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Dominion®

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Washington, DC 20555-0001

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DOMINION ENERGY KEWAUNEE, INC.
DOMINION NUCLEAR CONNECTICUT, INC.
VIRGINIA ELECTRIC AND POWER COMPANY
KEWAUNEE POWER STATION
MILLSTONE POWER STATION UNITS 1, 2 AND 3
NORTH ANNA POWER STATION UNITS 1 AND 2
SURRY POWER STATION UNITS 1 AND 2
RESPONSE TO GENERIC LETTER (GL) 2016-01, MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS

On April 7, 2016, the Nuclear Regulatory Commission (NRC) issued GL 2016-01 to all power reactor licensees, including those power reactors that have ceased operations but still have reactor fuel in onsite spent fuel pool storage. The GL requested that addressees submit information, or provide references to previously docketed information, which demonstrates that credited neutron-absorbing materials in the spent fuel pool (SFP) of power reactors and the fuel storage pool, reactor pool, or other wet locations designed for the purpose of fuel storage, as applicable, for non-power reactors, are in compliance with the licensing and design basis, and with applicable regulatory requirements; and that there are measures in place to maintain this compliance.

The GL requested that a response be provided within 210 days of the date of the GL. Accordingly, Dominion Energy Kewaunee, Inc. (DEK), Dominion Nuclear Connecticut, Inc. (DNC), and Virginia Electric and Power Company (Dominion), have provided their responses to the GL information request for Kewaunee Power Station, Millstone Power Station Units 1, 2 and 3, and North Anna and Surry Power Stations Units 1 and 2 in Attachments 1, 2, 3, and 4, respectively.

A158
NRR

If you have any questions regarding this submittal, please contact Ms. Diane E. Aitken at (804) 273-2694.

Respectfully,

Mark D. Sartain
Vice President – Nuclear Engineering
Dominion Energy Kewaunee, Inc.
Dominion Nuclear Connecticut, Inc.
Virginia Electric and Power Company

Vicki L. Hull
NOTARY PUBLIC
Commonwealth of Virginia
Reg. # 140542
My Commission Expires May 31, 2018

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Mark D. Sartain, who is Vice President – Nuclear Engineering of Dominion Energy Kewaunee, Dominion Nuclear Connecticut, Inc., and Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 1st day of November, 2016.

My Commission Expires: May 31, 2018.

Vicki L. Hull
Notary Public

There are no new commitments made in this letter.

Attachments:

1. Kewaunee Power Station - Response to Generic Letter 2016-01 Monitoring of Neutron Absorbing Materials in the Spent Fuel Pool

2. Millstone Power Station Units 1, 2, and 3 - Response to Generic Letter 2016-01 Monitoring of Neutron Absorbing Materials in the Spent Fuel Pool

3. North Anna Power Station Units 1 and 2 - Response to Generic Letter 2016-01 Monitoring of Neutron Absorbing Materials in the Spent Fuel Pool

4. Surry Power Station Units 1 and 2 - Response to Generic Letter 2016-01 Monitoring of Neutron Absorbing Materials in the Spent Fuel Pool

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Attachment 1

RESPONSE TO GENERIC LETTER 2016-01 MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS

Dominion Energy Kewaunee, Inc. (DEK)
Kewaunee Power Station

RESPONSE TO GENERIC LETTER 2016-01
KEWAUNEE POWER STATION

The information requested by Generic Letter (GL) 2016-01 is provided below.

REQUESTED INFORMATION

The NRC requested information in the following five areas for use in verifying compliance:

(1) A description of the neutron-absorbing material credited in the SFP nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP;

(2) A description of the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used;

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

(4) A description of how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR; and

(5) A description of the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events.

As clarified in GL 2016-01, the provision of the information requested above is dependent upon which of the four categories described in the GL is applicable to the licensee. Dominion Energy Kewaunee (DEK) has determined that Category 2 is applicable to Kewaunee Power Station (KPS). Specifically, Category 2 includes power reactor addressees that have an approved license amendment to remove credit for existing neutron-absorbing materials and that intend to complete full implementation of the license amendment no later than 24 months after the issuance of GL 2016-01. Those addressees may submit a response letter affirming that they will implement the approved license amendment request within the specified time.

By letter dated May 14, 2013 [ADAMS Accession No. ML13135A209], DEK submitted a certification of permanent removal of fuel from the reactor vessel pursuant to 10 CFR 50.82(a)(1)(ii). Therefore, as specified in 10 CFR 50.82(a)(i) the 10 CFR Part 50 license for KPS no longer authorizes operation of the reactor or emplacement or retention of fuel in the reactor vessel. The Post-Shutdown Decommissioning Activities Report (PSDAR) for KPS dated April 25, 2014 [ADAMS Accession No. ML14118A382], documented that DEK expects to have all spent fuel removed from the spent fuel pool (SFP) and transferred to the Independent Spent Fuel Storage Installation (ISFSI) by the

end of 2016. Due to unanticipated events that have occurred since the submittal of the April 25, 2014 PSDAR, DEK currently expects to have all spent fuel removed from the SFP by mid-2017. Once the spent fuel has been removed from the SFP and stored at the ISFSI, the SFP will have no further need for neutron absorbing materials.

