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PROPRIETARY INFORMATION – WITHHOLD UNDER 10 CFR 2.390
UPON REMOVAL OF ATTACHMENT 2, THIS LETTER IS DECONTROLLED

10 CFR 50.90

January 18, 2018

Serial: HNP-18-003

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

Shearon Harris Nuclear Power Plant, Unit 1
Docket No. 50-400 / Renewed License No. NPF-63

**Subject**: Response to Request for Additional Information Regarding License Amendment Request For Spent Fuel Storage Pool Criticality Analyses (CAC No. MF9996; EPID L-2017-LLA-0303)

Ladies and Gentlemen:

By application dated June 28, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17193B165), Duke Energy Progress, LLC (Duke Energy), submitted a license amendment request (LAR) for Shearon Harris Nuclear Power Plant, Unit 1 (HNP), regarding spent fuel storage pool criticality analyses.

The U.S. Nuclear Regulatory Commission (NRC) staff reviewed the LAR and determined that additional information is needed to complete their review. Duke Energy received requests for additional information (RAIs) from the NRC by letters dated December 20, 2017 (ADAMS Accession No. ML17339A566), and January 8, 2018 (ADAMS Accession No. ML18005A548). Responses to these requests are required by January 18, 2018.

Duke Energy's responses to both sets of RAI questions are provided in the enclosure to this letter. Attachment 2 of the enclosure contains information proprietary to Holtec International, and is supported by an affidavit signed by Holtec International, provided as Attachment 1 of the enclosure.

This additional information does not change the No Significant Hazards Determination provided in the original submittal. No new regulatory commitments are contained within this letter.

In accordance with 10 CFR 50.91(b), HNP is providing the state of North Carolina with a copy of this response.

Should you have any questions regarding this submittal, please contact Jeffrey Robertson, Manager – Regulatory Affairs, at (919) 362-3137.

I declare under penalty of perjury that the foregoing is true and correct. Executed on January 18, 2018.

Sincerely,

Tanya M. Hamilton

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Enclosure: Response to Requests for Additional Information

cc: J. Zeiler, NRC Senior Resident Inspector, HNP
W. L. Cox, III, Section Chief, N.C. DHSR
M. Barillas, NRC Project Manager, HNP
C. Haney, NRC Regional Administrator, Region II

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**SERIAL HNP-18-003**

**ENCLOSURE**

**RESPONSE TO REQUESTS FOR ADDITIONAL INFORMATION**

**SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1**

**DOCKET NO. 50-400**

**RENEWED LICENSE NUMBER NPF-63**

By application dated June 28, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17193B165), Duke Energy Progress, LLC (Duke Energy), submitted a license amendment request (LAR) for Shearon Harris Nuclear Power Plant, Unit 1 (HNP), regarding spent fuel storage pool criticality analyses.

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**RAI #1**

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.90, "Application for amendment of license, construction permit, or early site permit," states that a LAR must fully describe the changes desired. The LAR proposes changes to TS 5.6.1.3, "BWR [Boiling-Water Reactor] Storage Racks in Pools 'A' and 'B' at HNP," to credit the use of Metamic neutron absorbing rack inserts proposed to be installed in the BWR Boraflex storage rack cells in spent fuel pools (SFPs) A and B, in combination with the soluble boron present in the pools as a replacement for the neutron absorbing properties of the Boraflex panels.

The governing NRC staff regulatory requirements and guidance for design modifications of the SFP and storage racks include, but are not limited to the following: "Office of Technology (OT) Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978 (ADAMS Accession No. ML031280383); NUREG-0800 Standard Review Plan (SRP), Revision 4, dated September 2013 (ADAMS Accession No. ML 13198A258), Section 3.8.4, "Other Seismic Category I Structures," including Appendix D, "Technical Position on Spent Fuel Racks," and Section 3.8.5, "Foundations"; American Society of Mechanical Engineers (ASME) Code, Section III, Division 1, Subsection NF; and General Design Criteria 1, 2, and 4 of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants."

Section 3.5, "Rack Structural Evaluation/Seismic Considerations," of the LAR states that Section 6.0 of Attachment 5, "Holtec International Licensing Report HI-2177590 for Use of Dream Neutron Absorber Inserts in the Spent Fuel Pools 'A' and 'B' at Shearon Harris NPP" (NON-PROPRIETARY), describes the structural evaluation of the HNP SFP racks after DREAM inserts have been added to the existing Westinghouse BWR racks located in Pools A and B. The NRC staff identified that Attachment 5 focuses primarily on a discussion of the weight of the inserts being negligibly small in comparison to the overall dead weight of the SFP racks and pool structures, but does not provide sufficient technical information regarding the seismic analysis and evaluation of the SFP racks and pool structural qualification.

Section 6.1 of Attachment 5 states, in part, that "the effects of the Dream inserts on the structural design bases are evaluated by reviewing the existing analysis reports listed [as in Section 6.7] as References 6.7.1 through 6.7.3." Additionally, Section 6.6 states, in part, that "per the analysis in Reference 6.7.4, Dream inserts are found to be structurally adequate to perform their intended function under both normal and seismic conditions."

The staff requests that the licensee provide References 6.7.1 through 6.7.4, including a complete discussion of the structural analysis and adequacy of the existing SFP racks and pool structure outfitted with Metamic inserts designed to meet the NRC regulatory requirements and guidance discussed above.

