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10 CFR 50.54

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

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No. 1
Docket Number 50-346, License Number NPF-3
Response to Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools"

On April 7, 2016, the Nuclear Regulatory Commission (NRC) issued Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools" to all power reactor licensees except those that have permanently ceased operation with all power reactor fuel removed from on-site spent fuel pool storage.

The purpose of this letter is to provide a response for the Davis-Besse Nuclear Power Station (DBNPS), which has been determined to be a Category 4 licensee in accordance with Generic Letter 2016-01.

As a Category 4 licensee, information on the neutron-absorber material, criticality analysis of record and neutron-absorber monitoring program is requested depending on the type of neutron-absorber material present and credited in the spent fuel pool. DBNPS credits BORAL® in the spent fuel pool. Therefore DBNPS is required to provide the information requested in Areas 1, 2, and 4 of the Generic Letter 2016-01. The response is attached.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at (330) 315-6810.

I declare under penalty of perjury that the foregoing is true and correct. Executed on November __1__, 2016.

Sincerely,

Brian D. Boles

Attachment:
DBNPS Response to Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools"

cc: NRC Region III Administrator
NRC Resident Inspector
NRC Project Manager
Utility Radiological Safety Board

The requested information from Generic Letter 2016-01, Appendix A, "Guidance for Category 4 Responders to Generic Letter 2016-01," is presented in bold type, followed by the FirstEnergy Nuclear Operating Company (FENOC) response for the Davis-Besse Nuclear Power Station (DBNPS). Some of the requested information may not be provided, since it is not available and this is acceptable as documented in the September 10, 2015 NRC public meeting with the Nuclear Energy Institute (NEI) and the industry.

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 BORAL® panels were manufactured in 1998 by AAR Manufacturing Group Inc. and assembled into the racks by Holtec International. Four racks were initially installed in the cask pit (two in April 1999 and two in October 2001) for temporary spent fuel storage during re-racking activities. The remaining 17 racks were installed in the spent fuel pool (SFP) between October 2001 and April 2002. The initial four racks were relocated to the SFP at the end of the re-racking campaign.

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 materials of construction for boron carbide are specified in ASTM C750-89 Type III with exceptions, and the respective chemical analysis test report results are provided in Table 1. The aluminum powder grade 120 is per BPS 9000-06 and the respective chemical analysis test report results are provided in Table 2. The 1100-F aluminum alloy for clad material is per ASTM B221.

The minimum required weight percent of total boron in boron carbide is 70 weight percent. Each BORAL® panel contains boron carbide from one of three lots. As depicted in Table 1, each rack contains BORAL® panels made from boron carbide from either Lot M-143, M-146, or M-147.

Table 1 Boron Carbide Composition

AAR (mfr.) Lot #	M-143	M-146	M-147
Total Boron	76.5%	77.8%	77.8%
B + C	97.04%	97.98%	98.37%
B_2O_3	1.16%	1.42%	1.48%
Water Soluble Boron*	0.34%	0.45%	0.46%
Iron	0.049%	0.053%	0.039%
Sodium	0.001%	12 ppm	17 ppm
Fluoride	< 2 ppm	< 2 ppm	2 ppm
Chloride	< 5 ppm	7 ppm	5 ppm
B10 isotopic content	20.06%	20.01%	19.99%

* Test performed by Elektroschmelzwerk Kempten GMBH

Table 2 Aluminum Powder Composition

Component	Limits	Lots 980502, 980603, 980618 Actuals (Range)		Lot 980714 Actuals (Range)	
Al	99.5% minimum	99.74%	99.94%	99.71%	99.83%
Fe	0.25% maximum	0.04%	0.16%	0.10%	0.21%
Si	0.15% maximum	0.02%	0.08%	0.05%	0.06%
Other Elements	0.05% maximum each	0.00%	0.03%	0.00%	0.01%
Other Elements	0.15% maximum total	0.03%	0.06%	0.05%	0.05%

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

The minimum specified boron-10 areal density is 0.030 gram per square centimeter (g/cm^2).

The nominal specified boron-10 areal density is 0.0324 g/cm^2.

BORAL® summary reports were available for only two racks, but available vendor documentation packages for each rack confirms that neutron-absorbing materials used in all racks match the lot numbers presented in Table 1. However, minimum and maximum as-built areal densities are only available for one of the three lots and only for panels used in the first two racks installed at DBNPS. Those minimum and maximum as-built boron-10 areal densities are 0.0325 g/cm^2 and 0.0356 g/cm^2 for AAR Lot # M-143 panels, respectively.

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

BORAL® porosity and density were not provided by the manufacturer as part of material certification document packages.

The panel dimensions are as follows:

Thickness:	0.101 inches
Width:	7.5 inches
Length:	148 inches

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

The following points describe the qualification testing approach for compatibility.

1. Boron carbide testing was completed for soluble boron content to ensure that water soluble boron content is between 0.1 weight-percent minimum and 1.0 weight-percent maximum. The test results are provided in Table 1.