The NRC issued License Amendment 213 for KPS on June 23, 2014 [ADAMS Accession No. ML14008A297]. The amendment revised the Renewed Facility Operating License by removing the license conditions associated with license renewal and the period of extended operation. The amendment also added a license condition that requires DEK to submit a spent fuel pool storage rack neutron absorber material surveillance program for inclusion in its Technical Specifications (TS) if all spent fuel is not removed from the spent fuel pool by the end of 2017. The license condition (2.C.(16)) is stated as follows:

(16) Spent Fuel Pool Neutron Absorber Material Surveillance Programs

> If all spent fuel assemblies have not been removed from the spent fuel pool by December 31, 2017, the licensee shall request, prior to that date, an amendment to the license, pursuant to 10 CFR 50.90, to incorporate boron carbide and Boral surveillance programs (specified as Items 38 and 39 in Appendix A of NUREG-1958, "Safety Evaluation Report Related to the License Renewal of Kewaunee Power Station," dated January 2011) into the Technical Specifications.

As stated in the NRC safety evaluation accompanying Amendment 213, "By requiring that these programs be incorporated into technical specifications, if necessary after 2017, the license condition would ensure that neutron attenuation testing of the spent fuel pool storage racks would be subject to a technical specification-required surveillance program and assure that any changes to implementation of the neutron absorber material surveillance throughout the period that spent fuel is stored in the spent fuel pool would require NRC approval."

DEK hereby affirms that License Amendment 213 has been implemented, and License Condition 2.C.(16) is currently in effect. As noted above, the spent fuel currently stored in the SFP is planned to be relocated to the ISFSI by mid-2017, which, consistent with License Condition 2.C.(16), would preclude the need for a license amendment request for a neutron absorber material surveillance program. Relocation of the fuel from the SFP by mid-2017 is also prior to 24 months after the issuance of the GL (i.e., prior to April 2018).

No other neutron-absorbing material is credited in the KPS SFP NCS AOR as a result of, or following implementation of, License Amendment 213.

Attachment 2

RESPONSE TO GENERIC LETTER 2016-01
MONITORING OF NEUTRON-ABSORBING MATERIALS
IN SPENT FUEL POOLS

Dominion Nuclear Connecticut, Inc. (DNC)
Millstone Power Station Units 1, 2 and 3

RESPONSE TO GENERIC LETTER 2016-01
MILLSTONE POWER STATION UNITS 1, 2 AND 3

The information requested by Generic Letter (GL) 2016-01 is provided below.

REQUESTED INFORMATION

The NRC requested information in the following five areas for use in verifying compliance:

(1) A description of the neutron-absorbing material credited in the SFP nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP;

(2) A description of the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used;

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

(4) A description of how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR; and

(5) A description of the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events.

As clarified in GL 2016-01, the provision of the information requested above is dependent upon which of the four categories described in the GL is applicable to the licensee. Dominion Nuclear Connecticut (DNC) has determined that Category 4 is applicable to Millstone Power Station (MPS) Units 1, 2, and 3. Specifically, Category 4 includes power reactor addresses that are not Category 1, 2, or 3 and requests information in five areas depending on the type of neutron absorber material being used in the SFP. The level of detail for the information requested for Category 4 licensees is delineated in Appendix A of the GL, which describes the specific information to be provided for each type of neutron-absorbing material. The requested information is provided below for each MPS unit based on the type of neutron-absorbing material used in each unit's SFP.

Millstone Power Station Unit 1 (MPS1)

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:

The neutron-absorbing material credited in the MPS1 SFP NCS AOR is Carborundum. A description of its configuration in the SFP is provided in item d) below.

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

Plate Manufacturer	Carborundum's Electro-Minerals Division (EMD)
Date of Manufacture	1977
Date of Material Installation	1977

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

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

Six boron carbide powder lots were used in the construction of the MPS1 SFP racks. The minimum as-built Boron-10 (B-10/B) weight percent was 18.29 w/o.

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

Six boron carbide powder lots were used in the construction of the MPS1 SFP racks.

Minimum Certified Areal Density	No data available
Minimum As-built Areal Density	0.0920 g/cm^2
Maximum As-built Areal Density	0.0986 g/cm^2
Nominal As-built Areal Density	0.0959 g/cm^2

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

Plate Porosity	No data available
Plate Density	1.7 g/cm^3
Plate Nominal Width	5.88 inches
Plate Nominal Length	31.2 inches
Plate As-Built Average Thickness	0.216 inches

The nominal dimensions have been confirmed by as-built data.

