice material:*

SEABROOK'S RESPONSE:

Seabrook's rack design precludes access to the installed Boral panels for visual inspection so no visual inspection of the inservice Boral panels is performed. The remaining discussion items in this section are not applicable.

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;*

SEABROOK'S RESPONSE:

The Boral Monitoring Program relies on coupon monitoring. The Boral Monitoring Program is described in ML12136A126.

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

SEABROOK'S RESPONSE:

The Boral Coupon Tree with the initial set of 16 Boral test coupons was installed in SFP location V26 on 2/11/99. The 24 locations around SFP location V26 were loaded with discharged fuel from Cycle 6 between 4/8/99 and 4/9/99.

(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*

SEABROOK'S RESPONSE:

The Boral coupons are returned to the SFP after scheduled examination.

The Boral coupons and panels may be changed or degraded by chemical, thermal, galvanic, radiolytic reactions, and physical contact forces. The influence of these effects must be minimized when the coupons are separated from the SFP environment to avoid differences in degradation between the coupons and the actual rack panels. This effort to maintain the coupons in a state that represents, or bounds, the rack panels' degradation relies on the following process controls on the coupon exposure and examination cycle, in the performance of station procedures RN1745, "Boral Monitoring Program," and MN0526.12, "SF Storage Rack Coupon Removal and Installation." Process controls are attached to the applicable station work orders as "Decon & Handling Instructions," and covered at pre-job briefing. These controls are evaluated via self-assessment within each Boral Monitoring Report Engineering Evaluation. Controls applicable to the second party examination contractor are imposed as "Handling Precautions & Requirements" by binding contract executed 5/20/15.

The following process controls on the coupon exposure and examination cycle apply:

A. The coupon examination should occur in a relatively short period close the end of the reactor operating cycle when the SFP environment is at a minimum level of thermal and radiolytic activity.

B. The coupons should be handled with extreme care to avoid extraneous effects that are not associated with the SFP environment including heat, water, reagents, adhesives, denting or other physical changes to the coupons surface or appearance. Pre-job briefs must explain these precautions in detail to all plant personnel and examination contractors. These precautions need to be included into second party examination contracts.

C. The Subject Matter Expert must be present at all possible times when the coupons are being handled in the SFP and machine shop, packed, and examined by second party examination contractors. Transport of the coupon off-site by the Subject Matter Expert is recommended in lieu of a common carrier.

D. The Subject Matter Expert must observe and control the process of handling the jacketed coupons and bare coupons as they are removed from their jackets to avoid or note any damage. A post-inspection of the coupons is required after the detailed examination to avoid and note any unexplained changes just prior to, and during, the process of installing the coupon into their jackets.

E. The coupons must be decontaminated and dried in a desiccator, without application heat or vacuum drying, as soon as possible after removal from the SFP to avoid extraneous reactions.

F. Test coupons should be returned to the SFP on the coupon tree in a new SFP location to rehydrate prior to the next core offload in a fashion that is close to the exposure of the rack panels. A new SFP location is chosen for the Boral coupon tree to avoid exposing the same SFP rack location to the same level of exposure as the coupons.

G. The Seabrook coupons indicate a wide range of blister and corrosion damage. Some coupons have hundreds of blisters and larger corrosion areas while others of the same exposure history have few if any of these defects. To discard examined coupons after just one exam would create a database of random indications with few, if any, trends between examinations. Reuse of the coupons provides trends in coupon response to the SFP environment that can be correlated to coupon attributes such as clad thickness and cracks or pits. Maintaining a few coupons for infrequent or delayed examination provides coupon response data for comparison to coupons with repeated examinations.

H. In the alternative one can still restrict their observations to only the initial exam data for each of the coupons, which would indicate a random scatter pattern in the level of blister formation and corrosion without significant trends to SFP conditions.

I. The coupon jackets and coupon tree mimic the encapsulated Boral panels within the racks. [See Response to 1.d.ii herein.]

(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.

