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January 25, 2018

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

Calvert Cliffs Nuclear Power Plant, Unit 1
Renewed Facility Operating License No. DPR-53
NRC Docket No. 50-317

Clinton Power Station, Unit 1
Facility Operating License No. NPF-62
NRC Docket No. 50-461

James A. FitzPatrick Nuclear Power Plant
Renewed Facility Operating License No. DPR-59
NRC Docket No. 50-333

Nine Mile Point Nuclear Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-63 and NPF-69
NRC Docket Nos. 50-220 and 50-410

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Response to Request for Additional Information Regarding Generic Letter 2016-01

References:
1. NRC Generic Letter 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools," dated April 7, 2016 (ADAMS Accession No. ML16097A169)
2. Letter from P. R. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Response to Generic Letter 2016-01," dated November 3, 2016 (ADAMS Accession No. ML16308A470)
3. Letter from B. R. Sullivan (Entergy Nuclear Operations, Inc.) to U.S. NRC, "Response to Generic Letter 2016-01 – Monitoring of Neutron Absorbing Materials in Spent Fuel Pools," dated November 3, 2016 (ADAMS Accession No. ML16308A461)

4. Letter from B. Purnell (U.S. NRC) to B. C. Hanson (Exelon Generation Company, LLC), "Calvert Cliffs Nuclear Power Plant, Unit 1; Clinton Power Station, Unit No. 1; James A. FitzPatrick Nuclear Power Plant; Nine Mile Point Nuclear Station, Units 1 and 2; and Three Mile Island Nuclear Station, Unit 1 – Request for Additional Information Regarding Generic Letter 2016-01, 'Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools' (CAC Nos. MF9450, MF9448, MF9440, MF9429, MF9428, and MF9414, EPID L-2016-LRC-0001)," dated October 27, 2017 (ADAMS Accession No. ML17285B196)

5. Email from B. Purnell (U.S. NRC) to P. R. Simpson (Exelon Generation Company, LLC), "RE: Generic letter 2016-01 RAI Response Due Date," dated October 31, 2017 (ADAMS Accession No. ML17304B194)

On April 7, 2016, the NRC issued Generic Letter (GL) 2016-01, "Monitoring of Neutron-Absorbing Materials in Spent Fuel Pools" (i.e., Reference 1), to address degradation of neutron-absorbing materials in wet storage systems for reactor fuel at power and non-power reactors. Responses to GL 2016-01 for the stations listed above were submitted to the NRC in References 2 and 3. In Reference 4, the NRC requested additional information that is needed to complete the review. Reference 4 requested Exelon Generation Company, LLC's (EGC's) response to be submitted by December 26, 2017. However, in Reference 5, it was agreed that EGC would respond by January 25, 2018. In response to this request, EGC is providing the attached information.

There are no regulatory commitments contained in this letter. Should you have any questions concerning this letter, please contact Mr. Kenneth M. Nicely at (630) 657-2803.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 25th day of January 2018.

Respectfully,

Patrick R. Simpson
Manager – Licensing

Attachment: Response to Request for Additional Information

cc: NRC Regional Administrator – Region I
NRC Regional Administrator – Region III
Senior Resident Inspector – Calvert Cliffs Nuclear Power Plant
Senior Resident Inspector – Clinton Power Station
Senior Resident Inspector – James A. FitzPatrick Nuclear Power Plant
Senior Resident Inspector – Nine Mile Point Nuclear Station
Senior Resident Inspector – Three Mile Island Nuclear Station