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

A summary of qualification testing performed for Carborundum and the results of that testing are provided in EPRI Report 1019110, "Handbook of Neutron Absorber Materials for Spent Nuclear Fuel Transportation and Storage Applications – 2009 Edition," (November 2009). The testing included radiation testing, gas generation testing, leachability testing, and long-term mechanical property testing. Test results showed that the aqueous service environment of the SFP diminished the mechanical properties; however, the post-test strength is adequate to assure performance to $1x10^{11}$ rads. Note that a conservative estimate of the maximum MPS1 SFP carborundum cell fluence is $1.1x10^{10}$ rads. In-service test data showed a weight loss of approximately 0.4% per year.

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 MPS1 SFP racks consist of 1/8-inch thick type 304 austenitic stainless steel square tubes with 6.5-inch center-to-center spacing separated by cylindrical spacers at the tube corners. Carborundum absorber plates are placed in the cavity between the square tubes. The tubes are flared at each end and welded together at the ends to form a unitized array, which is welded to a pre-assembled base. The edge welding assures the design center-to-center spacing of 6.5 inches is maintained.

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

The panel cavities of the MPS1 SFP Carborundum racks were vented to prevent wrapper plate bulging due to offgassing. The Carborundum panels, therefore, are exposed to SFP water.

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

i) *estimated current minimum areal density;*

Specific numerical areal density values were not determined because the measured transmission ratios were so much less than the highest areal density calibration standard. A Carborundum standard, or material of a comparable areal density to Carborundum, was not available for inclusion in the calibration cell. Since the polynomial fit of the calibration cell results did not bound the measured transmission ratios, and significant uncertainty

would be introduced by extrapolation, a pass/fail determination was made for each panel.

Therefore, the estimated minimal areal density of the credited neutron-absorbing material in the MPS1 SFP is concluded to be significantly greater than 0.0505 g/cm^2.

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

The areal density of the neutron-absorbing material currently credited in the MPS1 NCS AOR is 0.048 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).*

During the 2007 BADGER (a computerized, in-situ scanning system that measures the condition of neutron absorbing materials) campaign, a gap was observed at the interface between the third and fourth absorber plates of SFP rack Panel 5-20-M West. During the 2013 BADGER campaign, a gap was observed at the interface between the second and third absorber plates of Panel 5-9-M North. These are the only anomalies identified during the BADGER testing campaigns.

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

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

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

BADGER testing for the MPS1 Carborundum SFP storage racks is performed approximately every five years. Justification for the 5-year surveillance interval is provided in the answer to question 3. During the last three BADGER testing campaigns (conducted in 2007, 2011, and 2013), 46, 45, and 16 panels were measured, respectively. More frequent calibration scans and duplicate panel scans, performed to reduce measurement uncertainty, resulted in fewer panels measured during the most recent campaign. During the 2013 campaign, the results of panel measurements taken with different scan times were compared and the results indicated that scan times could be reduced without affecting uncertainty. Therefore, we

expect to measure significantly more panels in future campaigns, assuming the same two-week campaign duration.

The sample size targeted for a BADGER testing campaign at MPS1 is consistent with Topical Report NEI 16-03 "Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools" (ML16265A248). The Topical Report states that if the panels to be tested have experienced the greatest exposure to those parameters that influence degradation, then no less than one percent of the total number of panels in the spent fuel pool should be tested. There are 4856 panels in the MPS1 SFP. Therefore, a sample size of 49 is appropriate. As discussed above, achieving this sample size is expected for future campaigns.

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

For the 2013 campaign, each panel tested was scanned with the probe heads being moved in four-inch increments from the bottom of the cell to the top of the cell. Total neutron counts were recorded at each level. A transmission ratio for each level was subsequently determined by dividing attenuated neutron count data by unattenuated neutron count data.

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 surveillance program acceptance criteria require that each measured panel show no signs of degradation and the B-10 areal density is bounded by that which was assumed in the AOR.

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

A subset of the testing region established for the 2013 BADGER campaign will be retested in future campaigns to permit trending.

v) *industry standards used.*

No industry standards are referenced in the vendor testing procedures used during BADGER testing at MPS1.

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

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

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

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

MPS1 does not perform visual inspections of in-service material.

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;

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

(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

(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.

MPS1 does not have a coupon-monitoring program.

iii) *If RACKLIFE is used:*

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

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

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

(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.

MPS1 does not use RACKLIFE.