SEABROOK'S RESPONSE:

Sixteen test coupons remain in active monitoring at Seabrook. Two or more of these will be examined at the end of each fuel cycle as dictated by the ongoing results. Since the coupons are returned to the SFP after scheduled examination there will be sufficient coupons for testing for as long as the SFP remains in service.

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

SEABROOK'S RESPONSE:

In-situ testing is not performed at Seabrook Station. The remaining discussion items in this section are not applicable.

AREA OF REQUESTED INFORMATION - 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.*

SEABROOK'S RESPONSE:

The vendor report included in the criticality LAR, HI-2114996, Revision 3 (safety evaluation - ML14184A795), describes the method of modeling the neutron absorbing material. The following is item 8 from Section 4.2.3.5.11 of the aforementioned report:

> "To account for potential blistering of the BORAL™ panels in the Region 1 racks, a uniform 0.045 inch void is assumed to extend outward from the BORAL™ panels. The BORAL™ panels are assumed to touch the box wall of racks. The total thickness of poison gap used in the analysis is therefore the sum of BORAL™ thickness (0.075 inch) and BORAL™ void thickness (0.045 inch), which is 0.12 inch. It is 0.03 inch larger than the original poison gap thickness of 0.09 inch. Accordingly, the flux trap of Region 1 racks is reduced from 1.05 inch to 0.99 inch since the BORAL™ panels are on both sides of the flux trap."

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.*

SEABROOK'S RESPONSE:

For the Boral panels credited in the NCS AOR, any surveillance result that shows a difference beyond that assumed in the NCS AOR is evaluated to determine if the NCS AOR remains valid with the discovered condition.

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

SEABROOK'S RESPONSE:

The vendor report included in the criticality LAR, HI-2114996, Revision 3 (safety evaluation - ML14184A795) in Section 1 states:

> "Ongoing coupon surveillance has revealed evidence of blistering and thinning/spalling of the aluminum clad on the Boral™ panels. To account for these conditions, criticality calculations use a reduced B-10 areal density in the Boral™, and assume a voided space on one side of each panel."

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

SEABROOK'S RESPONSE:

All panels are expected to meet the conditions of the NCS AOR. The analysis does not provide any allowances for degraded panels.

Attachment 4

GL 2016-01 Response - Duane Arnold Unit 1

AREA OF REQUESTED INFORMATION - 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:

DUANE ARNOLD'S RESPONSE:
See the specific responses below.

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

DUANE ARNOLD'S RESPONSE:
See the specific responses below.

PaR

PaR racks were approved for installation via License Amendment 45 (ML021890029) in 1978. The PaR racks contain a boron carbide aluminum cermet manufactured under a US patent and sold under the brand name Boral by AAR Advanced Structures, Livonia, Michigan. The date of manufacture of the Boral material is unavailable.

Holtec

Holtec racks were approved for installation via License Amendment 195 (ML021910481) in February 1994. The Holtec racks contain a boron carbide aluminum cermet manufactured under a US patent and sold under the brand name Boral by AAR Advanced Structures, Livonia, Michigan. The date of manufacture of the Boral material is unavailable.

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

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

DUANE ARNOLD'S RESPONSE:

PaR

The PaR racks are free standing and self-supporting. PaR spent fuel racks are a bolted anodized aluminum construction having a neutron absorber medium of natural B4C in an aluminum matrix core clad with 1100 series aluminum. The neutron absorber, marketed under the trade name of Boral, is sealed within two concentric square aluminum tubes forming the "poison can." The minimum weight of total boron per unit area of poison material is 0.129 g/cm^2 (0.0232 g/cm^2 Boron-10).

Holtec

Holtec racks are also, like PaR racks, free standing and self-supporting. The principal construction materials for the Holtec racks are ASME 240-type 304 stainless steel sheet and plate stock, and SA564 (precipitation hardened stainless steel) for the adjustable support spindle. The only non-stainless steel material utilized in the rack is the neutron absorber material which is a boron carbide aluminum cermet manufactured under a US patent and sold under the brand name Boral by AAR Advanced Structures, Livonia, Michigan. Boral panels are placed in the pockets formed between the (box) cell and outer sheathing plate. The minimum weight of total boron per unit area of poison material is 0.015 g/cm^2 Boron-10.