The reports should also include discussion of the following: the results of the time-history simulations for the major parameters of interest; applicable loads and loading combinations considered in the seismic analysis of the rack modules consistent with the current design and licensing basis described in the Final Safety Analysis Report; stress levels in the rack modules and their relationship to the ASME III Code, NRC's OT Position Paper and current licensing basis for HNP; the acceptance criteria for stress limits on the rack structure for Level A-D service limits for both Operating Basis Earthquake (OBE) and Safe Shutdown Earthquake (SSE) based on ASME III Code, Section III, Division 1, Subsection NF; safety margins against rack overturning for both OBE and SSE load conditions; maximum rack stresses including baseplate-to-pedestal and baseplate-to-rack cell welds; maximum rack displacement and location and discussion of the possibility of rack-to-wall impact between the rack modules; and a description of the analysis used to demonstrate that the existing SFP structure will continue to meet the acceptance criteria considering the presence of Metamic inserts.

**HNP Response to RAI #1:**

References 6.7.1 and 6.7.2 were used by Holtec for information references only and are not pertinent to the rack structural evaluation. Reference 6.7.3 is related to the Holtec rack design and not the Westinghouse design impacted by the scope of the LAR. Reference 6.7.4 contains information proprietary to Holtec and has been included as Attachment 2 to this enclosure. Attachment 1 of this enclosure contains the affidavit for the withholding of this proprietary information.

The racks, being ANS Safety Class 3 and Seismic Category I structures, are designed to withstand normal and postulated dead loads, live loads, loads due to thermal effects, and loads caused by the operating bases earthquakes and safe shutdown earthquake events in accordance with Regulatory Guide 1.29, and stress allowables defined by ASME Code, Section III. Additionally, the design and safety evaluation of the racks is in accordance with the NRC's OT Position Paper, including the modificications provided in Generic Letter 79-04, dated January 18, 1979 (ADAMS Accession No. ML031290521). The racks can withstand an uplift force equal to the maximum uplift capability of the spent fuel bridge crane.

As discussed in Section 6.2 of LAR Attachment 5, the rack inserts account for a small percentage of the total rack weight. Given that the DREAM inserts have a negligible effect on the loaded rack weight, it can also be concluded that the inserts will likewise have a negligible impact on the existing seismic qualification of the 11x11 BWR Boraflex racks. Additionally, in Section 6.3, it is again reiterated that the rack inserts have an infinitesimal impact on the fuel pool structural qualification because the total weight of the installed DREAM inserts is extremely small in comparison to the other load contributors (e.g. pool water, rack weight, fuel weight).

The original structural analysis for the Westinghouse Boraflex BWR spent fuel racks was performed by Westinghouse, as documented in their Proprietary Design Report WNEP-9014, "Evaluation of Modified Spent Fuel Pool Layout for PWR and BWR Fuel Racks," which

describes the analysis and provides details of the calculation methods and results for these racks.

Because of the structural nonlinearities of the rack support boundaries and the gaps between the fuel assembly and the fuel cell, the seismic analysis is a nonlinear time history analysis. The analysis is performed on a finite element model of an equivalent single cell which has the structural characteristics of a submerged rack assembly. The impact behavior between the fuel assembly and cell is represented by a three-dimensional dynamic gap element. The hydrodynamic mass between the fuel assembly and cell is modeled by three-dimensional mass matrix elements. The analysis is performed for a range of friction coefficients to assess both the rocking and sliding behavior of the racks, with the highest coefficient producing the highest impact loads and rocking displacements, and the lowest coefficient producing the highest sliding displacements.

From this model, acceleration time histories were generated and a dynamic transient analysis was performed to determine the maximum seismic loads and displacements. This was based on SSE loading. Loads are factored based on site Response Spectrum values to OBE for the purpose of structural evaluation.

The loads obtained from the seismic analysis of the single cell model were converted into overall rack loads and combined with other loading conditions. Once these loads were determined, classical methods were used to determine the resulting stresses in the fuel rack structural members. The resulting stresses were then compared to ASME Code Section III, Subsection NF and Appendix XVII, 1977 Edition, Winter 1979 Addenda criteria to determine minimum stress margins associated with the structural elements of the fuel rack.

The analysis addressed the hydrodynamic mass for the bounding fuel assemblies in the BWR racks. The addition of the rack insert reduces the amount of water that can contribute to the effects of hydrodynamic mass. As such, the addition of the rack insert is bounded by the hydrodynamic mass evaluation presented in the Westinghouse analysis.

HNP Engineering developed a Design Change package to allow the installation of the DREAM inserts in the Westinghouse BWR Boraflex racks. As part of this Design Change, an engineering evaluation was performed to assess the impact of the Dream Inserts on the existing rack structure and SFP structure. For this evaluation, the insert was assumed to behave similar to the fuel assembly, and therefore was considered to be part of the fuel assembly due to the small gaps between the cell and the fuel assembly. Also, due to the minimal incremental weight between the insert and the fuel assembly, the inserts are not expected to have an appreciable effect on the fundamental frequency of the seismic model, therefore adding the weight of the insert to the fuel assembly weight to assess the impact to fuel rack structure is reasonable. As stated above, the insert will have no negative impact on the hydrodynamic loads imposed on the fuel racks in the original Westinghouse analysis. Given this discussion, assuming the slight increase in weight of a fuel assembly (accounting for the rack insert contribution to the assembly weight), there remains sufficient margin in the original design as documented in WNEP-9014 to accommodate the inclusion of the inserts without impacting the structural integrity of the fuel racks. A verification check was performed for the components with the smallest safety margin from the original design (i.e., the support block to plate structural weld and cell load buckling) utilizing the original method of analysis documented in WNEP-9014. This check confirmed the above conclusion as compared to ASME Code Section III, Subsection NF and Appendix XVII,

1977 Edition, Winter 1979 Addenda criteria. Of particular note, allowable stress for SSE conditions are twice the allowable for OBE stresses and thus enveloped by OBE conditions since the SSE loads are less than twice the OBE loads. Therefore, the original rack design is based on the OBE stress conditions.