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;

In preparation for the 2011 MPS1 BADGER campaign, fuel assemblies were moved to create a testing region of forty-nine rack cells. This area was selected because it received a higher than average gamma exposure history than the rest of the SFP during the period 1978 through 2011. Note that since all fuel assemblies in the MPS1 SFP have been cooling for a minimum of twenty years, this conclusion would not change even though no fuel assemblies are currently stored in the testing region. Therefore, this area where BADGER testing is performed is representative of the entire SFP because it experienced the same SFP chemistry, the same SFP temperature history, and had a higher than average gamma exposure history than the rest of the SFP. Multiple daily calibration scans and repeat SFP panel scans minimize the impact of measurement error.

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

The sample size and the limited size of the testing region ensures that panels will be retested in subsequent campaigns, thereby providing the opportunity to trend the results

(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 Access and Management Systems Accession No. ML12254A064). Discuss the effect of rack cell deformation and detector or head misalignment, such as tilt, twist, offset, or other misalignments of the heads and how they are managed and accounted for in the analysis; and*

The uncertainties associated with the design of the BADGER system used for the 2011 MPS1 BADGER campaign led to unacceptable testing results, thereby initiating a redesign of the BADGER system. Dominion worked with NETCO to completely redesign the BADGER system, which

performed in a satisfactory manner during the 2013 MPS1 BADGER campaign.

To reduce uncertainty, the BADGER system redesign included the following hardware modifications (most of which were discussed in the September 30, 2012 technical letter report):

- The basic head structure (housing bottom and sidewalls) for the redesign was machined from a solid block of Type 6061 aluminum.
- Spring plungers were added to improve head alignment of the head within the spent fuel rack cell. The spring plungers maintain alignment between the source and detector heads even with a small amount of rack cell deformation. MPS1 has not experienced significant rack cell deformation due to swelling, because the MPS1 SFP racks were vented prior to installation.
- The placement of boron carbide powder provides additional shielding around the BF_3 neutron detector tubes.
- The detector encapsulation was modified to prevent water ingress (which could result in an electrical short and failure of the detector signal) and to electrically isolate the detector circuit from the housing.
- An external ground connection was added to mitigate external signal noise picked up through the spent fuel racks.
- The coaxial detector cables were replaced with nuclear grade triaxial cable.
- The preamplifiers were upgraded.
- The drive plate was completely rebuilt.

To account for the measurement uncertainties of BADGER in the analysis, the calibration standard is measured multiple times throughout the campaign to obtain a distribution of BADGER measurements. The measurements of the panels are then compared to the distribution of the standard measurements to determine if the panels have a larger or smaller areal density.

(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.

The MPS1 calibration cell was constructed with five standards of differing areal density. The standards were made from the same

aluminum/boron carbide composite material as NETCO-SNAP-IN® Rack Inserts. As described in the response to question (1)(e)(i), since a Carborundum standard (or material of a comparable areal density to Carborundum) was not available, a pass/fail determination was necessary.

(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*

BADGER testing determines the B-10 content of a SFP rack panel by correlating the measured counts (or transmission ratio) to that which was measured in the calibration cell. Degradation or aging of the B-10 content of the SFP rack panel would be identified during testing because suspect areas of the panel (or gaps) would be apparent in the analysis of the measured results. Degradation of the calibration cell is not an issue because the cell is removed from the SFP following each testing campaign.

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

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

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

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

MPS1 BADGER testing does not use reference panels.

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.*

The technical basis for determining the 5 year surveillance interval was to provide assurance that the assumptions in the SFP NCS AOR would remain bounded between testing campaigns.

The 2013 Badger campaign concluded that the B-10 areal density is significantly greater than 0.0505 g/cm^2. Conservatively assuming that the actual B-10 areal

density is 0.0505 g/cm^2, then 5% of the Carborundum would need to degrade to match the areal density credited in the SFP NCS AOR (0.048 g/cm^2).

Data presented in the EPRI Handbook of Neutron Absorber Materials shows that the degradation of Carborundum panels is a gradual phenomena. The rate of degradation is linear from 0 to 25% over a 60 year service life or ~0.4%/year. At this degradation rate, it would take about 12 years to degrade the Carborundum from 0.0505 g/cm^2 to 0.048 g/cm^2. Therefore, the 5 year surveillance interval is justified because degradation would be observed before challenging NCS AOR.

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.*

   The MPS1 NCS AOR includes the following conservatisms to address degradation:

   - Assumes 50% of initial B-10 content. This assumption very conservatively accounts for the loss of B-10.
   - Assumes one out of every twenty-five panels is missing. This assumption bounds small gaps between panels.

   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.*

   Following analysis of the last MPS1 surveillance coupons in 1994, in-situ testing of the Carborundum racks was initiated. Currently, BADGER testing results at MPS1 are used to ensure that the actual condition of the Carborundum is bounded by the SFP NCS AOR. Specifically, the areal density of each axial location in each measured panel is confirmed to be greater than areal density assumed in the NCS AOR.

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

Bias and uncertainty of the monitoring program are not part of the SFP NCS AOR. The monitoring program is intended to confirm, in part, that the assumptions in the SFP NCS AOR are still valid.