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

DUANE ARNOLD'S RESPONSE:

PaR

Minimum certified Boron-10 areal density: 0.0232 gm/cm^2
Minimum as-built: 0.0232 gm/cm^2
Maximum as-built: No information is available on the range of panel areal density values at the time of manufacture.

Holtec

Minimum certified Boron-10 areal density: 0.015 gm/cm^2
Minimum as-built: 0.0162 gm/cm^2
Maximum as-built: unavailable

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

DUANE ARNOLD'S RESPONSE:

PaR

Porosity: unavailable
Dimensions: Width 5.25 inches ± 0.03 inches, Thickness 0.115 inches ± 0.010 inches

Holtec

Porosity: unavailable
Dimensions: Width 5 inches ± 0.0625 inches, Thickness 0.07 inches ± 0.004 inches

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

DUANE ARNOLD'S RESPONSE:

PaR

Not available

Holtec

Not available

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*

DUANE ARNOLD'S RESPONSE:

PaR

Pockets are cast in alternate cavity openings of the grids into which the poison cans rest. This arrangement provides enough separation to ensure that no structural loads will be imposed on the poison cans. The Boral in the poison cans is positioned so that it extends at least 1 in. beyond the top and bottom of a fuel assembly of maximum active length. The outer can is formed into the inner can at the ends and totally seal welded to isolate the Boral from the pool water. Each can is pressure and vacuum leak tested.

Holtec

The cells are fabricated from two precision formed channels by seam welding them together. Each cell has two lateral holes punched near its bottom edge to provide auxiliary flow. In the next step, a picture frame sheathing is pressed formed in a precision die. The "picture frame sheathing" is attached to each side of the cell with the poison material (Boral) installed in the sheathing cavity.

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

DUANE ARNOLD'S RESPONSE:

PaR

Pockets are cast in alternate cavity openings of the grids into which the poison cans rest. This arrangement provides enough separation to ensure that no structural loads will be imposed on the poison cans. The Boral in the poison cans is positioned so that it extends at least 1 in. beyond the top and bottom of a fuel assembly of maximum active length. The outer can is formed into the inner can at the ends and totally seal welded to isolate the Boral from the pool water. Each can is pressure and vacuum leak tested.

Holtec

Each Boral plate is placed in a "picture-frame" sheathing, with the top of the sheathing welded to the top of the frame using a smooth, continuous filled weld. This picture frame is welded to other frame assemblies in a checkerboard pattern to form the SFP racks. The Holtec Boral plates/frames are open to the SFP environment, as flow holes have been drilled into the racks holding the plates in place allowing for full exposure to SFP water chemistry and temperatures.

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

i) estimated current minimum areal density;

DUANE ARNOLD'S RESPONSE:

PaR

The current minimum areal density as measured by BADGER testing is 0.0208 gm/cm^2. This was the lowest measured panel by the BADGER system, including measurement uncertainties.

NOTE: The 2013 BADGER test measured several panels below the areal density minimum value in the NCS AOR. The PaR racks are under an operable but nonconforming condition until corrective actions (e.g., new criticality analysis) are completed.

Holtec

The current minimum areal density is 0.0162 gm/cm^2.

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

DUANE ARNOLD'S RESPONSE:

The vendor report included in the criticality License Amendment Request, HI-971708 (safety evaluation -ML021920201), notes in Section 2.2 for the PaR racks "... minimum loading of 0.0232 g B-10/cm^2 (nominally 0.025 g B-10/cm^2)..." and for the Holtec racks "... Boral absorber of 0.0162 g B-10/cm^2 nominal loading." The information on the PaR racks is repeated in Section 3.1: "The boron content of the Boral panels is nominally 0.025 with an uncertainty of $\pm$ 0.0018 g/cm^2." For the Holtec racks, the information is supported by vendor report HI-92889 (safety evaluation - ML021910481) which was submitted with a previous license amendment request (LAR). Section 4.6.2.1 of that report notes the same nominal areal density, with an uncertainty of 0.0012 g/cm^2; therefore, the credited areal densities in the NCS AOR are 0.0250 $\pm$ 0.0018 g/cm^2 for the PaR racks, and 0.0162 $\pm$ 0.0012 g/cm^2 for the Holtec racks. Note that Duane Arnold has submitted a LAR updating the PaR racks analysis with considerable reduction to the areal density.