Calvert Cliffs Nuclear Power Plant, Unit 1

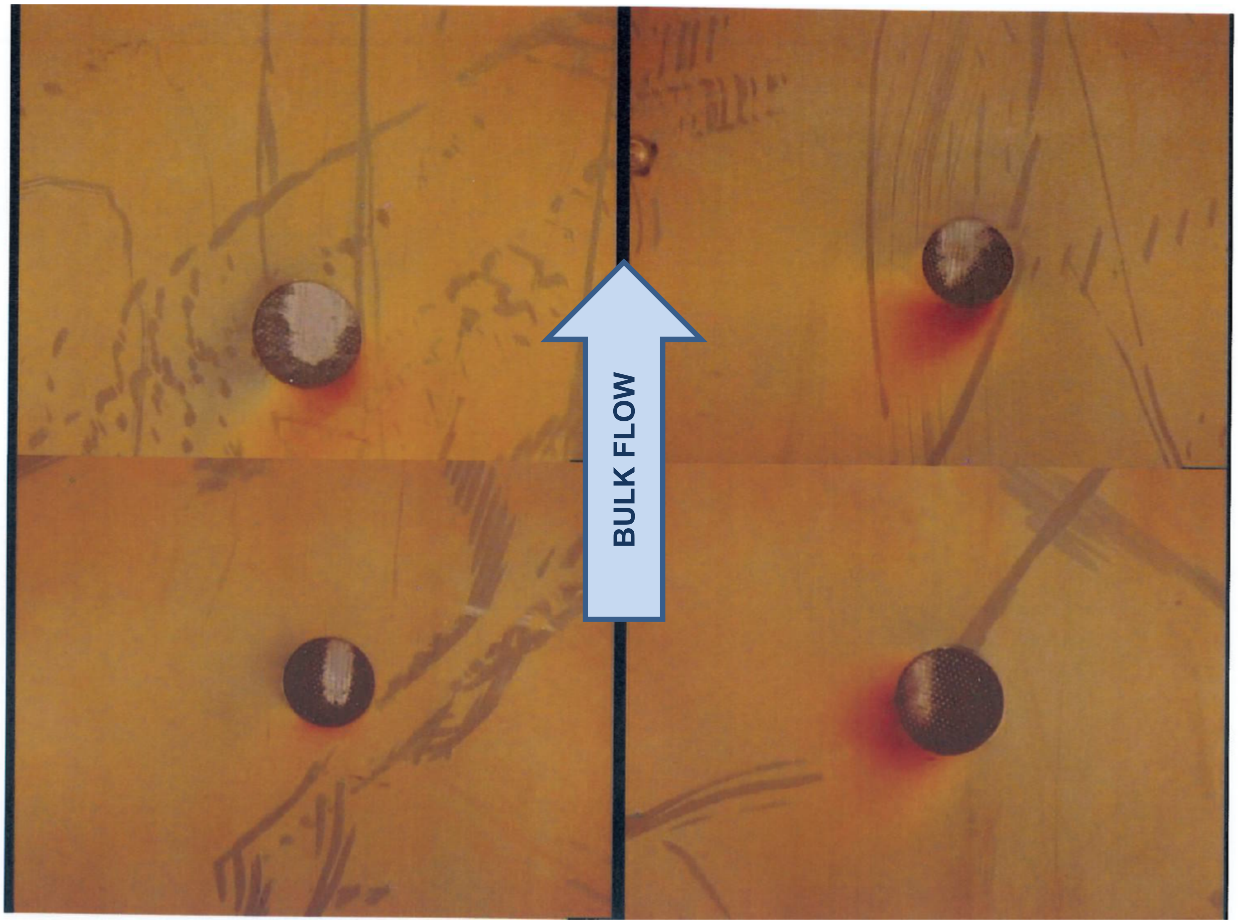
CCNPP-RAI-1

The licensee stated that there is an inspection hole above the top of active fuel (TAF) in the spent fuel pool racks, but the flow-induced erosion will not impact the Carborundum below the TAF (i.e., the region credited in the spent fuel pool criticality analysis of record). Explain why it is not possible for flow-induced erosion or dissolution of the Carborundum material to occur below the TAF.

Response

The flow-induced erosion at the coupon packet and the rack inspection holes is considered to only exist at those locations based on a thermal-hydraulic review of the rack geometry. The flow rate in the fuel storage rack channels is determined by decay heat driven natural circulation, which is predominantly axial flow. However, the presence of the inspection holes in the channels acts as a bluff body, resulting in the appearance of turbulent eddy and secondary flow at the hole. The combined axial and recirculating flows at the inspection hole over an extended period cause flow induced erosion to any surface which is present at the hole, whether it be the coupon or the rack absorber sheet (note that surface erosion is proportional with the square of mass flow rate). The nature of the turbulent eddy flow would not impact the Carborundum material that is not adjacent to the hole. As can be seen in the pictures of the rack inspection holes below, after ~35 years, Carborundum material remains in the lower portion of the inspection holes.

Four Spent Fuel Pool Rack Inspection Hole Photos (early 2014)



CCNPP-RAI-2

Explain how the Carborundum coupons are, and will continue to be, representative of the inservice material if the flow-induced erosion only affects the coupons and the data from the most eroded coupons is not considered.

