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Serial: RA-16-0030 10 CFR 50.54(f)
October 31, 2016

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

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1
DOCKET NO. 50-400 / RENEWED LICENSE NO. NPF-63

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261 / RENEWED LICENSE NO. DPR-23

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325, 50-324 / RENEWED LICENSE NOS. DPR-71 AND DPR-62

CATAWBA NUCLEAR STATION, UNIT NOS. 1 AND 2
DOCKET NOS. 50-413, 50-414 / RENEWED LICENSE NOS. NPF-35 AND NPF-52

MCGUIRE NUCLEAR STATION, UNIT NOS. 1 AND 2
DOCKET NOS. 50-369, 50-370 / RENEWED LICENSE NOS. NPF-9 AND NPF-17

OCONEE NUCLEAR STATION, UNIT NOS. 1, 2 AND 3
DOCKET NOS. 50-269, 50-270, AND 50-287 / RENEWED LICENSE NOS. DPR-38, DPR-47, AND DPR-55

SUBJECT: RESPONSE TO NRC GL 2016-01 MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS

REFERENCES:

1. NRC Generic Letter 2016-01, *Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools*, dated April 7, 2016 (ADAMS Accession No. ML16097A169)

Ladies and Gentlemen:

On April 7, 2016, the NRC issued Generic Letter (GL) 2016-01 (Reference 1) to collect information from licensees regarding neutron-absorbing material in the Spent Fuel Pool (SFP). Duke Energy Progress, LLC and Duke Energy Carolinas, LLC, referred to henceforth as “Duke Energy”, is submitting this letter to provide the Reference 1 requested information for Shearon Harris Nuclear Power Plant, Unit 1 (HNP), H. B. Robinson Steam Electric Plant, Unit No. 2 (RNP), Brunswick Steam Electric Plant, Unit Nos. 1 and 2 (BSEP), Catawba Nuclear Station, Unit Nos. 1 and 2 (CNS), McGuire Nuclear Station, Unit Nos. 1 and 2 (MNS), and Oconee Nuclear Station, Unit Nos. 1, 2, and 3 (ONS).

No neutron-absorbing materials (as defined in Reference 1) are currently credited to meet NRC subcriticality requirements in the SFP for CNS, ONS, and RNP. Therefore, CNS, ONS, and RNP have been determined to be Category 1 in accordance with Reference 1 and no other response is required. MNS, BSEP, and HNP have been determined to be Category 4 in accordance with Reference 1. Attachments 1, 2, and 3 provide the requested Category 4 information for MNS, BSEP, and HNP, respectively.

This submittal contains no new regulatory commitments. Should you have any questions concerning this letter, or require additional information, please contact Art Zaremba, Manager – Nuclear Fleet Licensing, at 980-373-2062.

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

Executed on October 31, 2016.

Sincerely,

Kelvin Henderson
Senior Vice President – Nuclear Corporate

JBD

Attachments: 1. Response to GL 2016-01, McGuire Nuclear Station
2. Response to GL 2016-01, Brunswick Steam Electric Plant
3. Response to GL 2016-01, Shearon Harris Nuclear Power Plant

cc: (all with Attachments unless otherwise noted)

C. Haney, Regional Administrator USNRC Region II
M. Riches, USNRC Senior Resident Inspector – HNP
J. Zeiler, USNRC Senior Resident Inspector – RNP
M. P. Catts, USNRC Senior Resident Inspector – BSEP
J. D. Austin, USNRC Senior Resident Inspector – CNS
G. A. Hutto, III, USNRC Senior Resident Inspector – MNS
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M. C. Barillas, NRR Project Manager – HNP
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M. D. Orenak, NRR Project Manager – CNS
G. E. Miller, NRR Project Manager – MNS
V. Sreenivas, NRR Project Manager – MNS
J. R. Hall, NRR Project Manager – ONS

Attachment 1

Response to GL 2016-01, McGuire Nuclear Station

The information in this attachment constitutes the response to Generic Letter (GL) 2016-01 for the McGuire Nuclear Station (MNS). Table 1 of the GL is shown below, which specifies the required Areas of Requested Information based on neutron absorber type. For MNS, the only credited neutron absorber is Boral. Responses required for the Boral neutron absorber are provided below, based on Table 1 and Appendix A of GL 2016-01.

Table 1. Areas of Information by Neutron Absorber Material Types

	Areas of Requested Information (described in Appendix A of GL-2016-XX)				
Neutron-Absorbing Material Type	(1)	(2)	(3)	(4)	(5)
Boraflex Carborundum Tetrabor	x	x	x	x	x
Boral	x	x*		x	
Borated stainless steel Metamic Boralcan Other metallic matrix composites	x	x*			

* Except for 2(b)(iii).

Area of Requested Information 1

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;

Boral Manufacturer: AAR Cargo Systems
Dates of Manufacture: 2002, exact dates not found in documentation
AAR Boral Certification Dates:
Lot M-213-11/13/02
Lot M-214-11/01/02

Mass Spec Boral B-10 measurement date: 11/07/02

Lot M-213 used in panels RG210426 - RG211084
Lot M-214 used in panels SG211085 - SG211159

Dates of Material Installation in Spent Fuel Pool:
Unit 1
Rack A1: 7/09/03

Rack A2: 7/08/03

Unit 2:
Rack A3: 6/09/03
Rack A4: 6/05/03

b) neutron-absorbing material specifications, such as:
i) materials of construction, including the certified content of the neutron-absorbing component expressed as weight percent;

As discussed in the Electric Power Research Institute (EPRI) neutron absorber handbook (Reference 1):

> Boral is a hot-rolled composite sheet consisting of (1) a core of uniformly mixed and distributed boron carbide and alloy 1100 aluminum particles; and (2) a surface cladding, on both sides of the core, serving as a solid barrier.

More detail on the manufacturing process may be found in section 5.2.1 of the aforementioned handbook.

The boron carbide within the Boral has a nominal weight percent shown in the table below:

Nominal B_4C	Minimum B_4C
36.5 w/o	32.71 w/o

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

Areal Density	^{10}B g/cm^2-
Minimum certified	0.0220
Minimum as-built	0.0226
Maximum as-built	0.0273
Nominal as-built	0.0240

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

Characteristics	Value
Porosity	not provided to Duke Energy
Minimum as-built Boral Density	2.3744 g/cm^3
Dimensions (as designed)	Length: 147 (+/- 0.25) inches Width: 7.5 (+/- 0.062) inches Thickness: 0.075 (+/- 0.004) inches

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

The qualification approach of the Boral plates is contained in HOLTEC report HI-2012684, Boral Production, Properties, and Fuel Pool Application. Similar descriptions of AAR BORAL processes are also available in the EPRI neutron absorber handbook (Reference 1).

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

The major components of the cell module are the fuel assembly cell, the Boral (neutron absorbing) material, and the wrapper. Spot welding is used to attach the wrapper to the outside of the cell. The wrapper covers the Boral material and also provides for venting of the Boral to the pool environment.

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

Boral consists of a sintered aluminum matrix, with a dispersion of boron carbide particles, sandwiched between two type 1100 aluminum panels. When installed in the rack, Boral sheathing is 304L Stainless Steel and covers the poison sheet. The poison sheet is fully vented to the Spent Fuel Pool environment such that water ingress is allowed by the sheathing.

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

i) estimated current minimum areal density;

There has been no visual evidence (based on coupon examination) of Boral degradation at MNS. Therefore, it is estimated that the current minimal areal density is the same as when the Boral plates were installed.

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

The credited B-10 areal density of the Boral is 0.020 ^{10}B g/cm^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).

Based on the visual inspection of coupons performed to date, there have been no observations of any degradation or deformation of the Boral neutron absorber at MNS.

Area of Requested Information 2

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:

Coupon Monitoring - The coupons are a leading indicator of the Boral material condition, because they are routinely exposed to a higher gamma flux than the typical region 1 spent fuel pool rack. The core offload procedure requires the eight assemblies with the highest cycle burnup be discharged to face-adjacent locations around the coupon tree.

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

Currently, a biennial visual inspection of the installed Boral coupons is performed. This action was determined to be prudent at the time of installation and has not been changed to date.

ii) parameters to be inspected and data collected;

This inspection involves looking at the exterior of the 10 coupons (in each pool) for any signs of visual degradation. A video recording is also obtained.

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;

While there are no numerical acceptance criteria related to the visual inspection of Boral coupons at MNS, if any signs of degradation or deformation are observed during the inspection, the corrective action program would be used to investigate and resolve any issues.

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

No active trending is performed of the video since no degradation has been noted. Videos are kept for future review.

v) industry standards used.

None

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

i) If there is visual inspection of inservice material:

Given the design of the SFP racks and the Boral wrapper, visual inspection of the in service Boral is not feasible. Items (2)(b)(i)(1) and (2)(b)(i)(2) are not applicable for MNS.

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

Not applicable, as described in item (2)(b)(i) above.

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

Not applicable, as described in item (2)(b)(i) above.

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;

Ten Boral coupons were provided for each pool on a "coupon tree" and placed inside a spent fuel pool storage cell. These coupons are constructed from the same Boral used in the spent fuel pool racks. The coupons are bolted to the coupon tree and are sheathed in stainless steel and vented the same as the Boral in the spent fuel pool racks. Being vented, exposure to the spent fuel pool environment is the same as those in service Boral sheets. The coupons are approximately 8 inches x 4 inches.

The following are the Boral samples used in the trees.