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).

DUANE ARNOLD'S RESPONSE:

PaR

No degradation has been recorded; however, as the BADGER results discovered as-found values were lower than the stated as-built specifications, there remains the potential for degradation in the PaR Boral.

Holtec

No degradation has been recorded.

AREA OF REQUESTED INFORMATION - 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:*

i) *approach used to determine frequency, calculations, and sample size;*

DUANE ARNOLD'S RESPONSE:

PaR

Duane Arnold was required to implement neutron attenuation testing of the PaR racks prior to entering the period of extended operation (PEO) in 2014, as accepted by the NRC as a condition for license extension. A follow-up test will be performed at a date to be determined based on the results of the baseline test and relevant industry experience, but within ten years after the baseline test and at a ten year frequency thereafter.

Holtec

Coupons are removed from the array on a prescribed schedule every 6 years, per NUREG-1955.

ii) *parameters to be inspected and data collected;*

DUANE ARNOLD'S RESPONSE:

PaR

Boral areal densities are to be obtained using a source opposite a detector with the cell inspected in the middle.

Holtec

The following measurements shall be made on each coupon removed from the SFP:

a. Visual examination and photographic documentation of appearance
b. Dimensional measurements (length, width, and thickness)
c. Neutron attenuation and (optional) radiography
d. Weight and specific gravity

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;*

DUANE ARNOLD'S RESPONSE:

PaR

In-situ neutron attenuation testing is performed to confirm that the Boral neutron absorber panels continue to meet the assumptions of the fuel pool criticality analysis (minimum areal density of 0.0232 gm/cm^2, after consideration for measurement uncertainty). The areal density going forward will be reduced to 0.015 gm/cm^2 based on the new NCS AOR.

Holtec

Of the measurements to be performed on the Holtec Boral surveillance coupons, the most important are:

- the neutron attenuation measurements (to verify the continued presence of the boron) and
- the thickness measurement (as a monitor of potential swelling)

Acceptance criteria for these measurements are as follows:

- A decrease of no more than 5% in Boron-10 content, as determined by neutron attenuation, is acceptable.
- An increase in thickness at any point should not exceed 10% of the initial thickness at that point.

Changes in excess of either of these two criteria requires investigation and engineering evaluation which may include early retrieval and measurement of one or more of the remaining coupons to provide corroborative evidence that the indicated change(s) is real. If the deviation is determined to be real, an engineering evaluation shall be performed to identify further testing or any corrective action that may be necessary. The remaining measurement parameters serve a supporting role and should be examined for early indications of the potential onset of Boral degradation that would suggest a need for further attention and possibly a change in measurement schedule. These include:

- visual or photographic evidence of unusual surface pitting, corrosion or edge deterioration,
- unaccountable weight loss in excess of the measurement accuracy, or
- the existence of areas of reduced boron density in the neutron radiograph

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

DUANE ARNOLD'S RESPONSE:

PaR

For the PaR racks a baseline neutron attenuation testing has been performed to determine the Boral areal density and the results used to confirm the Boral panels continue to meet the assumptions of the fuel pool criticality analysis. This test was performed prior to entering the period of extended operation. A follow-up test will be performed at a date to be determined based on the results of the baseline test and relevant industry experience, but within 10 years after the baseline test and at a 10-year frequency thereafter.

Holtec

The Duane Arnold Boral Surveillance Program monitors and trends any degradation of the Boral Coupons for the Holtec racks by comparing the as-found parameters of the coupon with the as-installed parameters. By comparing as-found parameters to the as-installed parameters, very small changes or degradation can be recognized and evaluated. The program requires removal and testing of a coupon prior to every third refuel outage. In the event changes in the Boral Boron-10 areal density are detected in the Holtec coupons, the findings will be evaluated for applicability to the PaR racks.

v) *industry standards used.*

DUANE ARNOLD'S RESPONSE:

PaR

None documented.