In the original Westinghouse analysis, rack stability was evaluated assuming each incremental row of fuel assemblies in the rack and it was found that the minimum factor of safety to overturn was much greater than the minimum 1.5 required by the OT Position Paper. In evaluating the impact of the inserts, it was assumed the addition of the inserts would have a non-concerning effect on the rack overturn analysis due to the large margin of safety in the original analysis. A verification check was performed on rack overturn utilizing the original method of analysis documented in WNEP-9014. This check determined that the minimum factor of safety to overturn remains significantly large, thus still yielding acceptable results.

The original Westinghouse analysis also considered rack sliding and deflection during seismic events. Based on the minimal rack displacement and deflection compared to the available rack-to-rack distance and rack-to-wall distance, the addition of the inserts will not result in rack-to-rack or rack-to-wall impact. Also, any decrease in rack gaps resulting in less than or equal to 75% of the original installation gaps post-OBE requires repositioning of racks or an analysis to determine acceptability as identified in site procedures.

The SFP structure was evaluated to affirm the integrity of the SFP steel liner. The existing site structural calculation of record determined that the most limiting rack design for the steel liner is an 8x9 PWR rack array. This calculation neglects the effects of buoyancy and determines a resulting bearing pad stress due to the 8x9 PWR rack array. A similar evaluation of the 11x11 Westinghouse BWR rack array was performed to determine the effect of inserts on the steel liner. This evaluation determined that the bearing pad stress for the BWR rack with inserts is bounded by the PWR rack results. On this basis, the SFP steel liner can accommodate the rack inserts.

Additionally a SFP floor slab evaluation was performed. The existing site structural calculation of record identifies the maximum allowable bending moment and shear for the slab. Based on this significant margin available for bending moment and shear, the effect due to the addition of inserts is negligible, ensuring that the SFP floor slab structural integrity is maintained.

**RAI #2**

In accordance with NRC's OT Position Paper (referenced in RAI 1 above), limiting values of pool water temperatures are discussed in the American National Standards Institute document ANSI-N210-1976, "Design Objectives for Light-Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations," whereas Section 9.1.3.III.I.d of the NRC SRP is applicable to the maximum heat load with normal cooling systems in operation. The design of the DREAM inserts must ensure that all fuel assemblies in the Westinghouse BWR Spent Fuel Storage Racks (SFSRs) will continue to be adequately cooled by circulation of water for the design-basis scenario. The LAR states in Section 5 of Attachment 5 that increased hydraulic resistance can result in elevated fuel cladding temperature and impact the Time-to-Boil evaluation.

a) Was the increase in hydraulic resistance considered in LAR Subsection 5.4.2, "Time-to-Boil Evaluation," and Subsection 5.5, "Local Water and Fuel Cladding Temperature?"

b) In Subsection 5.5, the Westinghouse BWR SFSRs are modeled as porous medium regions in which Darcy's Law governs fluid flow. Is the porous medium adjusted to account for the increase in hydraulic resistance? In the calculation of the maximum fuel clad temperature, is the hydraulic diameter calculated to consider the presence of the dream inserts?

**HNP Response to RAI #2:**

With respect to time-to-boil, the current licensing basis evaluation is for bulk boiling. The local hydraulic resistance does not impact the onset of bulk boiling. LAR Subsection 5.4.2 states that the effect of the DREAM inserts on the time-to-boil is that the inserts displace “a quantity of SFP water, which slightly reduces the thermal inertia of the SFP.” The reduction in the quantity of water was considered as described in the subsection.

With respect to fuel cladding temperature, the increase in hydraulic resistance is considered by reducing the flow area in the storage cell to reflect the presence of the DREAM insert. Reducing the flow area in the cell decreases the hydraulic diameter, which has two effects. First, it increases the local water temperature computed in the Computational Fluid Dynamics analysis by increasing the viscous resistance term. Second, it decreases the clad-to-water superheat by increasing the convective heat transfer coefficient (LAR equation at bottom of Attachment 5 page 5-9). Both effects are considered.

**<u>RAI #3</u>**

The applicable 10 CFR 50.68 requirement is that " ... [i]f credit is taken for soluble boron, the k-effective of the SFSRs loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water." The licensee submitted a licensing report (Attachments 4 and 5 to the LAR) that included documentation of a criticality analysis performed to demonstrate that this regulatory limit will be met if the proposed Technical Specification (TS) limit on the reactivity for fuel stored in the HNP SFP is satisfied.

**a)** The Attachment 5 licensing report references Revision 3 of a Holtec report, HI-210490, which provides information on the validation of the criticality code against critical benchmarks and experiments. The NRC has reviewed a previous revision of this validation report, but based on the licensing report, Revision 3 has some new information. Please provide Revision 3 of HI-210490 for the NRC staff to review.

**HNP Response to RAI #3a:**

HI-210490 Revision 3 includes a recalculation of a subset of experiments using NJOY created cross sections for experiments which are temperature dependent. No new or additional experiments have been added. The benchmark bias and bias uncertainty remain essentially unchanged. See the summary table below.