Unit 1

Location	Sample Number	Lot
1	SG211100-2-1	M214
2	SG211100-2-2	M214
3	SG211100-2-3	M214
4	SG211100-2-4	M214
5	RG210082-1-1	M213
6	RG210082-1-2	M213
7	RG210082-1-3	M213
8	RG210082-1-4	M213
9	RG210082-1-5	M213
10	RG210082-1-6	M213

Unit 2

Location	Sample Number	Lot
1	RG210145-2-1	M213
2	RG210145-2-2	M213
3	RG210145-2-3	M213
4	RG210145-2-4	M213
5	RG210145-2-5	M213
6	RG210145-2-6	M213
7	SG211111-1-4	M214
8	SG211111-1-3	M214
9	SG211111-1-2	M214
10	SG211111-1-1	M214

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

1/19/2004 for both coupon trees

(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

No coupons have been removed from the spent fuel pool during inspection.

(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.

Both Unit 1 and Unit 2 still have the original 10 coupons in their respective storage racks. In light of ongoing license renewal efforts and in an effort to enhance Duke and industry knowledge of Boral's long term robustness, consideration is being given to initiating a periodic coupon analysis program. The details are still being determined, and while no commitments are made in this response, it is expected that a coupon will be removed periodically for analysis. With 10 coupons in each pool, there are currently enough coupons for analysis through the additional 20 year period of extended operation.

iii) (Not requested for Boral material.)
iv) If in-situ testing with a neutron source and detector is used (e.g., BADGER testing, blackness testing):
(1) describe the method and criteria for choosing panels to be tested and include whether the most susceptible panels are chosen to be tested. Provide the statistical sampling plan that accounts for both sampling and measurement error and consideration of potential correlation in sample results. State whether it is statistically significant enough that the result can be extrapolated to the state of the entire pool;
(2) state if the results of the in-situ testing are trended and whether there is repeat panel testing from campaign to campaign;
(3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial

Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (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

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

- ***(a) describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results;***
- ***(b) describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results; and***
- ***(c) if the calibration includes the in-situ measurement of an SFP rack "reference panel," explain the following:***
    - ***(i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements;***
    - ***(ii) whether all surveillance campaigns use the same reference panel(s); and***
    - ***(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.***

In-situ testing has not been performed for the Boral neutron absorber material at MNS. Sub-items (2)(b)(iv)(1) through (2)(b)(iv)(4) are not applicable.

Area of Requested Information 4

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.

Since no degradation or deformation has been observed for the Boral material at MNS, modeling the material as below the minimum certified B-10 areal density is conservative. Fleet and industry data regarding Boral neutron absorber material is monitored regularly through the review of industry OE and through participation in groups such as the EPRI Neutron Absorber Users Group. Inspections from other sites within the Duke Energy fleet (i.e. Harris Nuclear Plant, where Boral has been in service longer and for which there is more rigorous surveillance performed) are also examined for leading indicators of potential issues.

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.

As mentioned in the response to item (2)(b)(ii)(4), an updated monitoring program is being developed for the Boral material at MNS through license renewal implementation. While details of the inspection/surveillance program are still being developed, and no commitments are made in this response, current industry guidance (such as NEI 16-03, *Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools*) will be referenced in these efforts.

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

The bias and uncertainty of monitoring or surveillance programs are not included in the NCS AOR.

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

The analysis of record does not account for absorber degradation in adjacent cells.

REFERENCES:

1. Electric Power Research Institute Report 1019110, *Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications*, 2009 Edition.

Attachment 2

Response to GL 2016-01, Brunswick Steam Electric Plant

The information in this attachment constitutes the response to Generic Letter (GL) 2016-01 for the Brunswick Steam Electric Plant (BSEP). Table 1 of the GL is shown below, which specifies the required Areas of Requested Information based on neutron absorber type. For BSEP, the only credited neutron absorber is Boral. Responses required for the Boral neutron absorber are provided below, based on Table 1 and Appendix A of GL 2016-01.

Table 1. Areas of Information by Neutron Absorber Material Types

	Areas of Requested Information (described in Appendix A of GL-2016-XX)				
Neutron-Absorbing Material Type	(1)	(2)	(3)	(4)	(5)
Boraflex Carborundum Tetrabor	x	x	x	x	x
Boral	x	x*		x	
Borated stainless steel Metamic Boralcan Other metallic matrix composites	x	x*			

* Except for 2(b)(iii).

Area of Requested Information 1

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;***

The Brunswick Steam Electric Plant (BSEP) has two spent fuel pools, one per unit. Each of the spent fuel pools is equipped with five High Density Fuel Storage System (HDFSS) modules. The modules were purchased from General Electric (GE). Eight of the HDFSS modules, serial numbers HD-1 through HD-8, were assembled by GE. Modules HD-9 and HD-10 were assembled by Chicago Bridge & Iron. The constituent fuel storage tubes were manufactured by AAR Brooks & Perkins under GE Purchase Order 334-BB115.

The racks were installed in the spent fuel pools in four plant modifications. The dates the racks were placed in service are given in the following table:

High Density Fuel Storage System Racks

S/N	Manuf.	Size	Build Date[1]	Unit	Install Date[2]
HD-1	GE	15x17	07/20/83	2	03/22/84*
HD-2	GE	15x17	07/20/83	1	01/11/85
HD-3	GE	15x17	07/20/83	2	03/22/84*
HD-4	GE	15x17	07/20/83	1	12/03/84
HD-5	GE	13x17	07/20/83	2	03/22/84*
HD-6	GE	13x17	07/20/83	1	01/11/85
HD-7	GE	13x15	07/20/83	2	12/08/87
HD-8	GE	13x15	07/20/83	1	11/13/86
HD-9	CB&I	13x19	07/20/83	1	11/13/86
HD-10	CB&I	13x19	07/20/83	2	12/08/87

[1] Date released by manufacturer

[2] Date released by licensee for storage of spent fuel

* This date is the date the acceptance testing was marked complete. Actual installation was after this date.

b) neutron-absorbing material specifications, such as:

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

Most of the structural material used in the fabrication of the HDFSS is type 304 stainless steel. This material was chosen because of its corrosion resistance and its ability to be formed and welded with consistent quality. The only structural material employed in the HDFSS that is not 304 stainless steel is a special low-friction material used as a foot pad between the module and the support pad. Boral plates, used as a neutron absorber, are an integral non-structural part of the basic fuel storage tube. These plates are sandwiched between the inner and outer wall of the storage tube and are not subject to dislocation, deterioration, or removal. The inner and outer walls of the storage tubes are welded together at each end for mechanical rigidity. Small openings are formed in the top and bottom of each tube assembly by leaving gaps in the weld to allow for the venting of the envelope between the inner and outer tube walls. At normal pool water operating temperature there is no significant deterioration or corrosion of stainless steel or Boral. To date, BSEP has not identified, and does not expect to identify, any records tracing the history of the Boral absorber panels installed in the racks; therefore, the certified content of boron carbide in the Boral matrix of the absorber panels is not known. The available information regarding absorber density is presented in the response to (1)(b)(ii).

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

The fuel storage tubes were ordered by GE from AAR Brooks & Perkins. The Boral absorber panels were manufactured with the specifications given in the table below. While the specific values for individual absorber panels are not available in BSEP records, GE has indicated that the minimum B-10 areal density in any absorber panel is 0.0133 g/cm^2.

Boral Absorber Plate Specification

Parameter	Value
Minimum B-10 areal density (specified)	0.010 g/cm^2
Minimum B-10 areal density (as-built)	0.0133 g/cm^2
Minimum Width (specified)	5.90 in.
Maximum Width (specified)	6.23 in.
Length (specified)	152.00 in.
Minimum Thickness (specified)	0.071 in.
Maximum Thickness (specified)	0.081 in.
Aluminum Clad Thickness (specified)	0.010 in.

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

Porosity of the neutron absorbers is not described in any BSEP records. Densities of the surveillance coupons range from 2.54 to 2.59 g/cm^3. For other dimensions, see the response to item (1)(b)(ii).

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

The Electric Power Research Institute (EPRI) Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications (Reference 1) describes the material qualification testing performed on Boral, including radiation, corrosion, and elevated temperature testing. EPRI continues to perform additional tests on Boral neutron absorber material, including an accelerated corrosion test which is ongoing and will provide additional data to industry regarding the continued use of Boral in the spent fuel pool environment.

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

Boral plates are sandwiched between inner and outer stainless steel storage tubes. See the response to (1)(b)(i).

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

Gaps are left in the welds at the ends of each fuel storage tube to provide for venting. Otherwise, the absorber panels are completely enclosed between the inner and outer stainless steel tubes. See the response to (1)(b)(i).

e) current condition of the credited neutron-absorbing material in the SFP, such as:
   i) estimated current minimum areal density;

With the installation of the HDFSS racks, BSEP also purchased and installed surveillance coupons in each spent fuel pool. An in-service test program was established, consisting of periodic examination of surveillance samples that were suspended underwater in the fuel storage pool. These samples consisted of two types; the first being 8-inch square coupons of Boral plate with stainless steel sheet (i.e. cladding) formed to both sides, and the second consisting of 6-inch square samples of Boral without stainless "cladding." The stainless "clad" coupons had two sides open to permit water access. Sufficient samples were included to permit destructive examination of a sample on inspection intervals of one to five years over the life of the facility. This surveillance test was performed four times total (twice for each unit). Results of coupon testing of the neutron absorber provided no indication of loss of absorbing material. Subsequently, the surveillance program was canceled and the sample coupons destroyed. The current estimated minimum areal density is therefore the same as the as-built minimum areal density in the table in item (1)(b)(ii).

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

For the analyses of record, there are three referenced in the BSEP Updated Final Safety Analysis Report (UFSAR). The initial analysis can be found in the modifications that installed the HDFSS racks and in the license amendment request for the spent fuel storage expansion. It was performed using the MERIT code. The analysis used a maximum bundle multiplication factor (k_∞) of 1.35 and an areal density of 0.013 g/cm^2 of boron-10 on an infinite two-dimensional lattice.