Response

The use of weight loss criteria as a surrogate for areal density assumes that the weight loss is occurring uniformly over the surface of the coupon primarily due to radiation exposure. Unfortunately, the presence of the inspection hole of the coupon packet holder has resulted in localized flow induced erosion at and, in the case of packet 18 coupons 2U and 2L, above the location of the inspection hole (see picture below). Inspection results indicate that approximately half of the 30% weight loss seen on coupon 2U can be attributed to the erosion hole (~11%) and losses from the edge (~4%) of the coupon. Performing this for all six of the packet 18 and 24 coupons removed in the December 2013 performance of the coupon inspections indicates that the weight loss from the areas of the coupons not associated with

localized erosion is 5 to 16%, with an average of ~11%, which is well within the inspection acceptance criteria for weight loss. Subsequent boron-10 areal density testing performed confirmed an average boron-10 loss of approximately 11% for those coupons.

In response to the flow induced erosion at the coupon packet inspection holes, CCNPP intends to perform areal density testing of all coupons removed during the performance of coupon testing. This will ensure that the isotopic composition of the coupon material is reflected in the criticality safety analyses supporting the in-service material.

Coupon Flow Erosion

CCNPP-RAI-3

In the response to Appendix A, Section 1(e)(iii), the licensee noted that bracket covers were installed to cover the holes on the coupon brackets in 2016. However, the inservice spent fuel racks still have an inspection hole above the TAF which could expose the inservice Carborundum to the spent fuel pool water. Given that the Carborundum coupons are no longer exposed to the complete spent fuel pool environment, describe how the coupons are representative of the inservice material.

Response

The coupons are still exposed to spent fuel pool (SFP) water since the coupon packets are not water-tight. The packet covers only prevent the exposure of the coupons to the eddy currents / secondary flow caused by the inspection holes. There is still axial flow across the Carborundum coupons – complete exposure to spent fuel environment. The flow rate past the coupon packets is higher than the flow rate around the in-service material, which is conservative. This

ensures that the areal densities measured in the coupons remain conservative to the in-service material. The change in packaging of the coupons simply removes the unnecessary additional degradation mechanism driven by the presence of the inspection hole.

CCNPP-RAI-4

The response to Appendix A, Section 1(e)(iii), states that the licensee plans to include measurement of the boron-10 (^{10}B) areal density as part of the future coupon testing, and the associated procedural change is in progress. Given that the acceptance criterion for the coupon test was not met in 2013, confirm that:

a. the procedure change to incorporate measurement of ^{10}B areal density has been incorporated into plant procedures; and

b. all future coupon tests will include measurement of ^{10}B areal density.

Response

The procedure change to implement areal density testing for every coupon surveillance campaign was implemented at Calvert Cliffs station in December 2017. Calvert Cliffs also has an NRC commitment from 2008 (Amendment 288) to perform areal density testing on coupons to be pulled in the years 2009 (past), 2017 (past), 2025, 2037, and 2053. This procedure change requires the testing of the boron-10 areal density for all future Carborundum coupons tested at Calvert Cliffs.

Clinton Power Station, Unit No. 1

CPS-RAI-1 (Generic RAI)

The licensee's November 3, 2016, letter states that CPS does not have a site-specific monitoring program. Instead, the licensee is relying on general industry operating experience as a surrogate for the condition of the Boral installed in the CPS spent fuel pool.

a. Describe how industry operating experience bounds the condition of the Boral at CPS, thereby providing assurance that any degradation or deformation that may affect the Boral at CPS is identified.

b. Discuss the criticality impact due to relevant material deformation identified in general industry operating experience, and how it can be accommodated by the nuclear criticality safety analysis of record for CPS without exceeding subcriticality requirements.

Response

The requested information is similar to information the NRC has requested from several other licensees. As a result, there are ongoing industry activities with NEI and EPRI to support development of an industry neutron-absorbing material (NAM) monitoring database and the development of a response that multiple licensees may be able to reference by May 31, 2018. Exelon Generation Company, LLC (EGC) is actively working with the industry on these activities. Therefore, EGC intends to provide a response to this RAI for CPS by May 31, 2018, contingent upon completion of the aforementioned industry activities.