Summary of Biases and Bias Uncertainties for the Validated Computer Codes

| Computer Code | Total Bias | Bias Uncertainty |
|---|---|---|
| Revision 2: MCNP5-1.51 with ENDF/B-VII (Appendix D) | 0.0001 | 0.0073 (0.0111) |
| Revision 3: MCNP5-1.51 with ENDF/B-VII (Appendix D) | 0.0001 | 0.0072 (0.0111) |

**RAI #3 (continued)**

**b)** A configuration where one Metamic rack insert is missing is included as part of the normal condition for the criticality evaluation. Based on the LAR and the Attachment 5 licensing report, this is because the rack insert must be removed before the fuel assembly can be moved. No further missing Metamic rack inserts are considered as part of the accident conditions. Please describe what controls will be in place at HNP to ensure that no more than one rack insert will be removed from the storage racks in a given SFP, at any time, or discuss the possible configurations that may occur with two or more rack inserts removed from the storage racks in a specific SFP and how this is accounted for.

**HNP Response to RAI #3b:**

Administrative controls shall be in place, implemented by site fuel handling procedures, which shall require no more than one Metamic rack insert to be removed at a time. This requirement shall ensure a maximum of one missing insert to be the normal configuration in the BWR SFP racks with Metamic rack inserts. Thus, any number of missing inserts greater than one shall be considered an accident condition, and has been evaluated as such in the analysis, as discussed in section 4.2.5.8 of Attachment 5. Due to the unique nature of the rack insert handling tool and its interface with the bridge crane, fuel assemblies cannot be moved while rack inserts are being moved, and vice versa.

**RAI #3 (continued)**

**c)** One of the most important parameters affecting the k-effective of the SFP is the reactivity of the fuel assemblies stored therein. The TSs for most BWR licensees are consistent with the standard TSs for BWRs, which includes a control on fuel assembly reactivity, typically via a k-infinity limit or an enrichment limit. Since the fuel being qualified for storage in this LAR is BWR fuel, the criticality controls should be consistent with widely accepted practice for BWR SFPs. The proposed TS language for HNP indirectly controls fuel assembly reactivity by restricting fuel storage to a number of fuel designs known to be less reactive than the design basis assembly used in the criticality evaluation. Please discuss why this indirect control on fuel assembly reactivity can reasonably be expected to meet the same purpose as the more direct language captured in the standard TSs.

**HNP Response to RAI #3c:**

The standard TS language mentioned, i.e. k-infinity limit or enrichment limit, is practical for SFPs where BWR fuel is transferred to and from the SFP actively, such as at an operating BWR facility. The population of BWR fuel in the Harris SFP is old and static, having been previously

shipped to the SFP from another BWR facility. The BWR fuel which is stored in the SFP is not moved within the SFP for typical facility reactor operations. Therefore, the location of each fuel bundle design in the SFP is well known and unnecessary to change for typical reactor operations. The placement of indirect controls on fuel bundles in Pool A and B cements the current state of the bundle population in Pool A and B and prevents the unlikely transfer of an unpermitted design into Pool A and B. Since the purpose of TS requirements is to prevent the placement of an unqualified fuel bundle into the SFP, these indirect controls meet the same purpose as more direct language. However, the TS fuel design limit may also be considered an enrichment limit, though unstated, since each fuel design does have a unique maximum enrichment.

Furthermore, please note that these indirect controls are quite conservative. The indirect controls are based on the analysis for fresh BWR fuel. Even should the most reactive BWR fuel design found in the Harris SFP, the GE13, be fully loaded into a Pool A or B BWR rack with Metamic inserts, the reactivity would still be below 1.0 with no credit for soluble boron (even when considering the maximum GE13 uniform fresh fuel enrichment in every fuel pin, with no Gd). Note that all BWR fuel in the SFP has some burnup and therefore the analysis shows that even under the worst possible condition, a rack fully loaded with fresh GE13 fuel, there remains a significant inherent conservatism. The indirect controls are considered for the reasons outlined above, i.e. the BWR fuel population is old and static. Considering the most reactive design that is actually present in Pools A and B, i.e. the GE7 design, rather than the GE13, also allows for the inclusion of additional significant safety margins in the analysis.

**RAI #3 (continued)**

Additionally, the staff has identified some instances where it is not clear if the reactivity impact due to specific conditions was adequately addressed in the criticality analysis. The potential reactivity impacts may be positive, so the staff needs additional information to verify the regulatory limit will not be challenged by these potential impacts.

**d)** The accident scenario identified in the licensing report as being the limiting accident scenario involves a fresh pressurized-water reactor (PWR) fuel assembly mislocated in a way that it is face adjacent to two PWR racks, one BWR rack, and diagonally adjacent to a third PWR rack (i.e., Figure 4.2.6 of the Attachment 5 licensing report). In this scenario, all PWR fuel except for the mislocated fuel assembly are modeled as burned fuel, consistent with the licensed storage configuration that allows unrestricted storage provided that minimum limits on burnup are met. The licensing report also describes a second licensed storage configuration for the PWR racks that consists of a 2-of-4 checkerboard of fresh fuel with empty storage cells. Please discuss whether loading of multiple face adjacent fresh PWR fuel assemblies (including the mislocated fuel assembly) would be possible, and if so, whether this would result in a higher local reactivity than having all PWR storage cells loaded with spent fuel.

**HNP Response to RAI #3d:**

The analysis does contain the evaluation of the case where the fresh fuel in the storage rack (in a checkerboard configuration) is face adjacent to the mislocated fresh bundle. These cases are described in Table 4.A.9 of the Attachment 5 licensing report. For the cases in Table 4.A.9 that consider the checkerboard of fresh and empty locations, the arrangement necessarily continues

across the rack to rack gaps. Therefore, the worst case configuration is where one fresh fuel assembly in the rack is face adjacent to the mislocated bundle. A comparison of the spent fuel cases and the fresh fuel cases shows that the spent fuel cases are more reactive.