Holtec

None documented.

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*

DUANE ARNOLD'S RESPONSE:

PaR

There are no visual inspections of in-service materials for the PaR racks.

Holtec

The coupons shall be examined visually with special attention paid to any edge or corner defects and to any discoloration or surface pitting that might exist. Color photographs of the coupons shall be obtained using magnification as necessary to clearly show and document any observed defects.

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

DUANE ARNOLD'S RESPONSE:

PaR

There are no visual inspections of in-service materials for the PaR racks.

Holtec

A single coupon is inspected from the coupon tree.

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;*

DUANE ARNOLD'S RESPONSE:

PaR

There are no coupons for the PaR racks.

Holtec

The coupon surveillance program will use a total of 10 test coupons each mounted in a stainless steel jacket, simulating as nearly as possible, the actual in-service geometry, physical mounting, materials, and flow conditions of the Boral in the Holtec storage racks. The Boral shall be from the same production run as the poison panels in the racks and dimensions of the coupon and mounting shall conform to the referenced drawing. Each Boral surveillance coupon shall be encased in a stainless steel jacket (of the same alloy used in manufacture of the racks) mounted with tolerances representative of those in the racks.

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

DUANE ARNOLD'S RESPONSE:

PaR

There are no coupons for the PaR racks.

Holtec

All coupons were installed in March 1995.

(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*

DUANE ARNOLD'S RESPONSE:

PaR

There are no coupons for the PaR racks.

Holtec

Coupons are not reinstalled for the Holtec racks.

(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.*

DUANE ARNOLD'S RESPONSE:

PaR

There are no coupons for the PaR racks.

Holtec

A single coupon is removed during each surveillance period. Per the Boral Surveillance Document, there are enough coupons to support testing for the life of the SFP assuming a 6-year surveillance frequency, with 5 coupons left. Coupons are currently scheduled to be removed and tested in 2017, 2023, and 2029.

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;*

DUANE ARNOLD'S RESPONSE:

In-situ testing is used for the PaR racks as those racks do not have coupons. Testing was first performed using the BADGER system in 2013, with results indicating some panels were below the Boral areal density assumed in the NCS AOR. NextEra Energy committed to provide a new NCS AOR for the PaR racks, and that was submitted in March 2016. See Duane Arnold Licensee Event Report (LER) 2013-003-00 (ML14064A183) and LAR (ML16077A234).

NextEra Energy prepared an engineering calculation to document the selection of panels for the initial 2013 BADGER testing of the Boral PaR racks. In the calculation, it is stated, "The panel selection is made based on obtaining a representative sample of all panels in the PaR racks, with no bias towards any rack." For the initial test, there were no susceptible panels identified that should have been preferentially selected.

A total of 60 panels were selected from 8 of the 12 PaR racks in the Duane Arnold SFP, in locations that would meet the requirements for BADGER testing (sufficient distance from SFP walls or fuel assemblies). The selection of 60 panels meets the guidance in Section 2.2 of NEI 16-03, which notes that using 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." It was concluded that by testing that many panels, the results would be statistically significant and could 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;

<u>DUANE ARNOLD'S RESPONSE:</u>

This discussion item is not applicable, as only one BADGER campaign has been performed at Duane Arnold.

(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 (Agencywide Document Access and Management System 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; and

<u>DUANE ARNOLD'S RESPONSE:</u>

Uncertainties in the results caused by sources of uncertainties as outlined in the report noted in the request are not included in the test results. This would require an additional rack-specific neutron transport analysis for each test (and panel). Since the measurement uncertainties in head configuration would be dependent on whether or not neighboring panels are degraded (or even at a different as built areal density), it would be nearly impossible to quantify each individual uncertainty without a destructive exam of each test panel. In addition, this would determine whether or not a bias in the test method occurs in various rack designs and/or with various absorbers.

Also, the report noted in the request deals primarily with the old BADGER system prior to the re-design in 2013. The BADGER test performed at Duane Arnold in 2013 was the first test performed with the new BADGER design.

