From: Guzman, Richard
To: "Mirzai, Mahvash"
Cc: "spyle@entergy.com"; "mhalter@entergy.com"; Walpole, Robert; Danna, James
Bcc: Guzman, Richard
Subject: Indian Point Unit 2 - REQUEST FOR ADDITIONAL INFORMATION - Proposed License Amendment Request Regarding Storage of Fresh and Spent Nuclear Fuel in the Spent Fuel Pool (EPID: L-2017-LLA-0408)
Date: Thursday, February 14, 2019 4:07:25 PM

Mahvash,

On December 19, 2018, the U.S. Nuclear Regulatory Commission (NRC) staff sent Entergy Nuclear Operations, Inc. (Entergy or the licensee) the subject Request for Additional Information (RAI) as a draft (via e-mail shown below). This RAI relates to a license amendment request submitted by Entergy dated December 11, 2017, proposing revisions to the Technical Specifications for Indian Point Unit 2 spent fuel storage. The RAIs were discussed with your staff on January 28 and January 31, 2019, to clarify the request. As agreed following the call, please provide your formal response to the RAIs by May 10, 2019 (i.e., approximately 90 days of the RAI issuance date).

Updated below is the official (final) RAI. A publicly available version of this e-mail and RAI will be placed in the NRC's ADAMS system. Please contact me should you have any questions in regard to this request.

Thanks,

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Rich Guzman
Sr. PM, Division Operator Reactor Licensing
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Office: O-9C7 | Phone: (301) 415-1030
Richard.Guzman@nrc.gov

From: Guzman, Richard [mailto:Richard.Guzman@nrc.gov]
Sent: Wednesday, December 19, 2018 2:32 PM
To: Mirzai, Mahvash
Subject: Indian Point Unit 2 - Proposed License Amendment Request Regarding Storage of Fresh and Spent Nuclear Fuel in the Spent Fuel Pool - DRAFT Request for Additional Information (EPID: L-2017-LLA-0408)

Mahvash,

Below are the draft RAIs supporting the staff's review of the subject LAR. As we discussed, please have your team review the questions and let me know when you could support a clarification call.

Thanks,
Rich

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Rich Guzman

Sr. PM, Division Operator Reactor Licensing
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U.S. Nuclear Regulatory Commission
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Richard.Guzman@nrc.gov

--FINAL---

REQUEST FOR ADDITIONAL INFORMATION
PROPOSED LICENSE AMENDMENT REQUEST REGARDING
STORAGE OF FRESH AND SPENT NUCLEAR FUEL IN THE
SPENT FUEL POOL

Entergy Nuclear Operations, Inc.

Indian Point nuclear power plant, Unit 2

DOCKET NUMBER 50-247

EPID: L-2017-LLA-0408

1.0 INTRODUCTION

By letter dated December 11, 2017, Entergy Nuclear Operations, Inc. (Entergy, the licensee) for Indian Point Unit 2 (IP2), submitted a license amendment request (LAR) proposing to revise the Technical Specification for IP2 spent fuel storage. On the basis of the provided information, the NRC staff has determined that additional information is needed for the staff to assess whether the licensee has acceptably demonstrated that the spent fuel pool will remain subcritical under all conditions and to complete its review. In order to verify compliance with 10 CFR 50.68 subcriticality requirements, the following RAIs are provided concerning the proposed technical specification changes described in Attachments 2 and 3 to the licensee's LAR.

RAI 1

The licensee's analysis cites J. C. Wagner, "Impact of Soluble Boron Modeling for PWR Burnup Credit Criticality Safety Analyses," *Trans. Am. Nucl. Soc.*, **89**, pp. 120 (2003) for its use of a constant soluble boron concentration rather than time-dependent soluble boron letdown curve for its depletion calculations. However, the licensee is not using the constant soluble boron concentration in a manner consistent with the reference. The reference is based on the fuel completing three full cycles of burnup and not an individual fuel assembly's lifetime burnup averaged soluble boron. An individual fuel assembly under the licensee's control may not actually complete three full cycles of burnup, which could lead to a non-conservatism. With respect to using the individual fuel assembly's lifetime burnup averaged soluble boron provide the following information to address the potential non-conservatism:

a. Describe how the "…multi-cycle burnup averaged soluble boron concentration …" is calculated.

b. Were any of the IP2 or IP3 cycles stopped appreciably short of reaching 0 ppm of soluble boron in the reactor?

c. Where were the cycle average soluble boron concentrations for the cycles listed in NET-28091-0003-01 Table 5.9?

d. How is the EOC burnup for each assembly determined? What does it represent? How does the EOC burnup compare to the cycle burnup.

e. How is the EOC burnup used to weight the cycle average PPM?

f. How is that used to determine whether or not a fuel assembly exceeds the soluble boron concentration used in the depletion analysis?

g. NET-28091-0003-01 Section 8.15, Burnup Penalty for High Soluble Boron Conditions, attempts to address the potential for an early cycle shutdown. However it is not clear what was modeled in the analysis. Provide the description of what was modeled.