The criticality analysis for ATRIUM-10 fuel was performed with a minimum areal density of 0.013 g/cm^2 boron-10 with an infinite array of a bounding reference fuel design. The criticality analysis for ATRIUM-10XM fuel was performed on the basis of the minimum Boral plate width and the minimum areal density of 0.010 g/cm^2 boron-10 in the plate. Since using the minimum value for areal density minimizes the overall boron-10 content, the calculations were performed in a conservative manner. Therefore, no manufacturing uncertainty is applied. It should be noted that the criticality analysis for ATRIUM-10XM specifically bounds earlier fuel types.

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).

Previous coupon samples did not show any loss of neutron absorbing capability in the Boral plates. Some blistering was observed during sample testing, but did not have an impact on the neutron attenuation capability of the samples. The most recent performance of the surveillance was in 1995. Subsequently, the surveillance program was canceled and the sample coupons destroyed.

Area of Requested Information 2

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:***

BSEP currently has no formal surveillance program for directly monitoring the performance of the neutron absorbers in the HDFSS racks. A procedure, "Boral Surveillance Sample Testing," was in place to periodically test surveillance coupons. A coupon sample holder was installed on each unit with sufficient coupons to sustain testing over the life of the racks. The program was canceled in 2000 and all coupons were destroyed based on the results of testing that had occurred (described below), and based on NRC communications around that time (e.g. Reference 2).

Boral plates are an integral non-structural element in the walls of the HDFSS racks that were installed in both spent fuel pools. Prior to installation of the racks in the spent fuel pools, neutron transmission testing was utilized to detect the presence, distribution and neutron absorption capability of the Boral on each side of the cells in the HDFSS racks. In the license amendment request to the NRC for the spent fuel storage expansion, the in-service test program consisting of periodic examination of the Boral surveillance samples was addressed. These samples were used to validate the integrity of the Boral within the HDFSS modules.

The Boral sample stations were initially installed in both Units 1 and 2, and testing was performed per site procedure in 1989 and 1995. Two stainless steel clad coupons and two bare coupons from each unit were pulled for each test. Following is a summary of these tests.

Test results from 1989 provided by AAR Brooks and Perkins Advanced Structures:

- Samples showed no physical changes indicative of degradation. Dimensional differences between baseline and testing are due to differences in measurement technique rather than physical change. There are no gauge marks on original samples to indicate where measurements were taken. Variations are also due to irregularities in the sample.
- B-10 areal density as high or higher than minimum baseline measurement.
- Neutron attenuation data indicates no change in the ability of the sample to capture thermal neutrons.
- No discernible changes that would have any effect on performance of fuel rack modules. No apparent differences between stainless steel encased samples and bare samples, indicating the stainless steel structure of the rack modules is not interacting with the Boral encased in the walls. Also indicates the performance of the surveillance samples fairly represents the performance of the fixed Boral in the fuel storage racks.

Test results from 1995 provided by AAR Advanced Structures:

- Visual observations showed little change from original condition. Small blisters on one sample. Tests concluded that the blisters do not damage the structural integrity of Boral

or affect its neutron attenuating properties. None of the samples showed signs of pitting or other deterioration.

- Measured attenuation exceeded that of new panels. Wet chemistry tests for B-10 areal density indicated densities exceed the design specification of 0.013 gm/crn^2, and predict a virtually infinite life.

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

As described in the response to item (2)(a), coupon testing was performed on two separate occasions for Boral coupons from the BSEP SFP. These inspections were performed roughly five years apart. Based on the results of the testing that had occurred, and based on NRC communications around that time (e.g. Reference 2), the coupon surveillance program was cancelled and all coupons were destroyed.

ii) parameters to be inspected and data collected;

Results from the coupon testing that was performed are summarized in the response to item (2)(a).

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;

As discussed in the response to item (2)(a), when coupon testing was performed, coupons exhibited acceptable results from the testing. As discussed in item (2)(a)(i), testing was cancelled based on a combination of results from testing and NRC communications.

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

Duke Energy monitors industry trends in neutron absorber material performance, including that of Boral, and maintains awareness of potential issues regarding Boral within the Duke nuclear fleet. Industry OE is reviewed periodically, watching for potential adverse trends and conditions that could be applicable to Boral, and any pertinent information from other Duke sites (such as Harris Nuclear Plant and McGuire Nuclear Station) is reviewed as well.

v) industry standards used.

Duke Energy, through monitoring of industry trends in neutron absorber material performance and through attendance and participation in the EPRI Neutron Absorber Users Group (NAUG), maintains awareness of potential issues regarding the different neutron absorbers used within the Duke Energy nuclear fleet. Industry OE is reviewed periodically, watching for potential adverse trends and conditions that could be applicable to the neutron absorbers employed by Duke Energy.

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

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

There is currently no prescribed periodic visual inspection of in-service Boral material at BSEP.

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;

As described in the response to item (2)(a), coupon testing was performed on two separate occasions for Boral coupons from the BSEP SFP. These inspections were performed roughly five years apart. Based on the results of the testing that had occurred, and based on NRC communications around that time (e.g. Reference 2), the coupon surveillance program was cancelled and all coupons were destroyed.

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

This item is no longer applicable for the Boral neutron absorber material in the BSEP SFP.

(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

This item is not applicable for BSEP.

(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.

There are no remaining coupons in the BSEP SFP.

iii) (Not requested for Boral material.)

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

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

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

(3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (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

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

- ***(a) describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results;***
- ***(b) describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results; and***
- ***(c) if the calibration includes the in-situ measurement of an SFP rack "reference panel," explain the following:***
  - ***(i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements;***
  - ***(ii) whether all surveillance campaigns use the same reference panel(s); and***
  - ***(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.***

In-situ testing is not performed on the Boral neutron absorber material at BSEP. Therefore, none of the items in (2)(b)(iv) are applicable to the Boral neutron absorber material in the BSEP SFP.

Area of Requested Information 4

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.***

Chapter 9 of the BSEP UFSAR cites three criticality analyses. The first is the original analysis performed for the initial installation of the racks. The second was performed to allow the storage of ATRIUM-10 fuel. The third was performed for the transition to ATRIUM-10XM fuel. The first and second criticality analyses both credit a boron-10 areal density of 0.013 g/cm^2. The ATRIUM-10XM criticality analysis credits an areal density of 0.010 g/cm^2. This value is less than the minimum as-built areal density of any of the absorber panels in the HDFSS racks, which is 0.0133 g/cm^2. The design of the racks places the Boral absorber plates in the space between the inner and outer fuel storage tube walls. This configuration leaves a gap in absorber material at the corners of each fuel storage tube as illustrated in Figure 1. That gap is not discussed in the original analysis or the analysis for ATRIUM-10. Illustrations in the geometric model for the original analysis imply the gap is modeled, but no dimension is given for the Boral plate width. Illustrations in the model for ATRIUM-10 imply that the model includes absorber material in the corners. The minimum specified plate width of 5.90 inches is modeled in the ATRIUM-10 criticality analysis. All three analyses use a two-dimensional model with reflective boundary conditions, such that no credit is taken for leakage in any direction.

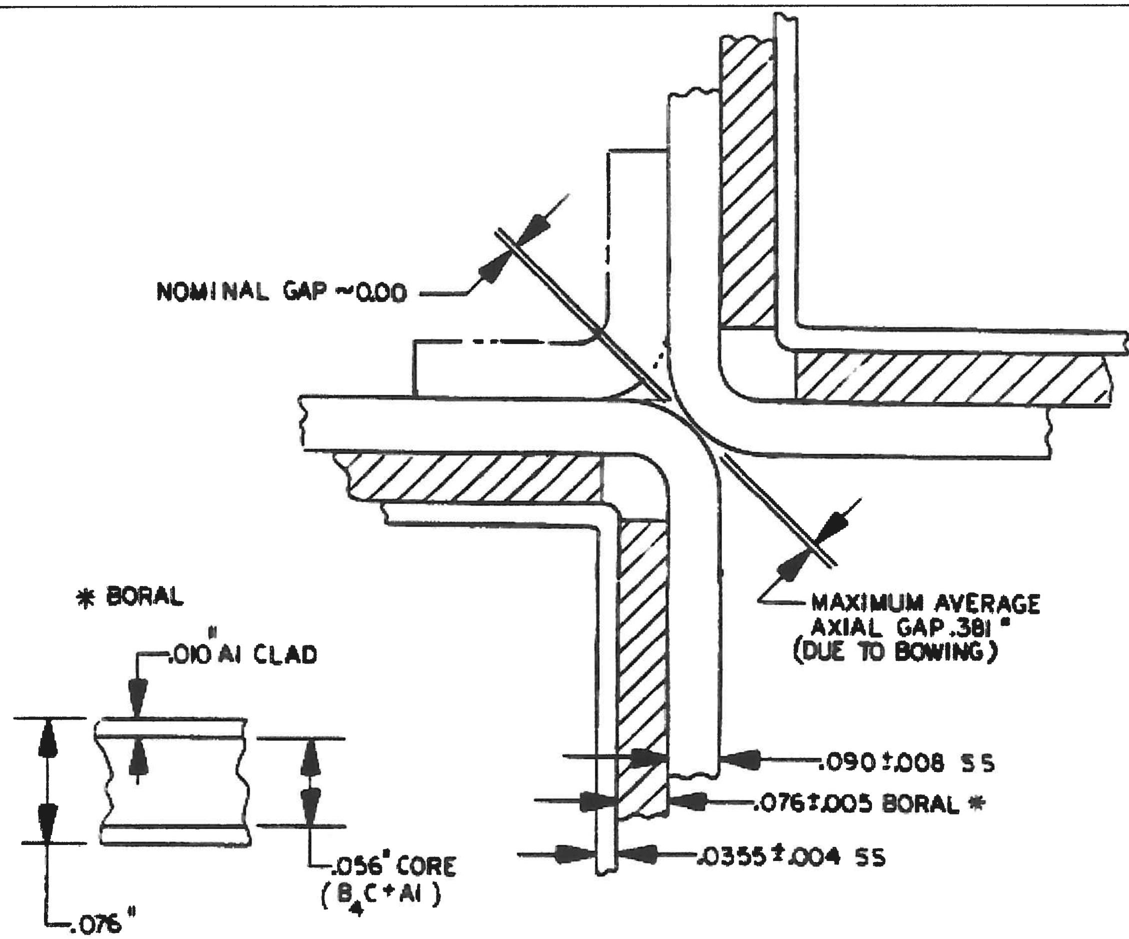

Figure 1 Fuel Storage Tube Diagram

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.***

In the absence of degradation, the analyses all bound the as-manufactured condition of the HDFSS racks. No consideration is given in the analyses for potential degradation or deformation of the absorber material. All analyses do consider the complete absence of a single absorber plate. (Note: in a model with reflective boundaries, a missing absorber plate is equivalent to periodic missing plates in an infinite lattice.)