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

Degradation in adjacent panels is not specifically accounted for in the NCS AOR; however, analysis of entire missing panels is included. If panel gaps were to be observed at the same elevation, this would be addressed. As described in the response to question (1)(e)(iii), the two gaps identified to date were at different elevations.

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.

Seismic analysis and fuel assembly drop accident analysis for the MPS1 Carborundum SFP racks was originally provided to the NRC in a LAR submittal (dated July 15, 1976) and in response to RAI's (dated December 3, 1976). These analyses conclude that there would be no impact on the material condition of the Carborundum as a result of a seismic event or fuel assembly drop accident. The reactivity impact of variation in SFP temperature is included in the MPS1 SFP NCS AOR, which assumes the material remains intact. As described in the response to question (1)(c), the maximum panel fluence is bounded by the material performance qualification testing. As described in the response to question (1)(e)(i), the B-10 areal density is significantly greater than the value assumed in the NCS AOR. BADGER testing has not identified any shifting or settling of SFP panels. Therefore, the neutron-absorbing material's ability to perform its safety function is unchanged from that which was assumed in the 1976 analysis.

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.*

   The periodic Carborundum surveillance (BADGER testing) confirms assumptions in the NCS AOR. It does not assess the ability of the neutron-absorbing material's performance in a design basis event. As described in the answer to question 5(a), the neutron-absorbing material's ability to perform its safety function is unchanged from that which was assumed in the 1976 analysis of design basis events.

Millstone Power Station Unit 2 (MPS2)

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:*

Borated stainless steel rodlets are credited in the MPS2 SFP NCS AOR. A description of their configuration in the SFP is provided in item d) below.

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

Manufacturer	Carpenter Technology Corporation – Carpenter Steel Division (Reading, PA)
Dates of Manufacture	1993-1994
Dates of Material Installation	1994-present

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

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

The borated stainless steel utilized for the manufacturing of the poison rodlets is Carpenter NeutroSorb PLUS ASTM A887-89 Type 304 B7 Grade A. The boron content is 2.0 w/o ± 0.1 w/o.

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

Manufacturing records for the thirteen batches of MPS2 borated stainless steel rods reported the following:

Minimum Certified Areal Density	No data available
Minimum As-built Areal Density	1.96 w/o total boron
Maximum As-built Areal Density	2.09 w/o total boron
Nominal As-built Areal Density	2.02 w/o total boron

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

Porosity of Borated Stainless Steel Pin	Unknown
Density of Borated Stainless Steel Pin	7.74 g/cm^3
Outside Diameter of Borated Stainless Steel Pin	0.870 ± 0.015 in.
Overall Length of Borated Stainless Steel Pin	152.5 ± 0.0625 in.

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

EPRI Report TR-100784, "Borated Stainless Steel Application in Spent-Fuel Storage Racks," (June, 1992) determined the maximum fluence over a 40-year service life in a SFP is 1 x 10^{12} neutron/cm^2. Extending the service life an additional 40 years to account for a 20-year plant operating license extension and an additional 20 years of storage could result in a maximum fluence of less than 2 x 10^{12} neutrons/cm^2. The maximum fluence is equivalent to less than one second of in-reactor exposure. Therefore, no measurable depletion of rodlet boron is expected to occur over the lifetime of the rodlets. Tests performed by EPRI, to an upper bound of 1 x 10^{17} neutrons/cm^2, determined that there was no significant change in borated stainless steel material properties. No significant change in material properties is projected over the lifetime of the rodlets, thus providing high confidence that the material and neutronic characteristics of the rodlets will remain within the assumptions of the NCS AOR.

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

Rodlets are installed in the fuel assembly's center guide tube and any two diagonally opposite guide tubes.

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

The rodlets are directly exposed to the SFP environment.

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

i) *estimated current minimum areal density;*

Manufacturing records for the thirteen batches of MPS2 borated stainless steel rods indicate the minimum total boron as 1.96 w/o. As described in the response to question (1)(c) and because the surveillance program has seen no degradation, there is no reason to believe that there has been any loss of B-10 content.

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

Currently, the MPS2 NCS AOR credits the rodlets as having 2.0 w/o $\pm$ 0.1 w/o total boron.

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).*

Four surveillances of the rodlets in the MPS2 SFP have been performed (1999, 2004, 2009, and 2014). In 2004, a small nick was identified on one rodlet. The size of the indication was approximately 1/16-inch x 1/8-inch. The assessment of this abnormality concluded that "minimal, if any, material has been removed" and it "does not affect the boron content of the rodlet."

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

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

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

Even though it is not expected that any significant degradation of borated stainless steel rodlets will occur during their service life, MPS2 has conservatively established a surveillance program. The MPS2 rodlet surveillance program, performed at approximately 5-year intervals, has been used to visually inspect 1 percent of the MPS2 stainless steel rodlets for material degradation. Currently, 27 rodlets, which have been in continuous use at MPS2 since installation in 1994, are designated as surveillance rodlets.