James A. FitzPatrick Nuclear Power Plant

JAF-RAI-1 (Generic RAI)

Discuss the criticality impact due to the material deformation identified at JAF, and how it can be accommodated by the nuclear criticality safety analysis of record without exceeding subcriticality requirements.

Response

The requested information is similar to information the NRC has requested from several other licensees. As a result, there are ongoing industry activities with NEI and EPRI to support development of an industry NAM monitoring database and the development of a response that multiple licensees may be able to reference by May 31, 2018. EGC is actively working with the industry on these activities. Therefore, EGC intends to provide a response to this RAI for JAF by May 31, 2018, contingent upon completion of the aforementioned industry activities.

<u>Nine Mile Point Nuclear Station Unit No. 1</u>

NMP1-RAI-1

Explain how NMP1 complies with license renewal commitment No. 16, including monitoring and trending of in-situ test results, if BADGER testing will not be conducted periodically during the period of extended operation.

Response

EGC is in compliance with the commitment for NMP1 to maintain a periodic in-situ (BADGER) testing program for the Boraflex racks; however, the updated test periodicity in the aging management program was not properly reflected in the documentation in 2016.

NMP1 performed BADGER testing in 2008 before entering the period of extended operation. At that time, the periodicity of the BADGER in-situ testing was set at once every eight years given the close agreement between the boron-10 areal density shown by coupons taken to date, the RACKLIFE model, and the 2008 BADGER testing. This eight-year periodicity requirement was then included into the Aging Management Program (AMP) document.

In 2016, NMP1 reviewed the eight-year periodicity of BADGER testing based upon results collected from Boraflex coupon measurements and RACKLIFE results from the coupon pulled from the SFP. The results showed that the boron-10 areal density changes were minimal.

The coupon and RACKLIFE boron-10 areal density degradation levels were showing losses of less than 3% of the original areal density; therefore, the decision was made to change the period of the required BADGER testing to 10 years to align with the implementation of the plans to remove all credit from the criticality safety analysis for Boraflex. However, EGC did not update the NMP aging management program document with the new period for BADGER testing when it was changed. EGC has entered this into the Corrective Action Program (i.e., Issue Report 4094907) to update the AMP documentation based upon the updated evaluation performed in 2016.

<u>Nine Mile Point Nuclear Station, Unit 2</u>

NMP2-RAI-1

Justify the use of the panel average ^{10}B areal density as the acceptance criterion, instead of the lowest measured ^{10}B areal density at a given point on the panel.

Response

BADGER testing data is reviewed for acceptability by looking at both the full-panel average boron-10 areal density as well as sectional panel averages down to a single reading (2-inch) average boron-10 areal density. A 2-inch panel average areal density measurement is the finest detail measurement (i.e., smallest area) that the current BADGER system can produce. This is due to the physical size of the neutron detectors, the neutron source and holder, and the geometry of the neutron absorbing material placement in the BADGER system. The one

BADGER test performed thus far for the NMP2 Boral racks (those without proper surrogate coupon material) utilized a conservative panel average boron-10 areal density determination method by assigning the minimum 2-inch panel average boron-10 areal density value, adjusted for the 3-sigma instrument uncertainty, for each panel to the entire panel. While the AMP for the Boral racks utilizes the phrase "Boral panel average areal density" as the acceptance criterion, the determination of the panel average boron-10 areal density is done such that local average panel boron-10 areal density impacts are accounted for. Thus, the determination of the boron-10 areal densities for the Boral panels using BADGER does take the lowest measured areal density into account.

NMP2-RAI-2

Explain how measurement uncertainty is accounted for in the acceptance criteria for BADGER testing.

Response

The 3-sigma uncertainty of the BADGER measurement system is accounted for when determining the resultant panel average (whole-panel or smaller segment) Boral boron-10 areal densities. The BADGER system determines the 3-sigma uncertainty for each 2-inch segment measurement and when determining a whole-panel average Boral boron-10 areal density the maximum 2-inch determined 3-sigma value is applied as the uncertainty for this value. When reviewing 2-inch average panel areal densities on their own, the corresponding 3-sigma measurement uncertainty values are used for each location.