RAI 2

In Attachment 1, "Analysis of Proposed Technical Specification Changes, Section 4.6 Configuration Modeling" sub-section "Normal Conditions, Item B Movement of Fuel" states: "Section 9.1 of the CSA addresses movement of fuel assemblies in and around the pool, fuel inspection, and fuel reconstitution. An assembly is isolated if there is 20 cm of water between assemblies. There are two locations where it would be possible to place two assemblies within 20 cm of each other outside of the rack: when a fuel assembly is in the fuel elevator and another fuel assembly is vertical in the upender. However, procedures will not permit moving an assembly within 25 cm of either of those locations when another assembly is in either the fuel elevator or upender." With respect to these restrictions provide the following information:

a. How procedures will prevent operators from moving an assembly within 25 cm of the fuel elevator or upender or within 20 cm of the storage racks.

b. Describe whether there are physical barriers that prevent moving an assembly within 25 cm of the fuel elevator or upender or within 20 cm of the storage racks.

c. How fuel handling operators will know the distance between a fuel assembly being moved and the fuel elevator, upender, or the storage racks.

RAI 3

The proposed new technical specifications are listed in Attachment 2. With respect to this proposed TS provide the following information:

a. Note 14 of Insert 3 states, "The edge of the spent fuel rack can be considered as a row of Water Holes." The analysis in NET-28091-0003-01 models the "edge" is of the spent fuel pool. Clarify whether the "edge" as used in the proposed TS could include the "edge" of the various racks within the spent fuel pool.

b. Proposed TS 4.3.1.1 is not consistent with the standard technical specifications. Provide the justification for deviating from the standard technical specifications.

RAI 4

NET-28091-0003-01, Revision 0, Section 3.4, "Plant Operation Data," defines a new term "T_{ave}." For the purposes of the analysis in NET-28091-0003-01 "T_{ave}" is defined as "…the average moderator temperature in the active fuel (not the vessel average temperature)." "T_{ave}" is used to determine the moderator and fuel temperature profiles used in the depletion portion of the analysis. The moderator and fuel temperature the fuel experiences during depletion can have a significant impact on the post irradiation reactivity of the fuel. Therefore the moderator and fuel temperature must be modeled appropriately. With respect to the determination and use of "T_{ave}" provide the following information:

a. Describe how "T_{ave}" is calculated and/or measured.

b. Describe any biases or uncertainties in "T_{ave}" and how they are included in the analysis.

RAI 5

The licensee's analysis and TS use the term 'averaged assembly peaking factor' when determining depletion parameters and the minimum assembly average burnup required for several storage categories. "The averaged assembly peaking factor is the assembly burnup divided by the sum of the cycle burnups for the cycles the assembly was in the core." The licensee's use of the 'averaged assembly peaking factor' is an attempt to take credit for a fuel assembly that isn't at its maximum fuel and moderator temperature for its entire life. However, the licensee has not shown that using the 'averaged assembly peaking factor' is an appropriate or conservative means of capturing the post irradiated reactivity of a given fuel assembly or set of assemblies, especially if the more limiting conditions occur closer to the time when the fuel assembly is stored in the SFP. As the 'averaged assembly peaking factor' hasn't previously been shown to be an acceptable means of determining depletion parameters and the minimum assembly average burnup required for several storage categories provide the following information:

a. Evidence that using the 'averaged assembly peaking factor' is an appropriate or conservative means of capturing the post irradiated reactivity of a given fuel assembly or set of assemblies, especially if the more limiting conditions occur immediately before storage in the SFP.

b. Describe any biases and uncertainties associated with using 'averaged assembly peaking factor' and how they are included in the analysis.

c. Describe and justify the data fitting method used to derive the equations in the proposed Technical Specifications for Reactivity Category 4.