2. No test results are available regarding the compatibility with the SFP 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

The fuel pool rack storage cells are composed of stainless steel walls with a single fixed BORAL® neutron-absorber panel. Panels are held in place by 0.035 inch stainless steel sheathing welded in place by skip and spot welds. Stainless steel boxes (cells) are arranged in an alternating checkerboard array pattern such that the connection of the box corners form storage cells between those of the stainless steel boxes. Panels are installed on all exterior walls facing other racks, as well as non-fueled regions, that is the SFP walls.

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

The neutron-absorbing central layer of BORAL® is clad with permanently bonded surfaces of aluminum. The two materials, boron carbide and aluminum, are chemically compatible and ideally suited for long-term use in the radiation, thermal and chemical environment of the SFP. The stainless steel sheathing is designed to isolate aluminum cladding on the BORAL® panels from direct contact with any fuel assembly rods, but the aluminum cladding is not isolated from the SFP water. The panels are open to the SFP environment at the corners (vents) of the welded sheathing and do not prevent ingress of water. Exact dimensions for the vents on the stainless steel sheathing are not specified in vendor drawings.

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

i) Estimated current minimum areal density;

The average areal density of the sixty panels measured in the 2015 BADGER testing campaign was 0.0340 g/cm^2, which was 5.1% above the nominal panel areal density assumed in the criticality analysis of record or NCR AOR. The minimum average areal density for any single panel (average of all measurements made over the entire span of that single panel) was 0.0308 g/cm^2.

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

The nominal BORAL® areal density of 0.0324 g/cm^2 is used to calculate reactivities in the NCS AOR. However, a reactivity penalty is included in the calculation of the final effective neutron multiplication factor (K_{eff}) to account for manufacturing tolerances. The minimum specified boron-10 areal density (0.030 g/cm^2) was used to determine this reactivity penalty and the penalty was combined statistically (square root of the sum of the squares) with the penalties for other various manufacturer tolerances.

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).

There has been no recorded degradation of the neutron-attenuation capability of the neutron-absorber material. In-situ measurements from the neutron-absorber tests have provided no indication of loss of neutron-absorbing material.

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 the method(s) used in the surveillance or monitoring program, including:

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

Based on recent industry testing campaigns, a testing population of 59 BORAL® panels is considered a good statistical representation, regardless of pool size. This sampling is statistically significant (95/95 confidence level) in that the results can be extrapolated to the state of the entire SFP. Sixty panels were tested during the 2015 DBNPS BADGER testing campaign. BADGER testing is performed once every 10 years, assuming a long-term in-service history and material stability is demonstrated through industry experience. The testing may be more frequent, if results of previous testing or industry operating experience indicates that unacceptable degradation may occur prior to the next scheduled test.

ii) Parameters to be inspected and data collected;

BORAL® neutron-absorber panels are monitored by neutron attenuation testing to calculate the boron-10 areal density. The program provides for additional optional measurement parameters and actions, including radiography, destructive wet chemical analysis or destructive inspection of the panels for confirming or further investigating results of in-situ testing. If necessary, an in-service rack panel may be removed and visual observations made for signs of blistering, pitting, bulging, discoloration, or the loss of material, which will be recorded by photograph to capture anomalies. If an in-service panel is removed as described above, the following parameters will also be verified:

1) Dimensions (length, width, height) of any anomaly
2) Weight (without drying)
3) Density
4) Boron-10 areal density (neutron attenuation testing)
5) Microscopic analysis (pit size and depth)
6) Localized degradation characterization
7) Characterization of material anomalies
8) Gap formation

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;

Acceptance criteria are determined based on confirming the boron-10 areal density assumed in the SFP criticality analysis. A nonconformance would result in corrective actions including re-testing, if appropriate.

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

The BORAL® monitoring program outlined in FENOC Procedure NOP-NF-3201, "Spent Fuel Storage Rack Neutron Absorber Monitoring Program," provides for monitoring the neutron absorption properties of the BORAL® neutron-absorbers in the spent fuel racks by in-situ testing.

In-situ testing provides information on radiological effects, thermal effects, and chemical effects of the SFP environment on the BORAL® panels. Measurements from in-situ neutron attenuation tests are compared to previous test results to determine whether degradation is occurring, and whether such degradation may affect the function of the BORAL® prior to the next scheduled test.

v) Industry standards used

EPRI 1025204, titled "Strategy for Managing the Long Term Use of BORAL® in Spent Fuel Storage Pools" is used.

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

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

Not Applicable – visual inspection is not currently required.

ii) If there is a coupon-monitoring program:

Not Applicable – no coupons are installed at DBNPS.

iii) If RACKLIFE is used:

Not Applicable – RACKLIFE® is only applicable to the Boraflex® neutron-absorber material, and therefore is not applicable to DBNPS.