(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;*

DUANE ARNOLD'S RESPONSE:

PaR

The Boral that was used in the calibration cell is not completely the same as the Boral in the Duane Arnold PaR SFP racks. Unavoidably, the Boral incorporated into the calibration cell is of more recent manufacture than the Boral used in the racks. At the time of manufacturing, the Boral was made for the Duane Arnold PaR racks by AAR Manufacturing, Inc. in the 1970's. The Boral made for the Duane Arnold BADGER Calibration stand was made by Ceradyne, Inc. in the 2010 years. Variations may include but are not limited to porosity and material performance. Differences in material behavior are due to differences in manufacturing processes. The original AAR manufacturing process utilizes machine oil to eliminate the risk of rapid oxidation reactions with the fine aluminum powder used in the formation of the Boral core cermet. The Ceradyne process removes the use of the machine oil and performs the production in a nitrogen atmosphere. These changes may affect the material performance behavior of the Boral including porosity and pitting/blistering potential. No adjustments were made for potential differences in manufacture of the plates. The rack specific calibration cell has Boral standards of varying known areal densities arranged axially, as well as gaps of known size. At the beginning of a test campaign, the BADGER probes are lowered into the calibration cell and the calibration cell is scanned. The bottom of the calibration cell establishes a reference elevation datum during calibration.

Holtec

In-situ testing is not performed for Holtec racks.

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

DUANE ARNOLD'S RESPONSE:

PaR

If it is assumed that in the over 30 years of operating life of the PaR racks a panel cavity has been completely filled with water, then the construction of the calibration stand was designed so that the calibration standards are contained in a sealed (dry) cavity and a flooded cavity. This would allow for spectral differences. In performing multiple calibration scans of both the flooded and dry standards, the average count rates for each standard were within the two sigma uncertainties of each other; therefore, they cannot be considered to be from different data sets. Consequently, any blister that exists will be bounded by this calibration scan example and be indistinguishable from the rest of the panel. In addition, even if a blister occurs, it does not allow for the release of the boron carbide crystals and therefore will not have an effect on areal density values.

Holtec

In-situ testing is not performed for Holtec racks.

(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;*

DUANE ARNOLD'S RESPONSE:

PaR

Duane Arnold does not use a reference panel; the vendor manufactures a reference cell outside of the SFP for use.

Holtec

In-situ testing is not performed for Holtec racks.

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

DUANE ARNOLD'S RESPONSE:

PaR

Duane Arnold does not use a reference panel; the vendor manufactures a reference cell outside of the SFP for use.

Holtec

In-situ testing is not performed for Holtec racks.

(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.

DUANE ARNOLD'S RESPONSE:

PaR

Duane Arnold does not use a reference panel; the vendor manufactures a reference cell outside of the SFP for use.

Holtec

In-situ testing is not performed for Holtec racks.

AREA OF REQUESTED INFORMATION - 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.*

DUANE ARNOLD'S RESPONSE:

The vendor reports included in the criticality LARs, HI-971708 and HI-92889 (safety evaluations - ML021920201, ML021910481), describe the method of modeling the neutron absorbing material. For both the Boral in the PaR racks and the Boral in the Holtec racks, the modeling basis is the as-manufactured condition.

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.*

DUANE ARNOLD'S RESPONSE:

For the Boral panels credited in the Holtec racks NCS AOR, any surveillance result that shows a difference from the original coupon is evaluated to determine if the NCS AOR remains valid with the discovered condition. For the Boral panels credited in the PaR racks NCS AOR, any surveillance result that shows a difference from the original panels is evaluated to determine if the NCS AOR remains valid with the discovered condition.

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

DUANE ARNOLD'S RESPONSE:

The vendor reports included in the criticality LARs, HI-971708 and HI-92889 (safety evaluations - ML021920201, ML021910481), do not include the bias or uncertainty of the monitoring or surveillance program.

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

DUANE ARNOLD'S RESPONSE:

All panels are expected to meet the conditions of the NCS AOR. The analysis does not provide any allowances for degraded panels.