<u>RAI 6</u>

NET-28091-0003-01, Revision 0, Section 5.5, "Limiting Depletion Parameters – Control Rod Operation," describes the licensee's analysis to address the effect of reactor operation with controls inserted on the post-irradiation reactivity of fuel assemblies. With respect to the operation and modeling of control rod insertion provide the following information:

a. There is an apparent disconnect in the analysis. The analysis for IP2 states that "…assemblies depleted with 20 rodlet Pyrex burnable absorbers conservatively bounds assemblies that were operated with Control Bank D at the bite position." IP2 fuel assemblies that were under control rod bank D with the control rods inserted to the "bite" position but were modeled as having a 20 rodlet Pyrex burnable absorber were not assigned a burnup penalty as expected. For IP3 the analysis states that IP3 always operated at the all rods out condition with no controls inserted to the "bite" positon. The analysis also states that all "…IP3 (A-U) batch grouping is depleted with a 20 rodlet Pyrex burnable absorber which is removed at 20 GWd/T." Based on the licensee's stated intention and the IP2 analysis, the NRC staff did not expect the IP3 (A-U) batch grouping to have a burnup penalty assigned. Yet in Table 5.14 some of those fuel assemblies do have a burnup penalty. Explain why the IP3 fuel assemblies require a burnup penalty but the IP2 fuel assemblies do not.

b. There is no information provided on the analysis performed to cover Batch Grouping IP3 (V-X). Provide a description of the analysis which was performed to cover Batch Grouping IP3 (V-X).

RAI 7

NET-28091-0003-01, Revision 0, Section 5.6, "Depletion Analysis Model," describes the licensee's analysis to justify the use of the TRITON depletion sequence in SCALE 6.1.2 as the depletion code of record for this analysis by comparing three sets of TRITON delta k-effective to three sets of CASMO-5 delta k-effective by listing the difference between them. Using the comparison of the delta between two state points from one computer code to the delta between two state points from another computer code is inadequate to determine that one code is acceptable for use based on similarity to the other code as this method of comparison says nothing about how the codes compare at the actual state points. With respect to the use of the TRITON depletion sequence in SCALE 6.1.2 as the depletion code of record for this analysis provide the following information:

a. A comparison of the TRITON depletion sequence in SCALE 6.1.2 to an NRC approved depletion code.

b. Identify whether or not any additional biases and uncertainties are necessary.

RAI 8

Using the licensee's 'batch grouping' method sets reasonably bounding depletion parameters for each 'batch group.' The licensee's analysis identified fuel assemblies that did not meet its desired SFP storage category for those fuel assemblies. NET-28091-0003-01, Revision 0, Section 5.7, 'Special Case Depletions,' describes the licensee's analysis to use fuel assembly specific depletion parameters to qualify those fuel assemblies for its desired category. With respect to the ‘Special Case Depletions’ analysis provide the following information:

a. NET-28091-0003-01, Revision 0, Table 5.9 indicates the depletion soluble boron for IP2 Batch F and IP3 Batch V is 580 PPM and 950 PPM, respectively. However, Table 5.21 indicates the special case depletions for IP2 F44 and its symmetric sisters and the IP3 V43/V48 sister used 540 PPM and 650 PPM, respectively. This reduction in the depletion soluble boron is not explained in the text. Provide the justification for using the lower depletion soluble boron.

b. NET-28091-0003-01, Revision 0, states, “L48 and its sisters (L37, L38, L39, L44, L51, L52, and L64) spent two cycles on the outside corner of the core.” Describe and provide the results of the radial burnup tilt of these fuel assemblies and its effect on their reactivity.

c. Two groups of fuel assemblies represented by assemblies W52 and X18 were depleted using their actual IFBA loading and burnup profiles. Describe and provide the results of the bias and uncertainty analysis associated with using the fuel assembly specific IFBA loading and burnup profiles.

d. NET-28091-0003-01, Revision 0, states, “V43 and V48 did not initially meet the Category 3 fuel requirement but with special depletions, these two assemblies qualify for Category 3.” If there were other changes from that ‘batch group’ depletion parameters than the already identified depletion soluble boron, describe and justify those changes.

<u>RAI 9</u>

Determining the axial burnup profile to be used is a key component of the nuclear criticality safety analysis. The licensee’s analysis has used a complex combination of familiar methods, but with new and unique variations to determine the burnup profiles for several different groupings of fuel assemblies. Those groupings will be addressed individually.

a. The first grouping is for fuel assemblies that do not have axial blankets. The licensee’s analysis indicates it used the burnup profiles from NUREG/CR-6801, “Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses.” NUREG/CR-6801 evaluates approximately three thousand actual burnup profiles from numerous plant design types. The profiles are divided into twelve groups based on burnup, with the lowest numbered group having the highest burnup. The overall group profile is considered bounding for that group because they are at least three standard deviations from the average for the group. The use of NUREG/CR-6801 profiles is inconsistent with NRC interim staff guidance in DSS-ISG-2010-01, "Final Division of Safety Systems Interim Staff Guidance, DSS-ISG-2010-01, Revision 0, Staff Guidance Regarding the Nuclear Criticality Safety Analysis For Spent Fuel Pools," (Agencywide Document and Management System (ADAMS) Accession Number ML110620086) because the licensee's analysis modified those profiles in new and unique ways. With respect to the axial burnup profiles used for non-blanketed fuel provide the following information:

1. The NET-28091-0003-01, Revision 0, Section 6.2.1, "Axial Burnup Distribution," speculates that there was some aspect of the group profiles for Groups 2 and 4 that make the profiles for Groups 3 and 5 inappropriate for use. The analysis then eliminated the profiles for Groups 3 and 5 and instead uses the profile from Group 2 to cover the burnup ranges of Group 2 and Group 3 and the profile from Group 4 to cover the burnup ranges of Group 4 and Group 5. This is inconsistent with NUREG/CR-6801 as the statistical analysis of the groups included in NUREG/CR-6801 indicates profiles for Groups 3 and 5 are more representative of their respective groups, less of statistical outliers, than the profiles for Groups 2 and 4 are of their respective groups. Additionally, NUREG/CR-6801 indicates it is generally acceptable to use the burnup profiles from a lower burnup group for higher burnups, yet the licensee's analysis has gone in the opposite direction. Provide the justification for eliminating the profiles for Groups 3 and 5 and using the profiles from Groups 2 and 4 instead.

2. The second modification to the NUREG/CR-6801 profiles was the licensee's averaging the profiles from one group with the next. The licensee indicated it started by assuming the group profile was only appropriate at the maximum burnup in the group. The licensee then performed a linear interpolation for each burnup profile node for a given assembly average burnup. The analysis claims this is conservative but provided no evidence to support that claim. NUREG/CR-6801 evaluated the profiles at the median burnup of the group range and determined the limiting group profile was conservative throughout that range. It is not clear how the licensee determined the burnup profiles that were used in the analysis. The example the licensee provides used the profile from Group 3, which the licensee had previously determined was inappropriate to use. No explanation was given for its use in this manner.

Additionally, Group 1 has no upper burnup bound. It is not clear whether the linear averaging preserves the total burnup of an assembly. With respect to the averaging of the burnup profiles provide description of how the averaged profile is calculated. Provide the description and results of the analysis that demonstrates the averaging of the burnup profiles is conservative.

b. The second grouping is for legacy fuel assemblies that do have axial blankets. The licensee's analysis divided these fuel assemblies into 5 batch groups. The method for determining the axial burnup profile in each group is described as taking the lowest burnup for each node of all the actual profiles in the group to amalgamate one profile for each batch group. These derived profiles are then further modified by using the top eight nodes and the "… ninth node from the top is used for the ninth and all lower nodes." The profiles derived using this method are listed in Table 6.2. The analysis states this method is conservative. However, the profiles listed in Table 6.2 have a volume averaged relative burnup greater than one. This indicates they are potentially non-conservative profiles as the modeled fuel assembly would have a higher burnup than the actual fuel assembly. With respect to the axial burnup profiles listed in Table 6.2 and used for blanketed fuel provide the following information:

1. The impact on the margin in the NET-28091-0003-01, Revision 0 analysis due to modeling the fuel assemblies with more burnup than they have.

2. Describe any biases or uncertainties associated with using these burnup profiles and how they are included in the analysis.

RAI 10

NET-28091-0003-01, Revision 0, Section 6.1, "SCALE 2x2 Radial Models," and Section 6.5, "Convergence of the 2x2 Infinite Model Calculations," discuss the 2x2 models in general terms, but no specifics are provided. Given the various possible combinations of batch groupings, burnup profiles, nodalization, and other parameters it is unclear what the licensee modeled to reach its conclusions. With respect to the 2x2 models provide the following information:

a. Describe which combinations were modeled using a 2x2 array and the results of those calculations.

RAI 11

In NET-28091-0003-01, Revision 0, Section 6.6.2, “Convergence of the Full Pool Model,” the discussion indicates the licensee performed six calculations with different starting distributions for the neutron source term. Four of those started the neutron source term near the SFP wall, leading to a significant portion of the initial source term leaking out of the SFP. Three of those started in Category 5 fuel which is intentionally required to have excess burnup to make it non-limiting, thus further reducing the portion of the initial source term than reaches the more reactive fuel. This paucity of sampling locations indicates that the models may be under sampled for such a loosely coupled system. With respect to the convergence of the full pool model provide the following information:

a. Provide at least one model with known convergence for comparison to the other cases, for both the unborated and borated cases.