**RAI #3 (continued)**

**e)** The Attachment 5 licensing report explains, in Section 4.2.3.7, that the spent PWR fuel was evaluated at a burnup that leads to an infinite array of PWR storage racks, with the PWR fuel loaded in all cells, yielding the same reactivity as an infinite array of the BWR racks with Metamic rack inserts, fully loaded with the design basis BWR fuel. The intent of doing so was to avoid a calculation in which the calculated k-effective is dominated by the higher reactivity PWR fuel rather than providing any meaningful information about the interface between the PWR and BWR storage racks. The NRC staff understands the intent, but this approach of reducing the reactivity of the PWR fuel relative to the maximum licensed reactivity also has the effect of reducing a potential neutron source adjacent to the BWR fuel. Therefore, the NRC staff requests the following clarifications:

1. Please describe how much the reactivity of the PWR fuel used in the interface evaluations was reduced relative to the PWR fuel from the design basis criticality calculations for the PWR storage racks, or provide information on the reactivity impact due to the presence of higher reactivity design basis PWR fuel models as a boundary condition to the BWR racks.
2. Please clarify if the same reduced reactivity spent PWR fuel models were used in the evaluations for the accident conditions. If so, please describe the potential impact on the reactivity calculated for the limiting mislocated fuel assembly scenario due to the use of reduced reactivity spent PWR fuel models.

**HNP Response to RAI #3e:**

1) The reactivity effect of the change in burnup and an evaluation of the reactivity impact of the PWR racks is provided in this response. As has been previously discussed, the PWR rack has been evaluated under a separate application. However, the results of that evaluation provide the loading curve which yield a burnup of about 42,380 MWD/MTU for 5.0 wt% PWR fuel. The PWR fuel considered in the application considers a burnup of about 46,000 MWD/MTU. The reactivity difference between the two cases in an infinite array of PWR fuel is about 0.0102 delta-k. This difference is of little relevance to the determination of the impact of the interface on the analysis of the BWR racks with Metamic inserts because the reactivity of the racks is dominated by the fuel in the center of the racks; this is especially shown by analysis for the BWR racks with Metamic inserts by the evaluation of alternative missing insert locations (see LAR Attachment 5 Table 4.A.4). Finally, fission distribution plots may provide some additional information to show these points. For this purpose, two figures are provided. Please note that these figures are based on normalized results and therefore the absolute values should not be compared. Rather, of interest is the relative values within each plot. In Figure 1 below, the fission distribution is shown for the SFP analysis case used in the interface evaluation. The BWR racks clearly are more reactive in the SFP geometry while also showing that the reactivity is well dominated in the center of the rack. In Figure 2 below, the PWR spent fuel burnup is changed to match that of the PWR burnup limit (increases PWR spent fuel reactivity by about 1% delta-k). It can be clearly seen that the reactivity of the PWR racks now dominates the SFP, as expected.

Furthermore, it can be seen that the maximum reactivity in the BWR racks is still dominated in the center of the BWR rack.

Figure 1
Radial Fission Distribution for PWR Spent Fuel (~46 GWD/MTU, reference case)

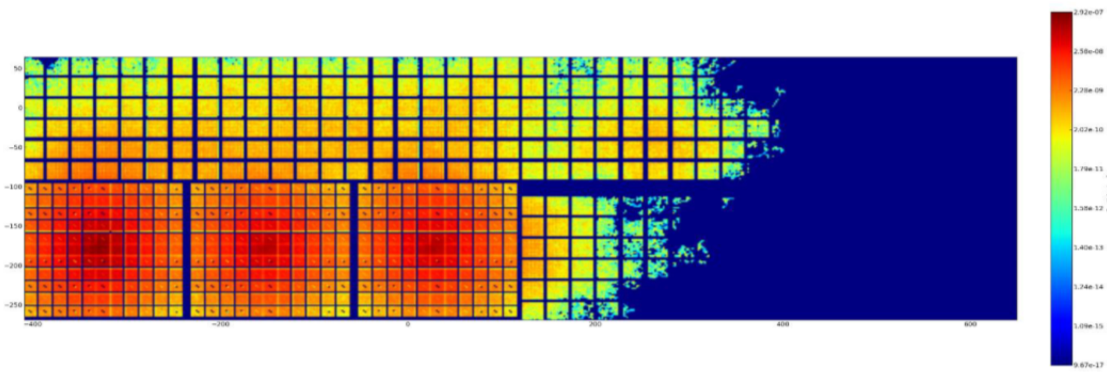
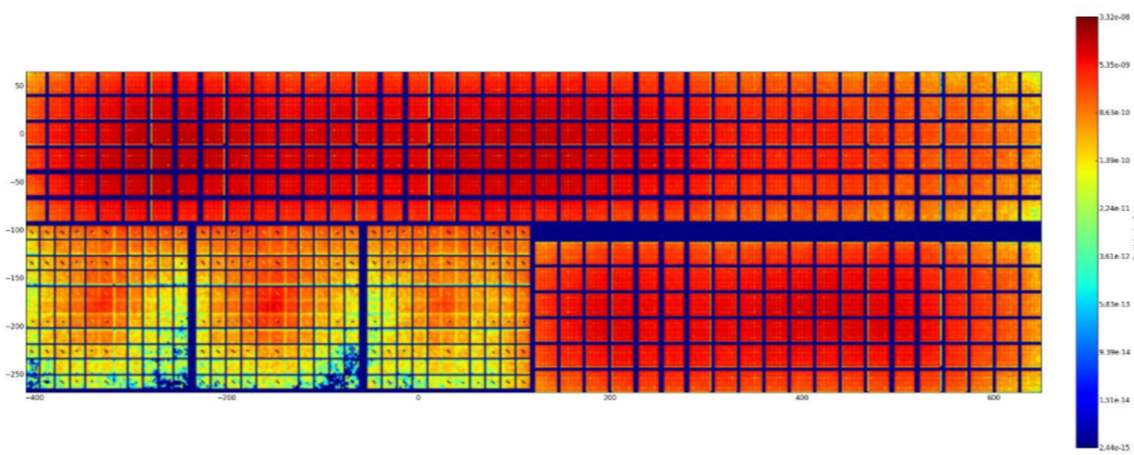