The surveillance frequency is consistent with Topical Report NEI 16-03 "Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools" (ML16265A248). The Topical Report states that for materials that have been used for several years in conditions similar to the pool environment (i.e., their ability to perform is well known), and for which stability in the material condition has been documented; initial and subsequent intervals up to 10 years is acceptable. Borated stainless steel meets this requirement; therefore, a surveillance frequency of five years is acceptable.

The sample size is also consistent with Topical Report NEI 16-03 "Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools" (ML16265A248). The Topical Report states that if the material to be tested has experienced the greatest exposure to those parameters that influence degradation, then no less than one percent of the total number of panels in the spent fuel pool should be tested. The surveillance rodlets have been in continuous use and, therefore, they meet this requirement. There are 2491 rodlets available for use; therefore, a sample size of 27 is appropriate.

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

During performance of the rodlet surveillance monitoring program, each surveillance rodlet is removed from the SFP and a detailed visual inspection is performed to identify any cracks, blisters, missing pieces of surface material, corrosion, or pitting. As described in the response to question (1)(c), no measurable depletion of rodlet boron is expected over the lifetime of the rodlets. Therefore, the only credible loss of boron would be by loss of material.

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;*

Any material abnormality observed during performance of the rodlet surveillance monitoring program would result in a more detailed assessment to evaluate the significance.

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

Following initial selection as surveillance rodlets, the same rodlets are re-inspected during subsequent periods of inspections to permit trending of rodlet material condition.

v) *industry standards used.*

The MPS2 rodlet surveillance procedure does not reference any industry standards.

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

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

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

The rodlet is removed from the SFP and a detailed visual inspection of the rodlet surface is performed to identify any cracks, blisters, missing pieces of surface material, corrosion, or pitting.

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

Twenty-seven rodlets, including rodlets from each of the thirteen manufacturing batches, are inspected at approximately five year intervals.

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;

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

(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.

(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.

MPS2 does not have a coupon monitoring program.

iii) If RACKLIFE is used:

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

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

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

(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.*

MPS2 does not use RACKLIFE.

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 Access and Management Systems Accession No. ML12254A064). Discuss the effect of rack cell deformation and detector or head misalignment, such as tilt, twist, offset, or other misalignments of the heads and how they are managed and accounted for in the analysis; 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.*

MPS2 does not perform in-situ testing.

Millstone Power Station Unit 3 (MPS3)

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:*

   The neutron-absorbing material credited in the MPS3 SFP NCS AOR is BORAL™. A description of its configuration in the SFP is provided in item d) below.

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

Manufacturer	AAR Advanced Structures in Livonia, MI.
Dates of Manufacture	Between 1998 and 2000
Dates of Material Installation	2000

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

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

      BORAL™ is not specified on a weight percent basis of the neutron absorbing component; therefore, this sub-item is not applicable to this material.

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

      Manufacturing records for the three MPS3 boron carbide lots that were used for the MPS3 BORAL™SFP racks reported the following data:

Minimum Certified Areal Density	No data available
Minimum as-built Areal Density	0.0310 g/cm^2
Maximum as-built Areal Density	0.0321 g/cm^2
Nominal as-built Areal Density	No data available

      The minimum certified and nominal as-built areal density values are not included in the manufacturing records.

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

      The BORAL™ porosity is not available.

The average density of the BORAL™ absorber is 2.44 g/cm^3.

The BORAL™ absorber panels have a thickness of 0.098 ± 0.006 inches and are 7.5 ± 0.0625 inches wide and 148 + 0.25/-0.0 inches long.

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

AAR Advanced Structures, and its predecessor Brooks & Perkins, conducted extensive qualification testing to demonstrate the suitability of BORAL™ for spent fuel storage and transportation applications. These qualification tests included radiation testing and corrosion testing. The results were as follows:

- Neutron attenuation testing and neutron radiography showed no loss of boron carbide. This was confirmed by chemical analysis. Tensile test results indicated no change in the ultimate strength.
- No pitting corrosion was observed and no gas generation was detected. The major change in the appearance of BORAL™ exposed to aqueous solution was a discoloration of the surface. It was concluded that the neutron absorption would not be compromised by the maximum observed corrosion rate during the design service life.

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*

Two different types of storage cells, designated as Region I and Region II, are used in the MPS3 SFP to incorporate BORAL™ panels.

Region I storage cells utilize a flux trap design with BORAL™ as a fixed neutron poison. This design's storage cells consist of a stainless steel canister, which controls the fuel assembly position within the array. BORAL™ fixed neutron poison panels are located on the four outer walls of each canister and a stainless steel wrapper maintains the BORAL™ poison panels in place.