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.

The surveillance program that was previously in place did not show any loss of neutron-absorbing capability of the Boral absorber panels. The current analyses of record assume that the absorbers remain in the as-built condition.

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

This item is not applicable to the Boral neutron absorber material in the BSEP SFP.

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

No consideration is given to degradation of multiple adjacent panels in the analyses of record.

REFERENCES:

1. Electric Power Research Institute Report 1019110, *Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications*, 2009 Edition.
2. Letter, Laurence I. Kopp (NRC) to Krishna P. Singh (HOLTEC International), stating there is no current NRC requirement for in-service surveillance on Boral in spent fuel pool storage racks, dated February 15,1995.

Attachment 3

Response to GL 2016-01, Shearon Harris Nuclear Power Plant

The information in this attachment constitutes the response to Generic Letter (GL) 2016-01 for the Shearon Harris Nuclear Power Plant (HNP). Table 1 of the GL is shown below, which specifies the required Areas of Requested Information based on neutron absorber type. For HNP, the credited neutron absorbers are Boral, Boraflex, and Metamic. Separate responses for each of the three absorber types are provided below, based on Table 1 and Appendix A of GL 2016-01.

Table 1. Areas of Information by Neutron Absorber Material Types

	Areas of Requested Information (described in Appendix A of GL-2016-XX)				
Neutron-Absorbing Material Type	(1)	(2)	(3)	(4)	(5)
Boraflex Carborundum Tetrabor	x	x	x	x	x
Boral	x	x*		x	
Borated stainless steel Metamic Boralcan Other metallic matrix composites	x	x*			

* Except for 2(b)(iii).

Area of Requested Information 1 (Boral)

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;***

Engineering Change (EC) Package	TYPE	Manuf.	Date Manuf.	Install Date.
PCR4517 SFPB	BWR	AAR	No Info.	1991
95-00278 SFPB	BWR	AAR	No Info.	1997
95-00442 SFPC	PWR BWR	AAR	No Info.	2000
54204 SFPC	PWR BWR	AAR	No Info.	2005
60290 SFPC	BWR	AAR	No Info.	2007

PWR spent fuel storage racks using Boral have been installed in HNP Spent Fuel Pool (SFP) B in two phases and SFPC in three additional phases (represented by the respective EC package number in the table above). Boral racks in SFPB are co-resident with PWR/BWR racks that contain Boraflex as a neutron absorber (PWR Boraflex racks do not credit Boraflex). Boral racks in SFPC are co-resident with racks that contain Metamic as the neutron absorber. The date of manufacture (Boral panels) was not provided in the available QA documentation.

b) neutron-absorbing material specifications, such as:

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

As discussed in the Electric Power Research Institute (EPRI) neutron absorber handbook (Reference 1):

> Boral is a hot-rolled composite sheet consisting of (1) a core of uniformly mixed and distributed boron carbide and alloy 1100 aluminum particles; and (2) a surface cladding, on both sides of the core, serving as a solid barrier.

More detail on the manufacturing process may be found in section 5.2.1 of the aforementioned handbook.

EC PACKAGE	TYPE	Material of Construction	NOMINALw/o Neutron Absorber (BORON in B_4C)
PCR4517 SFPB	BWR	Boron Carbide	Info unavailable
95-00278 SFPB	BWR	Boron Carbide	Info unavailable
95-00442 SFPC	PWR	Boron Carbide	78.28 w/o
	BWR		
54204 SFPC	PWR	Boron Carbide	78.28 w/o
	BWR		
60290 SFPC	BWR	Boron Carbide	78.28 w/o

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

EC PACKAGE	TYPE	Min. Cert. (g $^{10}B/cm^2$)	Min. As-built (g $^{10}B/cm^2$)	Max. As-built (g $^{10}B/cm^2$)	Nom. As-built (g $^{10}B/cm^2$) Boron
PCR4517 SFPB	BWR	-	0.0151	0.0190	0.0162
95-00278 SFPB	BWR	-	0.0151	0.0318	0.0162
95-00442 SFPC	PWR	-	0.0291	0.0337	0.0302
	BWR	-	0.0156	0.0319	0.0162
54204 SFPC	BWR	0.0372 0.0150	-	-	0.0162
	PWR	0.0280	-	-	0.0302
60290 SFPC	BWR	-	0.0153	0.0193	0.0162

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

EC PACKAGE	TYPE	Porosity	Mass Density	Width	Length	Thick
PCR4517 SFPB	BWR	Not Available	≈ 2.541 – 2.536 gm/cm^3 (EPRI)	5.0”	150.0”	0.075”
95-00278 SFPB	BWR	Not Available	≈ 2.541 – 2.536 gm/cm^3 (EPRI)	5.00”	150.0”	0.075”
95-00442 SFPC	PWR	Not Available	0.0907 lb/in^3	7.5”	145”	0.098”
	BWR	Not Available	0.0907 lb/in^3	5.0” Inner 3.5” Periphery	150”	0.075” Inner 0.101” Periphery
54204 SFPC	PWR	Not Available	0.0907 lb/in^3	7.5”	145”	0.098”
	BWR	Not Available	0.0907 lb/in^3	5.0” Inner 3.5” Periphery	150”	0.075” Inner 0.101” Periphery
60290 SFPC	BWR	Not Available	0.0907 lb/in^3	5.0” Inner 3.5” Periphery	150”	0.075” Inner 0.101” Periphery

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

The EPRI neutron absorber handbook (Reference 1) describes the material qualification testing performed on Boral, including radiation, corrosion, and elevated temperature testing. EPRI continues to perform additional tests on Boral neutron absorber material, including an accelerated corrosion test which is ongoing and will provide additional data to industry regarding the continued use of Boral in the spent fuel pool environment.

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

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	The neutron absorber is encapsulated using stainless steel sheathing that is attached to the spent fuel storage walls. The flanges of the sheathing are welded to the box using skip welds and spot welds.
95-00278 SFPB	BWR	
95-00442 SFPC	PWR	The neutron absorber is encapsulated using stainless steel sheathing that is attached to the spent fuel storage walls. The flanges of the sheathing are welded to the box using skip welds and spot welds.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	Sheathing is attached to each side of the box with the poison material installed in the sheathing cavity. The design objective calls for attaching the Boral tightly to the box surface. The sheathing is skip/tack welded as described in item (1)(d)(i) above.
95-00278 SFPB	BWR	
95-00442 SFPC	PWR	
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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

i) estimated current minimum areal density;

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	Results of the coupon testing of the Boral neutron absorber have provided no indication of loss of neutron absorbing material. Neutron attenuation testing has indicated no reduction in the measured areal density compared to the initial calculated values. Therefore, the estimated current minimum areal density is the same as when the material was fabricated and installed in the SFP.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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

EC PACKAGE	TYPE	AOR	INFORMATION
PCR4517 SFPB	BWR	HI-90526	Design basis B-10 areal density of 0.0150 (g/cm^2)
95-00278 SFPB	BWR	HI-90526	Design basis B-10 areal density of 0.0150 (g/cm^2)
95-00442 SFPC	PWR	HI-971760	Design basis B-10 areal density of 0.0280 (g/cm^2)
	BWR	HI-971760	Design basis B-10 areal density of 0.0150 (g/cm^2)
54204 SFPC	PWR	HI-971760	Design basis B-10 areal density of 0.0280 (g/cm^2)
	BWR	HI-971760	Design basis B-10 areal density of 0.0150 (g/cm^2)
60290 SFPC	BWR	HI-971760	Design basis B-10 areal density of 0.0150 (g/cm^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).

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517 SFPB</td><td>BWR</td><td>There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>95-00278 SFPB</td><td>BWR</td><td>The following issue has been observed. (coupon sample)

Visual Observations (Aluminum Cladding): Condition of Aluminum Cladding
• Pitting corrosion has been identified on the aluminum cladding of the BORAL sample coupon pulled from SFP-B (2013). The pitting was found to be in excess of the acceptance criterion (>25 pits/coupon side by NETCO standards) for physical appearance.
• Attributed to water chemistry. Water chemistry program was changed in 2005, making the SFP environment more conducive for BORAL.
• No blisters, swelling, gaps, cracks, or impact to neutron-attenuation was observed.</td></tr>
<tr><td rowspan="2">95-00442 SFPC</td><td>PWR</td><td rowspan="5">There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>BWR</td></tr>
<tr><td rowspan="2">54204 SFPC</td><td>PWR</td></tr>
<tr><td>BWR</td></tr>
<tr><td>60290 SFPC</td><td>BWR</td></tr>
</table>

Boral coupons were installed in support of BWR racks during the 1997 campaign. Coupons were not installed for any other Boral rack installation campaign.