The actual value for each 2-inch segment 3-sigma measurement uncertainty is statistically determined from natural counting uncertainty propagated over all data handling equations. Error propagation, where $f(x, \dots, z)$ is performed using the following equation.

$$\delta f = \sqrt{\left(\frac{\partial f}{\partial x}\,\delta x\right)^2 + \cdots + \left(\frac{\partial f}{\partial z}\,\delta z\right)^2}$$

<u>Three Mile Island Nuclear Station, Unit 1</u>

<u>TMI-RAI-1</u>

Provide the basis for determining the Metamic coupon surveillance frequency. Provide the minimum Metamic coupon surveillance frequency allowed by the program.

<u>Response</u>

Basis for Metamic Coupon Surveillance Frequency:

The use of Metamic as a neutron absorber in spent fuel pool applications was presented to the NRC in a topical report prepared by Holtec. Specifically, by letter dated August 8, 2002, as supplemented by letter dated January 31, 2003, Entergy requested a review of Holtec Report HI-2022871, "Use of Metamic in Fuel Pool Applications," for the proposed use of Metamic poison panels in the Arkansas Nuclear One (ANO), Units 1 and 2, SFPs. The NRC approved this topical report in a safety evaluation dated June 17, 2003 (ADAMS Accession No. ML031681432). The NRC concluded that the performance of the Metamic as a neutron absorber was similar to Boral; however, with fewer non-uniformities in the boron loading for Metamic. The NRC also reviewed results for mechanical properties and corrosion testing, concluding that Metamic is a suitable material for use in the SFP environment, conditioned on a coupon monitoring program.

The use of Metamic at TMI was implemented as a design change that included a review that was performed in accordance with 10 CFR 50.59. A summary of the 10 CFR 50.59 evaluation was submitted to the NRC on April 16, 2012 (ADAMS Accession No. ML12109A235).

As discussed in Holtec Report HI-2022871, testing of the Metamic material has confirmed that it has equivalent or better resistance to corrosion and has a greater neutron absorption capacity when compared to Boral. The Metamic high density racks are therefore suitable for long term deployment without any inspection and/or surveillance requirements beyond those already required for Boral material. Therefore, the Boral coupon testing schedule is bounding for Metamic coupons.

Minimum Metamic Coupon Surveillance Frequency:

The minimum Boral coupon measurement schedule provided in Holtec procedure HPP-90310-10, "Boral Surveillance Program for Three Mile Island Unit 1 High Density Racks," is shown below.

TABLE 6.1-1 – COUPON MEASUREMENT SCHEDULE

Coupon	Refueling[(1)]
1	1st[(2)]
2	2nd[(2)]
3	3rd[(2)]
4	5th[(2)]
5	8th
6	11th
7	14th
8	20th
9	25th
10	30th
11	35th
12	40th (or spare)

(1) Remove coupons for evaluation within the 1 or 2 months preceding the next refueling.

(2) Place freshly discharged fuel in the 8 surrounding cells at the beginning of the 1st, 2nd, 3rd, 4th, and 5th refueling cycles.

The Metamic Coupon Testing Schedule provided in procedure NF-TM-600-1000, "TMI Spent Fuel Rack Boral/Metamic Coupon Program," is shown below.

TABLE 3 – METAMIC COUPON TESTING SCHEDULE

Coupon	Remove Prior to Outage	Refueling After Rerack
202-418A-1	T1R20	1st *
202-452B-1	T1R21	2nd *
202-490A-1	T1R22	3rd *
202-454B-2	T1R23	4th *
202-487C-2	T1R24	5th
400-087B-1	T1R27	8th
400-091A-1	T1R30	11th
400-126B-4	T1R33	14th
400-098C-1	T1R36	17th
400-067C-3	T1R41	22nd

* Surrounded by freshly irradiated fuel in the outage before the scheduled removal date; surrounded by any fuel thereafter.

Comparing the Holtec schedule for Boral coupons to the site Metamic coupon testing schedule confirms that the site Metamic coupon testing schedule is more frequent than required by the schedule in Holtec's surveillance procedure. The third coupon on the schedule was removed for analysis in September 2017, prior to refueling outage T1R22.

Since the installation of the Metamic racks, TMI has been on a 2-year cycle schedule; however, the coupon testing is not held to a 2-year schedule. Regardless of cycle duration, the coupon testing schedule is based on refueling outages. Per the Metamic Coupon Testing Schedule, the minimum frequency for coupon surveillance testing is one coupon per five refueling outages.