<u>RAI 12</u>

NET-28091-0003-01, Revision 0, Section 7.3, “Eccentricity,” describes the analysis the licensee performed to consider the eccentric of position of fuel assemblies within a storage cell. The base k-effective calculation models all fuel assemblies in the center of their respective storage cell. However, the fuel assemblies can be anywhere within their respective storage cell. The ‘eccentricity’ portion of the analysis is intended to determine the reactivity effect of the fuel assemblies being in other than the center of their storage cell. The licensee’s analysis used an 8x8 storage cell array to calculate the eccentricity effect. The licensee’s analysis considered sixteen fuel assemblies to be eccentrically located while maintaining the outer rows of the 8x8 array centrally located. Using periodic boundary conditions on the 8x8 array effectively models an infinite number of these 8x8 arrays. But the boundary rows serve to minimize the nuclear interaction between them, therefore the resultant k-effective is representative of a single 8x8 array. The licensee’s analysis made two implicit assumptions: (1) that there is only one eccentric configuration that yields the maximum reactivity and (2) that the fuel assembly can only be in one of four distinct locations within a storage cell. With those assumptions the licensee calculated the probability of occurrence of the worst case eccentric positioning configuration to be 2.3E-10. The inverse would be the number of possible combinations. With respect to the eccentricity effect provide the following information:

a. Given the large number of possible combinations, justify the combination used to calculate the reactivity of the eccentricity effect.

RAI 13

NET-28091-0003-01, Revision 0, Section 8.5, "Alternate Arrangements for Region 1," describes how fresh poisoned fuel can be stored in Region 1. The analysis proposes two rules: (1) Each Category 1 cell must be face adjacent with at least three water holes and (2) Each Category 2 cell may not have more than one face adjacent to a Category 1 cell. With respect to the alternate arrangements for Region 1 provide the following information:

a. The analysis states that the k-effective for checker boarding Category 1 fuel in Region 1 is 0.8548. Table 8.12, "Dependence of k_{eff} on the Region 1 Arrangement," lists the k-effective for Arrangement Number 1, Reference – No Category 1 Arrangement, as 0.9665. Table 8.12 lists the k-effective for Arrangement Number 3, No Category 2 Arrangement, as 0.9651. In both Arrangement Number 1 and 3 there are Category 3 and 5 fuel assemblies in positions consistent with the "normal" configuration. Since Category 3 and Category 5 fuel are supposedly less reactive than Category 2 and the k-effective of a checkerboard of Category 1 fuel is 0.8548, replacing all the Category 2 fuel assemblies with a checkerboard of Category 1 fuel assemblies should have resulted in a larger decrease in reactivity than is being reported. Explain the apparent discrepancy.

b. The analysis states that the k-effective for checker-boarding Category 1 fuel in Region 1 is 0.8548. Table 8.12 lists the k-effective for Arrangement Number 4, Maximum Category 1 Arrangement, as 0.9584. Arrangement Number 4 is a modified checker-board of Category 1 fuel assemblies with ten Category 3 fuel assemblies placed between Category 1 fuel in accordance with Rule 1, and one Category 5 fuel assembly that is replacing a Category 1 fuel assembly. While an increase in k-effective over a pure checker-board of Category 1 fuel assemblies due to a few the Category 3 fuel assemblies interspersed with the Category 1 fuel would be expected, the reported increase for Arrangement Number 4 seems excessive. Describe the models used in detail and explain the large increase.

c. The Category 3 fuel assemblies in the Arrangement Number 4 are either on the periphery or one row from the periphery. Proposed Rule 1 would allow an additional dozen or more Category 3 fuel assemblies to be placed in more interior locations where there would be less leakage indicating that the stated bounding scenario may not be bounding. Demonstrate that the scenario analyzed remains bounding accounting for the maximum allowed number of Category 3 fuel assemblies in the Maximum Category 1 Arrangement.

d. The proposed rules would allow a Category 1 fuel assembly to be face adjacent with another Category 1 fuel assembly on one side. Provide the results of this case to demonstrate that it is bounded by the analyzed case.

RAI 14

NET-28091-0003-01, Revision 0, Section 9.5, “Multiple Misloads,” analyzes one scenario for Region 2. That scenario assumes that all cells that are permitted to contain fuel are modeled as misloaded with once burned 5.0 weight percent fuel with a burnup of 24 gigawatt-days per metric ton of uranium except for the water hole and 50% water hole locations, which remain empty. The analysis provides an inadequate justification for this being the limiting misloading because filling in the water hole and fresh fuel are not considered. Therefore, justify the limiting misloading analyzed in Region 2 by explaining why water hole, 50% water hole, and fresh fuel assemblies were excluded from the analyzed misloading scenario.

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