Area of Requested Information 2 (Boral)

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:

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517
SFPB</td><td>BWR</td><td>Coupon Monitoring: Coupons installed under EC package 95-00278 are relied upon as an indicator of neutron absorber performance.
Blackness/Badger/Racklife Testing: Not Performed
Industry OE: Industry OE is evaluated to assess impact on neutron absorber material</td></tr>
<tr><td>95-00278
SFPB</td><td>BWR</td><td>Coupon Monitoring: Surrogate Coupons have been manufactured from a comparable lot/batch of material used to manufacturer panels for the spent fuel pool. Able to detect aging/degradation mechanisms that the in-service neutron absorber materials experience.

Coupon trees associated with this EC are in BWR racks. BWR fuel assemblies (whether in SFPA or SFPB) were required to meet the Certificate of Compliance (COC) for the transfer cask and thus were/are relatively cool. Information from these coupon trees is likewise relied upon as an indicator for PWR racks (Boral PWR racks in SFPC). For fuel to be stored in SFPC it must be cooled for 5 years (per Technical Specification), and once moved assemblies are seldom relocated. As such the PWR fuel in BORAL racks contains older fuel that has been discharged for a number of years.

See (2)(a)(iii) for acceptance criteria.
Blackness/Badger/Racklife Testing: Not Performed
Industry OE: Industry OE is evaluated to assess impact on neutron absorber material (NAUG)
Water Chemistry Monitoring: per HNP procedure CRC-001, which follows EPRI guidelines</td></tr>
<tr><td rowspan="2">95-00442
SFPC</td><td>PWR</td><td rowspan="5">Coupon Monitoring: Coupons installed under EC package 95-00278 are relied upon as an indicator of neutron absorber performance.
Blackness/Badger/Racklife Testing: Not Performed
Industry OE: Industry OE is evaluated to assess impact on neutron absorber material (NAUG)
Water Chemistry Monitoring: per HNP procedure CRC-001, which follows EPRI guidelines</td></tr>
<tr><td>BWR</td></tr>
<tr><td rowspan="2">54204
SFPC</td><td>PWR</td></tr>
<tr><td>BWR</td></tr>
<tr><td>60290
SFPC</td><td>BWR</td></tr>
</table>

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

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	BORAL coupons were originally placed in the SFP with the associated racks. A monitoring program was not required and no significant degradation mechanism was thought to exist. In 2013 the BORAL coupon program was revived. Due to the low number of samples pulled (to date), a baseline has not been established. Once a baseline is established, a schedule for coupon pulls may be determined based on years of service to date and any degradation present on coupons that are analyzed. As stated earlier some pitting has been observed, but no loss of neutron absorber material (attenuation) has been seen.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

ii) parameters to be inspected and data collected;

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	1. Visual observations – YES (SS JACKET AND ALUMINUM CLADDING) looking for cracking, corrosion, pitting, and discoloration. 2. Dimensional measurements (hydrated) – YES (LENGTH, WIDTH, THICKNESS) 3. Neutron attenuation – YES 4. Weight – YES (hydrated and dry) 5. Dimensional measurements (dry) – YES (LENGTH, WIDTH, THICKNESS) 6. Specific Gravity – YES See (2)(a)(iii) for acceptance criteria.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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;

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517
SFPB</td><td>BWR</td><td>There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>95-00278
SFPB</td><td>BWR</td><td>Acceptance Criteria:
1. SS Jacket Condition (indication of the condition of the cell walls of the fuel storage rack)
2. Aluminum Cladding Condition (condition of aluminum cladding protecting B-10)
3. Coupon Sample Dimensions (Coupon thickness at any point should not exhibit an increase of greater than 10%)
4. Neutron Attenuation. (coupon should not exhibit a decrease of greater than 5% in B-10 content)

As discussed above the Boral panels within the racks are sandwiched between two stainless steel plates. The amount of extreme degradation required to compromise the structure (allow for relocation of panels) would be recognized during performance of the surveillance. The corrective action program would drive operability assessments well before realistic structural integrity of the BORAL panels was reached.

The safety function is assured by measuring the neutron attenuation of the material to calculate a pre-irradiated to post-irradiated B-10 g/cm^2. Should this value decrease by greater than 5%, the corrective action program is entered.</td></tr>
<tr><td rowspan="2">95-00442
SFPC</td><td>PWR</td><td rowspan="5">There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>BWR</td></tr>
<tr><td rowspan="2">54204
SFPC</td><td>PWR</td></tr>
<tr><td>BWR</td></tr>
<tr><td>60290
SFPC</td><td>BWR</td></tr>
</table>

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

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	Monitoring and trending is performed by the Reactor Engineering group. This group is the most knowledgeable of neutron absorber issues and frequents user group meetings (NAUG/NEI used Fuel management Conference). Operating Experience from the industry is brought in from these meetings and applied as necessary. Typically the work management process (Preventative Maintenance activities) are cyclically scheduled to perform Boral integrity tests. The engineer responsible for performing the Boral integrity test would be cognizant of issues with the neutron absorber and monitor degradation (should it occur). Should the results not meet the acceptance criteria, the corrective action program would be entered and drive an investigation.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

v) industry standards used.

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	No specific industry standards are referenced as the basis for the Boral coupon surveillance program implemented at HNP.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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

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

Visual inspections are not performed for the BORAL racks at Harris Nuclear Plant.

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;

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	Coupons have been manufactured from a comparable lot/batch of material used to manufacturer panels for the spent fuel pool. Coupons are located within a cell location in the corresponding racks (two trees are present). The coupons are sheathed in stainless steel with the Boral sandwiched in the middle and bolted around the periphery (environment designed to be similar to neutron absorber material within racks). The coupon dimensions are 4” x 6”, with the thickness corresponding to that of the material within the rack. The coupons are exposed to the same water chemistry and a similar (not necessarily bounding) gamma/neutron exposure as panels within the racks, thus provide a representation of neutron absorber condition. See discussion at beginning of Area of Requested Information 2 (Boral) for applicability to PWR racks.
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

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

EC PACKAGE	TYPE	INFORMATION
PCR4517 SFPB	BWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
95-00278 SFPB	BWR	Dates installed o CTREE1 = 10/22/1997 o CTREE2 = 10/22/1997
95-00442 SFPC	PWR	There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.
	BWR	
54204 SFPC	PWR	
	BWR	
60290 SFPC	BWR	

(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

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517 SFPB</td><td>BWR</td><td>There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>95-00278 SFPB</td><td>BWR</td><td>o If coupons are returned to the fuel pool, credit would not be taken for the coupons remaining representative of the materials in the rack. Additional information may be extracted from said coupons at some point in the future should a sound justification for their use be made. Currently the coupon procedure does not require examined coupons to be re-installed</td></tr>
<tr><td rowspan="2">95-00442 SFPC</td><td>PWR</td><td rowspan="5">There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>BWR</td></tr>
<tr><td rowspan="2">54204 SFPC</td><td>PWR</td></tr>
<tr><td>BWR</td></tr>
<tr><td>60290 SFPC</td><td>BWR</td></tr>
</table>

(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.

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517 SFPB</td><td>BWR</td><td>There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>95-00278 SFPB</td><td>BWR</td><td>o CTREE1 = 8 remaining coupons (1 is currently being processed)
o CTREE2 = 10 remaining coupons

There is currently not a commitment to have a BORAL coupon monitoring program. With this said HNP felt it prudent to start monitoring potential BORAL degradation. Once the program was instated the first coupon was pulled in June, 2013. A second coupon was pulled in August 2016 but results have not been obtained to date. Assuming this coupon yields similar results (compared to 2013) a schedule similar to the METAMIC program will be implemented (near the 20 year mark). The coupons have been installed for ≈20 years thus early failure mechanisms if present should be observable. The coupons should be in a period of long term monitoring.</td></tr>
<tr><td rowspan="2">95-00442 SFPC</td><td>PWR</td><td rowspan="5">There are no coupons installed for these racks, however coupons installed under EC package 95-00278 are used as a representative indicator of neutron absorber performance.</td></tr>
<tr><td>BWR</td></tr>
<tr><td rowspan="2">54204 SFPC</td><td>PWR</td></tr>
<tr><td>BWR</td></tr>
<tr><td>60290 SFPC</td><td>BWR</td></tr>
</table>

iii) (Not requested for Boral material.)

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

- ***(1) describe the method and criteria for choosing panels to be tested and include whether the most susceptible panels are chosen to be tested. Provide the statistical sampling plan that accounts for both sampling and measurement error and consideration of potential correlation in sample results. State whether it is statistically significant enough that the result can be extrapolated to the state of the entire pool;***
- ***(2) state if the results of the in-situ testing are trended and whether there is repeat panel testing from campaign to campaign;***
- ***(3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (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***
- ***(4) describe the calibration of the in-situ testing device, including the following:***
    - ***(a) describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results;***
    - ***(b) describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results; and***
    - ***(c) if the calibration includes the in-situ measurement of an SFP rack "reference panel," explain the following:***
        - ***(i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements;***
        - ***(ii) whether all surveillance campaigns use the same reference panel(s); and***
        - ***(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.***

In-situ testing with a neutron source and detector has not been performed for any of the Boral SFP racks at HNP.

Area of Requested Information 4 (Boral)

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.***

<table>
<tr><th>EC PACKAGE</th><th>TYPE</th><th>INFORMATION</th></tr>
<tr><td>PCR4517 SFPB</td><td>BWR</td><td rowspan="2">The HOLTEC criticality analysis references back to the original Westinghouse 11x11 BWR rack design. The racks are considered equivalent to or better than the original. For example the B-10 areal density has been increased from 0.0103 to 0.015 gm/cm^2.