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;

A total of 69 panels (56 primary and 13 alternates) were initially selected for testing. Panel selection criteria considered the cell service history based on whether "hot" freshly discharged, "medium" mildly cooled, or "cold" legacy fuel that had been discharged long ago, had been resident in the candidate cell. The cells were classified as "High", "Medium," or "Low" in terms of service history. A set of 60 uniquely identified BORAL® panels were subjected to non-destructive testing. A sample of 60 tested panels exceeds the minimum sample requirement of 59 samples needed to provide a 95 percent confidence level that 95 percent of the population lies above the smallest observed value, as discussed in NUREG/CR-6698, "Guide for Validation of Nuclear Criticality Safety Calculational Methodology." Based on the panel selection exceeding the minimum sample requirement of NUREG/CR-6698, the sample 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;**

   The first campaign of BORAL® monitoring was conducted late in 2015. The test frequency is at least once per 10 years. FENOC administrative procedure NOP-NF-3201 recommends that test results be trended to assist with identifying any conditions, which could lead to neutron-absorbing material degradation.

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**

   NETCO implemented a detailed redesign of the BADGER system to address potential sources of in-situ testing uncertainties, such as signal reliability as a result of instrument stability and alignment, and insufficient shielding. Many of the NETCO-identified elements addressed in the redesign were noted by the NRC commissioned report "Boraflex, RACKLIFE, and BADGER" (ML12216A307). The BADGER upgrades include a more reliable, consistent, and stronger neutron pulse signal achieved with upgraded cables, upgraded pre-amplifiers, and well-sealed detector housings. NETCO also increased the stability of the probe heads to reduce uncertainty in head alignment. Additional detector shielding was added to filter out detected neutrons that were not transmitted through the absorber panel. Drive system and software enhancements add a level of reliability and a finer level of control.

All of these developments were subjected to testing at NETCO's test facility before use in a commercial environment, as required by the NETCO design control process.

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 calibration cell is designed to replicate the dimensional, material and neutronic characteristics of the DBNPS fuel storage racks, thereby facilitating calibration of the BADGER equipment for use at DBNPS.

The calibration cell is an I-shaped arrangement of three simulated fuel storage cells held in fixed configuration by a rectangular frame. This creates two panels for use in the calibration cell. One panel will incorporate three-partial length BORAL® panels of known areal density bounding the nominal areal density of the DBNPS SFP.

Two of the three fuel storage cells are constructed from 14 gage (0.075") stainless steel L-shaped channels. Two of each L-shaped channels are welded together to form each cell. The center resultant cell is then completed by adding two flat side panels. To simulate the presence of absorber panels on the exterior walls of the fuel cells, eight full length BORAL® panels are placed on outside walls of all fuel storage cells.

In keeping with possible rack conditions, BORAL® panels of known areal density and varying lengths are affixed with Dow Corning 732 silicone adhesive to the two interior cell walls between the storage cells. The BORAL® panels are enclosed by wrapper plates, which are tack welded to the fuel cell walls.

Replication of the DBNPS fuel rack has been accommodated by means of three types of neutron-absorber panels.

Panel Type 1 refers to three partial length BORAL® panels used for calibration. Panel Type 2 refers to the single full length BORAL® panel used for a calibration check. The Type 3 designation refers to BORAL® panels which provide peripheral neutron shielding.

BADGER calibration is accomplished as follows:

- The calibration cell is positioned on top of the DBNPS fuel rack or in the fuel transfer canal.
- The BADGER equipment is then used to measure the areal density of the BORAL® standards.
- Subsequent measurements of BORAL® panels are calibrated to the known areal density values of the BORAL® standards.
- Calibration scans at a minimum must be performed at the beginning and end of each test day.

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

The calibration cell has neutron-absorbers of known areal density from laboratory neutron attenuation testing of different values. Since in-situ measurements detect the level of neutron-absorbing elements, other materials have a limited impact on the results of the measurements.

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.

Not Applicable – Reference panels are not used for calibration.

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.

Not Applicable – BORAL® neutron-absorber racks are used at DBNPS.

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.

For the NCS AOR, a nominal boron-10 loading of 1.08 times the minimum loading is used. The minimum boron-10 loading is 0.030 g/cm^2 therefore, the nominal boron-10 loading used in the NCS AOR is 0.0324 g/cm^2. However, as stated earlier in the response for item 1.e.ii, a reactivity penalty based on the minimum allowable boron-10 loading of 0.030 g/cm^2 is included in the NCS AOR. The aluminum cladding on the BORAL®, is assumed to be homogenized with the boron carbide and aluminum mixture in the core of the panel. There are no currently observed mechanisms for loss of neutron-absorber material in BORAL® panels. Panel degradation, including blisters, gaps, cracks, and shrinkage of the BORAL® panel are not modeled in the NCS AOR.

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 BORAL® monitoring program BADGER testing results are trended to identify any conditions that could lead to absorbing material degradation. For BORAL®, which does not have any industry-identified mechanisms that result in loss of boron-10, the results provide confirmation that no material degradation is occurring, and therefore the measured BORAL® areal density is expected to be bounded by the SFP NCS AOR. Coupon monitoring is not performed at DBNPS.

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

The DBNPS SFP NCS AOR does not specify or reference a monitoring or surveillance program.

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

The DBNPS SFP NCS AOR does not account for degradation of the boron-10 areal density in adjacent panels.

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).

Not Applicable – BORAL® neutron-absorber panels are used at DBNPS.