Figure 2
Radial Fission Distribution for PWR Spent Fuel (~42 GWD/MTU, at PWR loading curve)



2) The same PWR isotopic compositions were used for all spent fuel calculations. A higher reactivity in the PWR racks due to a slightly lower burnup is expected to increase the reactivity of the limiting mislocated accident scenario. However, please note the following:

- It is expected that the maximum reactivity of the mislocated bundle accident is in the vicinity of the mislocated bundle, either in the BWR rack or the PWR rack (if near the mislocated bundle; note that there are two sets of mislocated accident cases, one

case for the location in the center between two PWR racks and adjacent to one BWR rack and one case adjacent only to the BWR rack).

- A comparison between the two mislocated bundle cases shows that the case with the PWR racks adjacent to the mislocated bundle are more reactive than just the BWR rack case. Therefore, lowering the burnup of the PWR spent fuel would be expected to increase the reactivity of this case, but not the other because of the large distance between the mislocated bundle and the PWR racks.

- The mislocated case with the PWR racks included is overly conservative because the gaps cannot physically fit a PWR bundle in that location. The PWR bundle is used however in order to bound a dropped BWR assembly; additionally it provides an overall bounding approach to the analysis.

- Furthermore, the centrally mislocated case does not consider the administratively controlled Metamic insert orientation, i.e. there is no Metamic panel between the mislocated bundle and the BWR fuel in the model but one is required to be present. Therefore, the reactivity effect of the BWR fuel on that accident scenario is exaggerated.

- The inclusion of Administrative Requirement 3 shows that removing the BWR fuel from the corner location reduces the reactivity of the accident by about 0.0314 delta-k. This is about 3 times the effect determined for the reactivity difference between the burnup used in the evaluations and the burnup limit. In that configuration, with a BWR bundle in the corner location, the reactivity for the non-Administrative Requirement 3 cases with 1000 ppm soluble boron is 0.9266, about 0.0386 delta-k higher than the limiting result presented in LAR Attachment 5 Table 4.7.1 for the Administrative 3 Requirement results. Thus, for a calculated reactivity effect that is reasonable expected to be significantly greater than a small decrease in burnup for the PWR fuel, the limit of 0.95 could be shown to be met using the large amount of analysis margin shown in Table 4.7.1.

- This approach is overly conservative since not only is it physically impossible to fit the larger PWR bundle in that location in the SFP, but also the reactivity effect from a dropped spent BWR fuel bundle is expected to be significantly less than a fresh PWR fuel bundle; thus, if a less conservative approach was to be considered the other mislocated case outside the BWR rack only would be the bounding case since it also bounds the dropped spent BWR bundle scenario (in the center location). Therefore, increasing the reactivity of the PWR spent fuel for these cases would not have any material impact on the BWR racks.

- The analysis approach was intended to be as conservative as possible and it is not desirable to make it less conservative. Even with the overly conservative approach, substantial margin exists between the final result and the regulatory limit to account for the increase in reactivity from lowering the burnup of the PWR spent fuel.

- Finally, the analysis only credits 1000 ppm of soluble boron for these cases. The TS limit is 2000 ppm. Table 4.7.1 shows that, even with the overly conservative approach taken, there remains 0.0315 delta-k in margin to 0.95 with only 1000 ppm

of soluble boron. That margin alone is more than sufficient to offset the increase in reactivity expected from changing the burnup of the spent fuel. However, it may not be necessary to do so considering all the additional conservatisms considered above.

**RAI #3 (continued)**

**f)** The design basis criticality evaluation documented in the Attachment 5 licensing report includes the assumption of a single missing Metamic rack insert, located in the interior of the design basis BWR storage rack. A missing rack insert could happen in any location, and the licensing report does not appear to address the reactivity impact of configurations in which the missing rack insert occurs in a peripheral location near the interface with the PWR racks, or in a location near the limiting mislocated fuel accident scenario. Please discuss the criticality impact due to the missing rack insert for locations at the periphery of the BWR rack, particularly when the configuration being analyzed does not utilize a repeating infinite array. Please further justify that the previously analyzed case of a single missing Metamic rack bounds the additional scenarios discussed in this question or provide results for the limiting case.

**HNP Response to RAI #3f:**

Locations other than the center of the BWR rack have been evaluated for a missing Metamic rack insert, as shown in section 4.2.3.3 of Attachment 5. From these cases, the limiting location for a missing insert was determined to be at the center of the rack.