Westinghouse Original Criticality Analysis (89CP*-G-0005)
o Considerations on the following variables
    o Poison loading
    o Poison particle size
    o Rack construction
    o Rack material thickness
    o Water density
    o Calculation method uncertainty
The AOR does not have tolerances explicitly accounting for neutron absorber degradation.</td></tr>
<tr><td>95-00278 SFPB</td><td>BWR</td></tr>
<tr><td rowspan="2">95-00442 SFPC</td><td>PWR</td><td>The AOR has tolerances for the following aspects
o Boron Loading Tolerance (equivalent to 100[1-0.0280/0.0302]=7.3%)
o Boral width tolerance
o Cell lattice spacing and cell box inner dimension
o Stainless Steel thickness tolerance
o Fuel Enrichment and density
The AOR does not have tolerances explicitly accounting for neutron absorber degradation.</td></tr>
<tr><td>BWR</td><td>The AOR has tolerances for the following aspects
o Boron Loading Tolerance (equivalent to 100[1-0.0162/0.0150]=7.4%)
o Boral width tolerance
o Cell lattice spacing and cell box inner dimension
o Stainless Steel thickness tolerance
o Fuel Enrichment and density
o Zirconium flow channel
The AOR does not have tolerances explicitly accounting for neutron absorber degradation.</td></tr>
<tr><td rowspan="2">54204 SFPC</td><td>PWR</td><td>See above (SFPC)</td></tr>
<tr><td>BWR</td><td>See above (SFPC)</td></tr>
<tr><td>60290 SFPC</td><td>BWR</td><td>See above (SFPC)</td></tr>
</table>

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.*

The surveillance program (coupon samples) looks at the following criteria for acceptability:

1) Stainless Steel Jacket Condition (indication of the condition of the cell walls of the fuel storage rack)
2) Aluminum Cladding Condition (condition of aluminum cladding protection B-10)
3) Coupon Sample Dimensions (Coupon thickness at any point should not exhibit an increase of greater than 10%)
4) Neutron Attenuation. (coupon should not exhibit a decrease of greater than 5% in B-10 content)

   Limits discussed above would push the user into the corrective action program.

The above criteria is used for acceptability of the spent fuel pool racks. The first two criteria are qualitative in nature. As such if excessive staining, pitting, or blistering is present, entry into the corrective action program is required. The corrective action program drives evaluation of the neutron absorber material and potential impacts on criticality and structural concerns. The localized increase in thickness is used to check for the presence of swelling. The 10% criteria was chosen as a reference point when swelling would become a concern (relocation of material, etc). The 5% criterion for neutron attenuation is a reference point where the reactivity impact starts to become noteworthy. This criteria provides margin to the nominal B-10 loading value, allowing for alternate measures to be implemented as necessary.

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

The surveillance program acceptance criteria are designed to provide an early indication of issues. This early indication is intended to be well within the uncertainty of the surveillance program. The surveillance program is not designed to identify margin to the NCS AOR but rather kick off a more detailed evaluation.

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

The AOR does not have tolerances explicitly accounting for neutron absorber degradation in adjacent panels.

Area of Requested Information 1 (Boraflex)

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;

Neutron absorber material – Boraflex
Neutron absorber manufacturer – Brand Industrial Services (BISCO)
Rack manufacturer -- Westinghouse
Dates of manufacture/installation – 1981 / 1982

Both PWR and BWR SFP racks containing Boraflex poison material were installed at HNP; however, credit is no longer taken for the Boraflex material in the PWR racks in SFPs A and B. Therefore, the response for HNP to this Generic Letter with respect to Boraflex neutron absorber material will focus on the BWR racks in the A and B pools, in which the Boraflex is still credited in the current licensing basis.

   b) neutron-absorbing material specifications, such as:
      i) materials of construction, including the certified content of the neutron-absorbing component expressed as weight percent;

In its as-manufactured state, Boraflex material consists of a matrix of poly dimethyl siloxane (PDMS), or silicone rubber, with boron carbide filler material. In addition to the boron carbide filler, the manufacturer of the polymer (Dow Corning) added finely divided crystalline silica as a reinforcer and extender. In the as-manufactured condition, Boraflex consists of ~50 w/o boron carbide, 25 w/o PDMS and 25 w/o crystalline silica.

Nominal B_4C weight percent is 49.5 for Boraflex material provided to HNP.

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

B-10 areal density values:
Minimum certified (by calculation using manufacturing data)– 0.0103 g $^{10}B/cm^2$
Minimum as-built – 0.010990 g $^{10}B/cm^2$
Maximum as-built – 0.0122 g $^{10}B/cm^2$
Nominal as-built – not provided

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

Porosity values were never communicated for the Boraflex material. The elastomer material density ranged from 1.3869 – 1.3889 g/cc.

The Boraflex sheets were manufactured to be rectangles 151 inches long by 5.1 inches wide and 0.045 inches thick.

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

As discussed in the EPRI Neutron Absorber Handbook, section 9.2.5:

> While in these tests small specimens of Boraflex were subjected to massive doses of fast neutron and gamma radiation (excess of 10^{12} rads combined) over relatively short periods of time, the qualification tests were flawed in that they did not adequately reproduce the spent fuel pool service environment. The testing did not adequately address the synergistic effects of gamma radiation combined with long-term exposure to the pool water.

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***

As discussed in the EPRI Neutron Absorber Handbook, section 9.2.6:

> Sheets of Boraflex material were simply unrolled and adhered to the stainless steel rack walls using an adhesive material. The stainless steel cell walls were tack welded at various points along the length of the cell.

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

Although the Boraflex material is enclosed in a sheath of stainless steel, the material is exposed to the SFP water due to the tack welding of the material.

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

Following the release of GL 96-04, Duke Energy Progress (then Progress Energy) recognized the potential impact of the degradation of Boraflex in the SFP racks. In the initial operability evaluation, it was determined that partial soluble boron credit of 400 ppmB (Tech Specs require 2000 ppmB at all times) and burnup credit for the BWR fuel would more than compensate for the reactivity impact of complete degradation of the Boraflex material in the BWR SFP racks at HNP in maintaining the required regulatory margin to criticality.

In the time since the initial operability evaluation was performed, several actions have been taken to ensure management of the Boraflex degradation and to ensure proper reactivity margin has been maintained in the BWR Boraflex racks at HNP.

One of the interim/compensatory actions performed in support of the operability evaluation of the BWR Boraflex racks was an evaluation of margin between the AOR-required Boraflex B-10 areal density and the reactivity of real BWR assemblies placed in the HNP SFP. Based on the results of that calculation, Duke Energy determined an acceptable Boraflex loss of B_4C of up to 32.75% while maintaining all appropriate margin to the regulatory limits.

As further assurance of margin, a calculation was performed to evaluate the margin provided by the soluble boron in the HNP SFP. Soluble boron currently is not credited in the BWR Boraflex rack NCS AOR. A correlation of soluble boron that could account for a range of BWR Boraflex panel degradation was produced, with 1240 ppm soluble boron mitigating 100% Boraflex

degradation. As mentioned previously, soluble boron is already incorporated in the HNP Tech Specs (minimum 2000 ppm), since partial credit is required for other SFP storage racks at HNP. The soluble boron provides further assurance of actual safety margin in addition to extra margin to the regulatory limits.

Following a recent (2015) update to the BWR Boraflex racks operability evaluation, the BWR assemblies previously located in the most vulnerable (most degraded Boraflex) SFP A and B cells were re-located to other BWR cells, and no fuel is being placed in the cells from which these assemblies were migrated. This action provides additional assurance of margin.

i) estimated current minimum areal density;

RACKLIFE analyses have been performed periodically to obtain information about the estimated B-10 areal density in the BWR Boraflex racks. In the latest iteration of these analyses, several different scenarios were modeled based on different assumptions about the conditions of the SFP environment and the racks themselves at the time the calculation was performed. In its evaluations of the Boraflex racks, Duke Energy has chosen to base judgments about the degradation of the Boraflex material on a conservative scenario that assumes all the panels originally contained the minimum B-10 areal density, based on manufacturing tolerances at the time the material was made and installed at Harris. This scenario is described as "Case 1" in the final NETCO report. Based on the RACKLIFE calculation performed and the scenario chosen from which to pull results, the estimated maximum loss of B_4C content in the panels is still less than the value determined to be acceptable in preserving the proper regulatory and safety margin to criticality in the SFP. Rather than rely directly on explicitly calculated predicted B_4C (and B-10) losses, Duke Energy has used the data to make conservative engineering judgments about the level of degradation in the panels and the resultant actions that should be taken to mitigate the potential risk of further degradation. It should be noted here that the maximum predicted losses of B_4C content occur in BWR cell panels that are adjacent to PWR racks in the SFP. As mentioned earlier, these BWR Boraflex cells immediately adjacent to the PWR racks have been emptied of fuel, specifically because they have experienced the most absorber degradation of all the Boraflex panels.

In summary, although there is not an explicit current calculated minimum areal density for these Boraflex panels, the minimum estimated areal density of any Boraflex panel where fuel is still stored satisfies the regulatory requirements for sub-criticality safety.

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

The NCS AOR credited areal density of the BWR SFP rack Boraflex material is 0.0103 g $^{10}B/cm^2$.

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).

In a 2005 transmittal to the NRC (ADAMS Accession No. ML051230320), Duke Energy (Progress) reported on degradation of the Boraflex material at that time. Subsequent to this supplemental response to NRC Generic Letter 96-04, Duke Energy has had an updated

RACKLIFE analysis performed and determined that the most prudent and durable action is to embark on a rack insert campaign.

There are no coupons for BWR Boraflex absorber material in the HNP SFP, since there were PWR Boraflex rack coupons in the SFP when the BWR Boraflex racks were installed, and the PWR racks were known to be more limiting (higher gamma exposure). PWR Boraflex coupons have been examined from the HNP SFP, and the typical shrinkage, gaps, and cracks have been observed. It is inferred that these material conditions are also indicative of the BWR rack Boraflex material.