Region II storage cells utilize a non-flux trap design with BORAL™ as a fixed neutron poison. This design's storage cells are formed by welding open stainless steel canisters together at the corners. Therefore, the Region II storage cells are a combination of individual canister storage cells and developed storage cells. The developed storage cells result from the welding process. As an example, the welding of four canisters at the corners of each canister produces a single developed storage cell at the center of the four canisters. BORAL™ fixed neutron poison panels are

located on the four outer walls of each canister and are held in place by a stainless steel wrapper.

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

The BORAL™ panel is enclosed in a stainless steel wrapper thereby providing protection from direct physical exposure to the SFP environment.

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

i) *estimated current minimum areal density;*

Currently, the estimated minimal areal density of the credited neutron-absorbing material in the MPS3 SFP is 0.0302 g/cm^2.

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

Currently, the credited areal density of the neutron-absorbing material in the MPS3 NCS AOR is 0.0302 g/cm^2 (+0.000 and - 0.0022 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).*

Past surveillance results have not identified any degradation or deformation.

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.*

MPS3 instituted a coupon surveillance program upon installation of the BORAL™ SFP racks. Coupons are suspended on a mounting (called a "tree"), placed in a designated cell, and surrounded by spent fuel. Coupons are removed from the array on a prescribed schedule and certain physical and chemical properties are measured from which the stability and integrity of the BORAL™ in the storage cells may be inferred. Each surveillance coupon is approximately 4 inches wide and 8 inches long. The coupon surveillance program uses a total of eight test coupons. When mounting the coupons on the tree, the coupons are positioned axially within the central 8 feet of the fuel zone where the gamma flux is expected to be reasonably uniform. Each coupon was carefully pre-characterized prior to insertion in the pool to provide reference initial values for comparison with measurements made after irradiation. The surveillance coupons were pre-characterized for weight, length, width, thickness, and areal density. In addition to the eight test coupons, two coupons were preserved as archive samples for comparison with subsequent test coupon measurements.

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

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

The frequency of the coupon surveillances was based on vendor recommendations and was consistent with industry practice at the time the coupon program was established. Specifically, surveillance intervals were 18 months for the first three coupons; 36 months for the fourth coupon; and 54 months for subsequent coupons.

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

The surveillance program includes visual inspection of the coupon followed by determination of weight, dimensions, specific gravity, and B-10 areal density.

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 surveillance program acceptance criteria require that the coupon show no signs of degradation and the B-10 areal density be bounded by that which was assumed in the NCS AOR.

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

The surveillance results are compared to the assumptions in the NCS AOR. In addition, the coupon's measured areal density and its as-built areal density are used to calculate the percent loss in areal density. The percent loss in areal density is the metric used to monitor degradation.

v) *industry standards used.*

The following ASTM Standards are referenced in the coupon analysis procedure:

- ASTM Standard C992, "Specification for Boron-Based Neutron Absorbing Material Systems for Use in Nuclear Spent Fuel Storage Racks."
- ASTM Standard E6, "Definitions of Terms Relating to Methods of Mechanical Testing."

- ASTM Standard G1, "Recommended Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens."
- ASTM Standard G4, "Guide for Conducting Corrosion Coupon Tests in Plant Equipment."
- ASTM Standard G15, "Definitions of Terms Relating to Corrosion and Corrosion Testing."
- ASTM Standard G16, "Recommended Practice for Applying Statistics to Analysis of Corrosion Data."
- ASTM Standard G46, "Recommended Practice for Examination and Evaluation of Pitting Corrosion."
- ASTM Standard G69, "Practice for Measurement of Corrosion Potentials of Aluminum Alloys."
- ASTM Standard C1187, "Standard Guide for Establishing Surveillance Test Progress for Boron Based Neutron Absorbing Materials for Use in Nuclear Fuel Storage Racks."

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

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

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

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

MPS3 does not perform visual inspections of the in-service BORAL™ panels.

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 BORAL™ coupons were manufactured at the same time as the BORAL™ panels used in the racks and include material from all three boron carbide lots. For the first five fuel cycles, the BORAL™ coupon tree was surrounded by freshly discharged assemblies to maintain a high gamma dose and higher than average water temperatures. Subsequently, the BORAL™ coupon tree has experienced average SFP conditions. Therefore, the coupon history is representative of the BORAL™ in the SFP racks.

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

The coupon tree was placed in a MPS3 BORAL™ SFP storage cell in 2000 (coincident with the SFP rack installation).

(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

To date, no BORAL™ coupon has been returned to the SFP.

(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.

Five of the eight coupons have been removed for testing (three remain). Two alternatives are being pursued to extend the life of the coupon-monitoring program. These include extending the interval between surveillances and/or changing the measurement process to permit reinsertion of the coupons into the SFP.