As discussed in the response to RAI 3 sub-item b, fuel handling procedures shall require movement of only one rack insert at a time, and due to mechanical interfaces of the handling tools and bridge crane, fuel assemblies cannot be moved while rack inserts are being moved (and vice versa); therefore, a missing rack insert at the corner of the BWR rack concurrent with a mislocated fuel assembly is not credible, for instance. Additionally, due to existing administrative restrictions in the proposed technical specifications, no fuel assembly will reside in the corner nearest the limiting fuel assembly mislocation accident; therefore, a missing insert in this location would be negligible to criticality margin due to the large water gap created by the empty cell.

**RAI #3 (continued)**

**g)** The Attachment 5 licensing report includes an analysis of a postulated scenario where a seismic event occurs that results in a reduction in the spacing between SFP fuel storage racks. The results show that a reduction in SFP rack spacing can lead to a significant increase in reactivity. Please clarify what magnitude of seismic activity (e.g., relative to operating basis and safe shutdown earthquakes) would be necessary to result in spacing reductions such as that analyzed in the licensing report and further identify whether existing analyses allocate sufficient margin to accommodate such spacing reductions. If sufficient margin is not allocated, then please describe what controls are in place at HNP to ensure that smaller rack spacings resulting from a postulated seismic event do not become part of the normal condition (e.g., verification of adequate spacing between racks in the HNP SFP).

**HNP Response to RAI #3g:**

Section 4.2.5.6 of Attachment 5 discusses that the evaluation of rack movement due to seismic event considers a situation in which the racks are closer than physically possible ("All gaps are reduced so that the racks are closer than possible due to the baseplate extensions."). As such, the limiting case is presented, with results provided in LAR Attachment 5 Table 4.A.9, regardless of the specific seismic event. As shown in Table 4.A.9, there is sufficient reactivity margin for this accident scenario with partial credit for soluble boron as described in the report.

Site procedures ensure that, following a seismic event (if operating basis earthquake condition is exceeded), the SFP rack gaps are examined, and if the gaps are <75% of their originally installed values, which is still a greater gap than that evaluated in Attachment 5 of this LAR, the racks are repositioned, or an analysis is made to evaluate the new condition. Such an evaluation would include any potential impact to the nuclear criticality safety against the licensing basis.

**MCCB RAI #1**

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.68, "Criticality accident requirements," provides the regulatory requirements for maintaining sub-criticality in the spent fuel pool (SFP). Specifically, 10 CFR 50.68(b)(4) states, in part, that the k-effective ($k_{eff}$) in the SFP:

> …must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 confidence level, if flooded with unborated water.

The HNP Technical Specification (TS) 5.6.1.3, "BWR [Boiling-Water Reactor] Storage Racks in Pools 'A' and 'B'," ensures that the sub-criticality requirements of 10 CFR 50.68(b)(4) are met. The calculated $k_{eff}$ found in the Holtec International Report No. HI-2177590, "Licensing Report for Use of DREAM Neutron Absorber Inserts in the Spent Fuel Pools 'A' and 'B' at Shearon Harris NPP," Revision 1 (Nonproprietary), is used to demonstrate compliance with the TS requirement for $k_{eff}$. The $k_{eff}$ found in the Holtec Licensing Report is, in part, calculated using a value for the Boron-10 areal density (B-10 AD), as well as the thickness and width of the Metamic inserts, provided in the Holtec Licensing Report. In order to verify the assumed values for the B-10 AD and the condition of the material, the licensee has proposed to institute a Metamic Surveillance Program.

During the LAR pre-submittal meeting for the "BWR Storage Rack Inserts, Updated NCS [Nuclear Criticality Safety] Analysis at Harris Nuclear Plant," held September 29, 2016 (ADAMS Accession No. ML16267A029, meeting summary ML16286A015), the licensee provided a list of affected TSs. One of the bullets described a change to TS 6.8, "Procedures and Programs," to add "BWR Boraflex Storage Racks – Metamic Rack Insert Monitoring Program." Controlling the Metamic Rack Insert Monitoring Program in the TSs would appear to provide an approach to demonstrate reasonable assurance that the requirements of 10 CFR 50.68(b)(4) will be met. This is because if certain elements of the monitoring program, such as neutron attenuation testing, frequency of testing, or the acceptance criteria, are altered, it may cause the program to become ineffective, which would then impact the assumptions used to calculate $k_{eff}$, TS 5.6.1.3,

and ultimately compliance with 10 CFR 50.68(b)(4). As noted in the Holtec Licensing Report included with the LAR, the Holtec Metamic inserts are relied upon for criticality control in the SFP storage racks.

As discussed in the pre-submittal meeting, the proposed change to TS 6.8 would appear to provide an approach that demonstrates reasonable assurance of compliance with 10 CFR 50.68(b)(4), with respect to monitoring the condition of the Metamic inserts. Given that the LAR did not include the change to TS 6.8 as noted in the pre-submittal meeting, explain how Duke Energy intends to demonstrate compliance with 10 CFR 50.68(b)(4), as it relates to controlling the proposed Monitoring Program that will monitor the condition of the Metamic inserts.

**HNP Response to MCCB RAI #1:**

As discussed in Section 4.2 of the LAR, "Precedent," the NRC previously approved the use of Metamic in SFPs C and D at HNP as a neutron absorber in the form of fuel storage racks via letter dated January 29, 2009 (ADAMS Accession No. ML090270022). Per Section 3.8 of the aforementioned letter, "Conclusions on the Metamic Coupon Sampling Program," the staff found that the proposed surveillance program HNP committed to implementing, which includes visual, physical and confirmatory tests, was capable of detecting potential degradation of the Metamic material that could impair its neutron absorption capability. The staff concluded that the Metamic Coupon Sampling Program was an acceptable surveillance method to monitor possible degradation of the Metamic material in an adequate timeframe to allow for compensatory measures to be taken.