Area of Requested Information 2 (Boraflex)

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:***

As noted earlier, based on NETCO RACKLIFE analyses, actions have been taken to address degradation of the Boraflex material, which will ultimately culminate in the removal of credit for the Boraflex material through a license amendment request. There are no other specific surveillance or monitoring programs applicable to the BWR Boraflex SFP racks at HNP. As mentioned in the response to item (1)(e)(iii), there were coupons corresponding to the PWR Boraflex SFP racks. These coupons were used in the past to make judgments about the BWR Boraflex material; however, meaningful corollary information is no longer obtainable from these coupon samples, as the PWR Boraflex rack material (which is no longer credited in the NCS AOR for those racks) has experienced significantly higher levels of degradation than the BWR Boraflex rack material.

Responses to subsequent item 2 questions will be provided based on the experience and results with RACKLIFE at HNP.

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

RACKLIFE analysis updates are driven by two scenarios: if the length of time exceeds the validity of the existing analysis, or if fuel is moved in such a way that the results of the previous analysis are rendered invalid. The entire SFP is modeled in the RACKLIFE analyses, including multiple distinct SFPs and storage rack types found therein.

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

The primary result of interest of the RACKLIFE analysis is an estimation of the loss of B_4C, and, thus, B-10 content, of the BWR Boraflex panels in the HNP SFP.

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;***

The primary acceptance criterion for continued operability of the Boraflex BWR panels at HNP is the maximum acceptable panel degradation discussed earlier in the response to item (1)(e)(i). The aforementioned RACKLIFE analyses have been reviewed, and follow-up actions have been taken through the corrective action program to ensure continued safe storage of fuel in the BWR Boraflex SFP racks at HNP. Amongst those actions, several calculations were performed, all of which aided in developing an understanding of the margin to the regulatory limits that truly exists in the HNP SFP BWR Boraflex racks. Ultimately, as discussed earlier, a rack insert project is being pursued, and this action will provide a durable future state for these racks.

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

The HNP Boraflex BWR SFP racks represent an ongoing effort within Duke Energy's corrective action program, from the initial operability determination and until a license submittal is made to remove credit for any remaining Boraflex material in the SFP environment. The current operability date is July 2018, at which point rack inserts are projected to be installed or the operability evaluation will be updated.

v) industry standards used.

Duke Energy and its predecessor companies have supported the EPRI Neutron Absorber Users Group (NAUG) with routine attendance and participation in discussions regarding industry experience with various neutron absorber materials in the SFP, including the use of Boraflex. Duke Energy has used the NAUG meetings and other industry interactions to stay abreast of developments in the use of tools (such as RACKLIFE) to understand and mitigate potential degradation mechanisms in SFP rack neutron absorber materials.

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

Due to the nature of the BWR Boraflex rack material at HNP (sheathed in stainless steel), visual inspection of the Boraflex material is not practical HNP.

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

This item is not applicable to the BWR Boraflex panels at HNP.

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;

This item is not applicable to the BWR Boraflex panels at HNP. As mentioned earlier in the response to item 2, there were PWR Boraflex rack coupons at HNP, but, as expected, the Boraflex material in those racks has degraded more quickly than in the BWR racks, and meaningful data is no longer attainable for application to the BWR Boraflex racks.

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

This item is not applicable to the BWR Boraflex panels at HNP.

(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

This item is not applicable to the BWR Boraflex panels at HNP.

(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.

This item is not applicable to the BWR Boraflex panels at HNP.

iii) If RACKLIFE is used:
(1) note the version of RACKLIFE being used (e.g., 1.10, 2.1);

Version 2.0 was used to model the HNP SFP environment and degradation of the BWR Boraflex rack material.

(2) note the frequency at which the RACKLIFE code is run;

See the response to item (2)(a)(i).

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

Based on discussions between Duke Energy and NETCO, BADGER testing for the BWR Boraflex racks at HNP would be virtually impossible based on a lack of available space within which to move fuel assemblies to allow for proper testing. There are very few empty cells in these racks. Therefore, this testing has not been performed on the BWR Boraflex SFP racks at HNP.

Based on the RACKLIFE results using multiple conservative modeling assumptions and the most up-to-date SFP water chemistry data, a SFP rack insert project is being pursued. Duke Energy and HOLTEC International have a contract in place, which will ultimately result in Metamic neutron absorber inserts. A license amendment request is expected to be submitted to remove any remaining credit for Boraflex in the BWR SFP racks.

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

See the response to item (1)(e)(i) for information on the current calculated Boraflex condition.

The RACKLIFE model option chosen by Duke Energy to base decisions on is the model that assumes all the Boraflex began its service at the minimum as-manufactured areal density.

NETCO was contracted to develop and run the RACKLIFE model used to predict Boraflex degradation of the BWR Boraflex racks. NETCO was chosen due to their vast experience with the RACKLIFE code and their knowledge of inputs used throughout the industry in support of site specific RACKLIFE models, including escape coefficients. The HNP RACKLIFE model was initially developed using escape coefficients typical for other PWR and BWR sites. The fully developed model was then run and the resulting degradation/silica release was graphed and compared to actual silica release rates/concentrations measured in the SFPs. The escape coefficients were then adjusted to get the predicted silica release rates to match the actual measured values observed in the plant.

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

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

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

(3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (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

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

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

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

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

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

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

(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.

BADGER testing currently is not being performed at HNP. Given the decision to procure and install rack inserts, there are no plans for in-situ blackness testing at HNP.

Area of Requested Information 3 (Boraflex)

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

There is no specific surveillance interval for the BWR Boraflex panels at HNP. Once the RACKLIFE results provided a conservative estimate of B_4C loss in the panels, Duke Energy embarked on the rack insert project to provide an alternative to the Boraflex prior to that time when the Boraflex material would degrade below the analytically determined maximum allowed degradation (see the response to item (4)(a) for more information).

Area of Requested Information 4 (Boraflex)

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.

When the original NCS AOR for the BWR Boraflex racks at HNP was performed, degradation of the Boraflex material was not considered.

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.

As previously discussed, there is no formal monitoring program of coupons or in-situ testing in place for the BWR Boraflex racks at HNP. Based on the most recent RACKLIFE results, proper regulatory and safety criticality margin currently exist in the BWR Boraflex racks. An operability evaluation has been performed, and actions are being taken to remove credit for the Boraflex material, culminating in an eventual license amendment request.

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

Bias and uncertainty of monitoring are not included in the NCS AOR; however, several important choices have been made with regards to the operability evaluation of the BWR Boraflex racks at HNP:

- RACKLIFE results are based on conservative (minimum) initial B-10 areal density in the Boraflex material
- RACKLIFE escape coefficients were adjusted to match actual SFP water chemistry conditions based on real measured data from the SFP
- Fuel assemblies have been moved from the most limiting cells
- Soluble boron (required for PWR racks) is present and monitored per HNP Tech Specs, even though not currently required in the BWR rack NCS AOR

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

Degradation of adjacent panels is not accounted for in the NCS AOR for the BWR Boraflex panels. The impact of PWR fuel assemblies adjacent to the BWR Boraflex racks has been included in the RACKLIFE analysis. The Boraflex SFP rack cells adjacent to the PWR racks were determined to be limiting locations, and BWR fuel assemblies have been removed from these locations to proactively maintain more criticality margin.

Area of Requested Information 5 (Boraflex)

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

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

The following accident conditions are considered in the NCS AOR:

- Drop of fuel assembly on the top of the racks
- Drop of fuel assembly next to the un-poisoned periphery of the racks.
- Inadvertent loading of the wrong type of fuel into a storage cell.
- Loss of cooling systems.

Seismic events were not directly addressed in the NCS AOR.

The Boraflex stainless steel sheathing provides stability and helps ensure the neutron absorber remains in place under design basis events. EPRI performed an evaluation of the performance of degraded Boraflex under seismic conditions that showed promising results; however, it is understood that at some point of degradation, the conclusions of this testing are no longer applicable. None of the accident conditions evaluated in the NCS AOR would result in significant changes to the physical characteristics of the Boraflex material itself, changes to the overall rack geometry notwithstanding.

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

Duke Energy is addressing the degraded condition of the BWR Boraflex panels in the HNP SFP by pursuing a rack insert project, and, subsequently, eliminating credit in the NCS AOR for the Boraflex material. In the interim, compensatory actions and calculations are in place to verify the safety of the BWR Boraflex racks. Fuel has been moved from the most susceptible locations in the racks, and conservative modeling of the Boraflex degradation has been performed. Currently un-credited soluble boron in the SFP provides additional assurance of safety margin.

Area of Requested Information 1 (Metamic)

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;***

PWR spent fuel storage racks using Metamic have been installed in HNP Spent Fuel Pool (SFP) C in two phases. Phase IV consists of four (4) racks identified as racks C-C4, C-C5, C-D4 and C-D5. Phase V consists of three (3) racks identified as racks C-C6, C-C7 and C-D6. These PWR racks using Metamic as the neutron absorber are co-resident with other PWR and BWR racks which use Boral as the neutron absorber.

<u>Phase IV Racks:</u>
Neutron absorber material – Metamic
Neutron absorber manufacturer – Metamic, LLC
Rack manufacturer -- HOLTEC International
Dates of manufacture/installation – 2008 / 2008

<u>Phase V Racks:</u>
Neutron absorber material – Metamic
Neutron absorber manufacturer – Nanotec Metals, Inc.
Rack manufacturer -- HOLTEC International
Dates of manufacture/installation – 2012 / 2014

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

Metallurgically, Metamic is a metal matrix composite (MMC) consisting of a matrix of aluminum reinforced with Type 1 ASTM C-750 boron carbide. In the as-manufactured condition for both Phase IV and V racks, the Metamic consists of ~30.5 w/o boron carbide and 69.5 w/o Type 6061 aluminum powder.