MPS3 BORAL™ Coupon Measurement Schedule		
Coupon #	**Refueling After Rerack in 2000 (Refueling Outage #)**	**Year**
1	1st Refueling after Rerack (RFO 8)	2003
2	2nd Refueling after Rerack (RFO 9)	2004
3	3rd Refueling after Rerack (RFO 10)	2005
4	5th Refueling after Rerack (RFO 12)	2008
5	8th Refueling after Rerack (RFO 15)	2013
6	11th Refueling after Rerack (RFO 18)	2017
7	14th Refueling after Rerack (RFO 21)	2022
8	Spare	N/A

iii) *If RACKLIFE is used:*

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

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

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

(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.

MPS3 does not use RACKLIFE for the BORAL™ racks.

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 Access and Management Systems Accession No. ML12254A064). Discuss the effect of rack cell deformation and detector or head misalignment, such as tilt, twist, offset, or other is alignments 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.*

MPS3 does not perform in-situ testing of the BORAL™ racks.

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.*

The MPS3 NCS AOR includes a 7.3% tolerance for loss of B-10. This value was used by the SFP rack vendor in the initial NCS AOR. No deformations were modeled. Note that no significant dimensional changes, material loss, or deformations have been observed in the surveillance program.

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.*

Historical coupon tests have not identified any signs of degradation or resulted in a measured B-10 areal density less than assumed in the NCS AOR. Therefore, the NCS AOR is bounded.

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

Bias and uncertainty of the monitoring program are not part of the SFP NCS AOR. The monitoring program is intended to confirm, in part, that the assumptions in the SFP NCS AOR are still valid.

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

Historical coupon tests have not identified any signs of degradation or loss of B-10. Therefore, it is unnecessary to account for degradation in adjacent panels.

Attachment 3

RESPONSE TO GENERIC LETTER 2016-01 MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS

Virginia Electric and Power Company (Dominion)
North Anna Power Station Units 1 and 2

RESPONSE TO GENERIC LETTER 2016-01
NORTH ANNA POWER STATION UNITS 1 AND 2

The information requested by Generic Letter (GL) 2016-01 is provided below.

REQUESTED INFORMATION

The NRC requested information in the following five areas for use in verifying compliance:

(1) A description of the neutron-absorbing material credited in the SFP nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP;

(2) A description of the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used;

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

(4) A description of how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR; and

(5) A description of the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events.

As clarified in GL 2016-01, the provision of the information requested above is dependent upon which of the four categories described in the GL is applicable to the licensee. As indicated in GL 2016-01, "Category 1 includes power reactors that do not credit neutron-absorbing materials other than soluble boron in their AOR. In some cases, no neutron-absorbing material is present in the spent fuel storage racks, and in other cases, credit for the neutron-absorbing material has been removed through a regulatory action (e.g., approved license amendment). Those addressees may submit a response letter confirming that no neutron-absorbing materials other than soluble boron are currently credited to meet NRC subcriticality requirements in the SFP."

Based on the above, Dominion has determined that Category 1 applies to North Anna Power Station (NAPS) Units 1 and 2.

Specifically, Amendment No. 227 to Facility Operating License No. NPF-4 and Amendment No. 208 to Facility Operating License No. NPF-7 for NAPS Units 1 and 2, respectively, dated June 15, 2001 [ML01170557], consisted of changes to the NAPS

Technical Specifications (TS) to eliminate Boraflex credit from the spent fuel pool criticality calculations.

Although no credit is taken for the presence of Boraflex in the spent fuel racks in the criticality analyses, the Boraflex panels remain in their current locations in the SFP racks.

Attachment 4

RESPONSE TO GENERIC LETTER 2016-01 MONITORING OF NEUTRON-ABSORBING MATERIALS IN SPENT FUEL POOLS

Virginia Electric and Power Company (Dominion)
Surry Power Station Units 1 and 2

RESPONSE TO GENERIC LETTER 2016-01
SURRY POWER STATION UNITS 1 AND 2

The information requested by Generic Letter (GL) 2016-01 is provided below.

REQUESTED INFORMATION

The NRC requested information in the following five areas for use in verifying compliance:

(1) A description of the neutron-absorbing material credited in the SFP nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP;

(2) A description of the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used;

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

(4) A description of how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR; and

(5) A description of the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events.

As clarified in GL 2016-01, the provision of the information requested above is dependent upon which of the four categories described in the GL is applicable to the licensee. Dominion has determined that Category 1 applies to Surry Power Station (SPS) Units 1 and 2. Category 1 includes reactor power addressees that do not credit neutron-absorbing materials other than soluble boron in their NCS AOR.

The SPS Units 1 and 2 SFP NCS AOR does not credit neutron absorbing materials other than soluble boron. Criticality in the SPS Units 1 and 2 SFP is prevented by the use of geometrically safe configurations.