This program, implemented via Plant Operating Manual EPT-863, "Metamic Integrity Test and Metamic Coupon Tree Movement," was found to adequately monitor the condition of the Metamic material as a means to verify the continued presence of a sufficient amount of neutron absorber in the spent fuel racks and maintain the neutron multiplication factor, $k_{eff}$, within the regulatory limits of 10 CFR 50.68(b)(4), in alignment with HNP TS 5.6.1.4.a. The proposed surveillance program for the Metamic rack inserts, as outlined in Section 3.6 of the LAR, is equivalently structured for the Metamic rack inserts and will continue to adequately monitor the condition of the Metamic material in the HNP spent fuel pools, specifically for that of the Metamic rack inserts, maintaining compliance with 10 CFR 50.68(b)(4) for the BWR racks with inserts in pools 'A' and 'B' in accordance with the proposed TS 5.6.1.3.a.1. Upon approval of the proposed amendment, HNP would be committed to implementing the Metamic Rack Insert Monitoring Program, as proposed in the LAR, at the time of amendment implementation.

As a commitment, any changes to the program would be evaluated in accordance with Duke Energy procedure AD-LS-ALL-0010, "Commitment Management," and reported to the NRC via the Commitment Change Summary Report, which is submitted annually or along with the Updated Final Safety Analysis Report update as required by 10 CFR50.71(e).

**<u>MCCB RAI #2</u>**

In order to determine if there is any degradation of the Metamic, acceptance criteria are to be established in a surveillance program. Appropriate acceptance criteria provide reasonable assurance that the assumptions made regarding the neutron absorbing material in the fuel storage criticality analysis are maintained.

Section 3.6 of the LAR, “Metamic Surveillance Program,” does not list the acceptance criteria associated with the surveillance program. However, the LAR does provide certain test parameters that will be included in the surveillance program (i.e., visual observation and photography, neutron attenuation testing, dimensional measurements, and weight and specific gravity measurements). Provide the acceptance criteria that will be used in the surveillance program including criteria for the parameters measured as part of the surveillance program. In addition, describe how measurement uncertainty of the coupons is incorporated into the acceptance criteria.

**HNP Response to MCCB RAI #2:**

The Metamic rack insert coupon surveillance program will be established consistent with guidance detailed in NEI 16-03, “Guidance for Monitoring of Fixed Neutron Absorbers in Spent Fuel Pools.” Test parameters for the Metamic rack insert coupons fall into two (2) categories:

1. Physical condition, and
2. $B^{10}$ areal density measurements.

Physical condition parameters to be included in the coupon surveillance program consist of:

1. Coupon length, width, and thickness at multiple locations on the coupon,
2. Coupon weight,
3. Coupon specific gravity, and
4. Visual observation of coupon for cracking, corrosion, pitting, swelling and discoloration.

The post-irradiation measured physical condition parameters will be compared to the pre-irradiation values to verify expected performance of the neutron absorber material and to identify any unexpected changes which would require additional evaluation. No specific acceptance criteria are established for the physical condition parameters. Unexpected changes in these parameters identified during coupon testing will require, per procedure, entry into the corrective action program for evaluation. This evaluation will include, at a minimum, any potential impacts to the $B^{10}$ areal density and potential impacts on the criticality analysis due to dimensional changes of the neutron absorber material.

An acceptance criterion will be established for the $B^{10}$ areal density measurement parameter. Consistent with NEI 16-03 guidance, the coupon $B^{10}$ areal density will be measured at multiple locations on the coupon by neutron attenuation measurement. Measurement uncertainty will be quantified and included with the measured areal density values, and the measured $B^{10}$ areal density will be compared to the coupon's initial pre-irradiated $B^{10}$ areal density value. The acceptance criterion will be that this measured value will be greater than or equal to the pre-irradiation value (within the provided measurement uncertainty). Failure to meet the acceptance criterion will require, per procedure, entry into the corrective action program for documentation and evaluation. This evaluation will include, at a minimum, a comparison of the measured value to the minimum $B^{10}$ areal density value used in the criticality analysis.

**SERIAL HNP-18-003**

**ENCLOSURE**

**ATTACHMENT 1**

**AFFIDAVIT FOR WITHHOLDING OF PROPRIETARY INFORMATION**

**SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1**

**DOCKET NO. 50-400**

**RENEWED LICENSE NUMBER NPF-063**

**5 PAGES PLUS COVER**

HOLTEC INTERNATIONAL

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Holtec International Document ID 2635002--AFFIDAVIT-02

**AFFIDAVIT PURSUANT TO 10 CFR 2.390**

I, Debabrata (Debu) Mitra Majumdar, being duly sworn, depose and state as follows:

(1) I have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is information in the following report.

a. HI-2167295, "Structural Evaluation of Harris DREAM Insert", Revision 3"

This report contains Holtec Proprietary Information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

**AFFIDAVIT PURSUANT TO 10 CFR 2.390**

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraph 4.b, above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have

been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

**AFFIDAVIT PURSUANT TO 10 CFR 2.390**

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

**AFFIDAVIT PURSUANT TO 10 CFR 2.390**

STATE OF NEW JERSEY )
) ss:
COUNTY OF CAMDEN)

Mr. Debabrata (Debu) Mitra Majumdar, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at Camden, New Jersey, this 11th day of January, 2018

Debabrata (Debu) Mitra Majumdar, Ph.D.
Corporate Director – Engineering Analysis
Holtec International

Subscribed and sworn before me this 11 day of January, 2018.

MARIA C. MASSI
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires April 25, 2020