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

<u>Phase IV Racks:</u>
Minimum certified – 0.0304 g $^{10}B/cm^2$
Minimum as-built – 0.0314 g $^{10}B/cm^2$
Maximum as-built – 0.0330 g $^{10}B/cm^2$
Nominal as-built – not provided

<u>Phase V Racks:</u>
Minimum certified – 0.0304 g $^{10}B/cm^2$
Minimum as-built – 0.0305 g $^{10}B/cm^2$
Maximum as-built – 0.0332 g $^{10}B/cm^2$
Nominal as-built – not provided

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

Specific porosity values were not provided for the Metamic material, but Metamic is described by the manufacturer as a porosity-free material. The elastomer material density ranged from 2.634 – 2.664 g/cc. Range provided encompasses both Phase IV and V racks.

The Metamic sheets were manufactured to be rectangles 145 inches long by 7.5 inches wide and 0.104 inches thick.

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

A comprehensive qualification test program sponsored by EPRI and Reynolds Metals has been completed for Metamic absorber materials for use in spent fuel storage applications. Samples were subjected to pre- and post-test characterization including:

- visual inspection
- high resolution photography
- dimension measurements
- dry weight
- density
- Boron-10 areal density
- hardness
- X-radiography
- tensile strength
- yield strength
- elongation

The test scope of the qualification program included the following tests:

- radiation testing
- accelerated corrosion testing
- short-term elevated temperature testing
- long-term elevated temperature testing

Testing results identified no negative performance characteristics. Specific testing details and results can be found in EPRI Reports 1019110, Handbook of Neutron Absorber Materials for Spent Fuel Transportation and Storage Applications (2009 Edition) and 1003137, Qualification of METAMIC for Spent-Fuel Storage Applications.

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

A stainless steel sheathing is attached to each side of a rack cell with the Metamic absorber material, in the form of rectangular panels, installed in the sheathing cavity. The design objective calls for attaching the absorber material tightly on the cell surface. The flanges of the sheathing are welded to the cell using skip welds and spot welds. The sheathing serves to locate and position the poison sheet accurately and to preclude its movement under seismic conditions.

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

Although the Metamic panels are tightly enclosed in stainless steel sheathing to the rack cell, the material can become exposed to the SFP water due to the tack welding of the sheathing to the rack cell.

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

i) estimated current minimum areal density;

Results of coupon testing of the Metamic neutron absorber have provided no indication of loss of neutron absorbing material. While neutron attenuation testing of coupons in 2010, 2012 and 2014 indicated a slight reduction in the measured areal density compared to the initial calculated value, the decrease is within the uncertainty of the measurement and no actual reduction in areal density was determined to be present. Therefore, the estimated current minimum areal density is the same as when the material was fabricated and installed in the SFP, which is provided in the response to item (1)(b)(ii).

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

The NCS AOR credited minimum areal density of the PWR SFP rack Metamic material is 0.0280 g $^{10}B/cm^2$.

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).

NETCO reports for the Metamic coupons tested in 2010, 2012 and 2014 show no blisters, pitting, gaps, cracks, loss of material (see areal density above), or loss of neutron-attenuation capacity (see areal density above). Only minor increases in coupon thickness have been noted with a maximum increase of 4% noted in the 2012 coupon.

Area of Requested Information 2 (Metamic)

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:***

A coupon surveillance program is used to monitor the performance of the Metamic spent fuel storage racks at HNP. This response item is fully addressed in the Safety Evaluation supporting Amendment No. 129 to Renewed Facility Operating License No. NPF-63 (Reference 2).

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

The frequency of inspections for coupon surveillance programs are typically determined based upon qualification testing of the neutron absorber material and the experience base of the absorber material used in similar SFP environments. The qualification testing of Metamic for spent fuel storage applications showed excellent results resulting in the conclusion that it will perform acceptably for the long term. However, as one of the newer neutron absorber materials in use for spent fuel storage applications, the experience base for Metamic is relatively limited resulting in the need for an aggressive initial surveillance schedule until more data on its behavior becomes available. HNP has coupon trees for both Phase IV and V racks, each containing ten (10) coupons. The surveillance schedule for each coupon tree has the first five (5) coupons being pulled for testing at two (2) year intervals to allow for adequate data points to support reasonable trending results. The current schedule then relaxes the testing schedule to provide data for more long term usage. The current schedule will provide results for a 40 year period assuming continued acceptable performance. The schedule can be revised if unanticipated negative conditions are observed. Sample size was established to pull one coupon per coupon tree surveillance interval to ensure data will be available through the 40 year surveillance period.

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

This response item is fully addressed in the Safety Evaluation supporting Amendment No. 129 to Renewed Facility Operating License No. NPF-63 (Reference 2).

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;***

This response item is fully addressed in the Safety Evaluation supporting Amendment No. 129 to Renewed Facility Operating License No. NPF-63 (Reference 2).

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

This response item is fully addressed in the Safety Evaluation supporting Amendment No. 129 to Renewed Facility Operating License No. NPF-63 (Reference 2).

v) industry standards used.

No specific industry standards are referenced in the basis for the Metamic coupon surveillance program implemented at HNP.

Duke Energy and its predecessor companies have supported the EPRI Neutron Absorber Users Group (NAUG) with routine attendance and participation in discussions regarding industry experience with various neutron absorber materials in the SFP, including absorber material surveillance programs and results. Duke Energy has used the NAUG meetings and other industry interactions to stay abreast of developments in the industry and to better understand and mitigate potential degradation mechanisms in SFP rack neutron absorber materials.

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

Due to the nature of the Metamic rack material at HNP (sheathed in stainless steel, no pre-fabricated inspection ports), visual inspection of the in-service Metamic material is not practical.

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

This item is not applicable to the Metamic racks at HNP. (see response to item (2)(b)(i)(1))

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;

The Metamic coupons utilized for the surveillance program are cut from the same Metamic panels (material lots) as those used for rack fabrication. The Phase IV coupons are 8 inches tall x 6 inches wide x 0.104 inch thick. The Phase V coupons are 8 inches tall x 4 inches wide x 0.104 inch thick. The coupons are bare Metamic and exposed to the SFP water with no sheathing or jacketing used. The coupons are attached to a "tree" using stainless steel bolts and washers which mimic the interaction of the Metamic material with the storage rack sheathing and cell walls. The coupons are positioned axially within the central eight (8) feet of the active fuel zone where the gamma flux is expected to be reasonably uniform. The coupon "trees" are placed in rack locations surrounded by spent fuel assemblies to ensure they are

exposed to typical gamma dose and SFP temperatures. The Metamic racks are installed in SFP "C" which has a requirement that spent fuel must be decayed at least 5 years prior to storage due to system heatload removal restrictions. This limits the available doses and temperatures to which the racks are exposed. There is a coupon "tree" for both the Phase IV and V racks, each containing 10 coupons. The coupon "trees" have a handling hook/baseplate arrangement at the top which allows the "trees" containing the coupons to be positioned in the middle of an interior rack cell location.

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

Phase IV Racks: Coupon tree CTREE3 installed 02/2009

Phase V Racks: Coupon tree CTREE4 installed 09/2014

(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

HNP procedurally allows for coupons that have been pulled and sent off for analysis to be re-installed on the coupon tree. Coupons that have been pulled for testing and re-installed would not be pulled again until after the original ten (10) coupons have been tested per the test schedule which covers a 40 year timeframe. It is expected that the re-installed coupons would provide some useful information on the material condition. While there is some industry experience with coupons of other absorber materials exhibiting degraded performance after being pulled for testing, dried, and then re-installed in water, this is not expected to occur with Metamic coupons as Metamic is considered a non-porous material and not subject to the issues associated with water intrusion into porous materials.

(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.

Phase IV Coupon Tree (CTREE3):

10 coupons total
3 previously pulled for testing and subsequently re-installed
7 coupons remaining to support original testing schedule

Phase V Coupon Tree (CTREE4):

10 coupons total
0 previously pulled for testing and subsequently re-installed
10 coupons remaining to support original testing schedule

	CTREE3		CTREE4	
Coupon	Surveillance Interval	Test Date (approx.)	Surveillance Interval	Test Date (approx.)
1	2	2010	2	2017
2	4	2012	4	2019
3	6	2014	6	2021
4	8	2016	8	2023
5	10	2018	10	2025
6	15	2023	15	2030
7	20	2028	20	2035
8	25	2033	25	2040
9	30	2038	30	2045
10	40	2048	40	2055

The period of extended operation for HNP begins October 2026 with plant operation ending October 2046, therefore there are adequate coupons for the life of the SFPs.

iii) (Not requested for Metamic material.)
iv) If in-situ testing with a neutron source and detector is used (e.g., BADGER testing, blackness testing):
(1) describe the method and criteria for choosing panels to be tested and include whether the most susceptible panels are chosen to be tested. Provide the statistical sampling plan that accounts for both sampling and measurement error and consideration of potential correlation in sample results. State whether it is statistically significant enough that the result can be extrapolated to the state of the entire pool;
(2) state if the results of the in-situ testing are trended and whether there is repeat panel testing from campaign to campaign;
(3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include

the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (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

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

- ***(a) describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results;***
- ***(b) describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results; and***
- ***(c) if the calibration includes the in-situ measurement of an SFP rack "reference panel," explain the following:***
    - ***(i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements;***
    - ***(ii) whether all surveillance campaigns use the same reference panel(s); and***
    - ***(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.***

In-situ blackness testing is not currently being performed at HNP. Monitoring of the condition of the Metamic material is being performed using a coupon surveillance program.

REFERENCES:

1. Electric Power Research Institute Report 1019110, *Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications*, 2009 Edition.
2. NRC letter, *Shearon Harris Nuclear Power Plant, Unit 1 - Issuance of Amendment Regarding the Use of Metamic as a Neutron Absorbing Material and Revised Loading Patterns in the Spent Fuel Pool*, dated January 29, 2009 (ADAMS Accession No. ML090270022).