10 CFR 50.90

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102-07449-MLL/TNW
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References:
1. Arizona Public Service Company (APS) letter number 102-07149, *License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated November 25, 2015, [Agencywide Documents Access and Management System (ADAMS) Accession Numbers ML15336A251 and ML15336A087]
2. APS letter number 102-07342, *Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated October 6, 2016 (ADAMS Accession Number ML16286A240)

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Units 1, 2, and 3
Docket Nos. STN 50-528, 50-529, and 50-530
Supplemental Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis

In Reference 1, Arizona Public Service Company (APS) submitted a license amendment request (LAR) to revise the PVNGS Technical Specifications (TS) for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3. The proposed amendment would modify TS requirements to incorporate the results of an updated criticality safety analysis for both new and spent fuel storage. In Reference 2, APS provided a response to an NRC staff request for additional information.

On February 9, 2017, a conference call was held with the NRC staff regarding the LAR. At the completion of the conference call it was determined that clarifying information provided during the call was beneficial to the NRC staff to support the completion of their review. Specifically, the NRC staff requested clarification regarding the storage of used fuel assemblies in the spent fuel pool that are missing fuel pins (rods) and how biases and uncertainties are addressed for such assemblies. The enclosure to this letter contains the clarifying information, within the context of the original RAI response. This response supersedes the previous response provided as RAI-1 of Reference 2. The APS responses to RAIs 2 through 12 of Reference 2 remain unchanged.

The APS responses do not affect the conclusion of the no significant hazards consideration determination [10 CFR 50.91(a)] provided in the original LAR.

This submittal does not contain new regulatory commitments as defined by NEI 99-04, *Guidelines for Managing NRC Commitment Changes*, Revision 0. The existing commitment made in Reference 2, identified in the relevant RAI response, RAI-1, is reiterated here for completeness. Specifically, the APS response to RAI-1, subpart g, states:

> APS commits to incorporate fuel reconstitution limitations described in the APS response to the NRC staff Nuclear Performance and Code Review Branch (SNPB) RAI-1, into PVNGS procedures prior to reconstituting fuel, following implementation of the criticality license amendment.

By copy of this letter, this response is being forwarded to the Arizona Radiation Regulatory Agency in accordance with 10 CFR 50.91(b)(1).

Should you have any questions concerning the content of this letter, please contact Michael D. DiLorenzo, Licensing Section Leader, at (623) 393-3495.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: March 3, 2017
(Date)

Sincerely,

Lacal, Maria L(Z06149)
Digitally signed by Lacal, Maria L(Z06149)
DN: cn=Lacal, Maria L(Z06149)
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MLL/TNW/CJS/af

Enclosure: Supplemental Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis – Nuclear Performance and Code Review Branch (SNPB)

cc:	K. M. Kennedy	NRC Region IV Regional Administrator
	S. P. Lingam	NRC NRR Project Manager for PVNGS
	M. M. Watford	NRC NRR Project Manager
	C. A. Peabody	NRC Senior Resident Inspector for PVNGS
	T. Morales	Arizona Radiation Regulatory Agency (ARRA)

Enclosure

Supplemental Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis– Nuclear Performance and Code Review Branch (SNPB)

Introduction

By letter dated November 25, 2015 [Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML15336A251 and ML15336A087] (Reference 1), as supplemented by letters dated January 29 (Reference 2), June 30 (Reference 3), October 6 (Reference 4), November 9 (Reference 6), and November 23, 2016 (Reference 7) (ADAMS Accession Nos. ML16043A361, ML16182A519, ML16286A240, ML16321A002 and ML16328A426, respectively), Arizona Public Service Company (APS) submitted a license amendment request (LAR) to amend Facility Operating License Nos. NPF-41, NPF-51, and NPF-74, and revise the Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3, Technical Specifications (TSs). The LAR proposes to install NETCO-SNAP-IN® neutron absorbing rack inserts into some spent fuel pool (SFP) storage rack cells coupled with six classifications of fuel (i.e., regions) by initial enrichment, burnup, and decay time in six storage configurations (i.e., arrays) for criticality control. Approval of the license amendment will establish the new licensing basis for how APS meets the effective neutron multiplication factor ($k_{effective}$ or k_{eff}) criticality control requirements.

The U.S. Nuclear Regulatory Commission (NRC) Nuclear Performance and Code Review Branch (SNPB) provided official requests for additional information (RAIs) by Reference 8 (ADAMS Accession Number ML16197A006). Each of the NRC staff information requests of Reference 8 were addressed in Reference 4 and supplemental documents provided by References 6 and 7. On February 9, 2017, a conference call was held with the NRC staff regarding the LAR. At the completion of the conference call it was determined that clarifying information provided during the call was beneficial to the NRC staff to support the completion of their review. Specifically, the NRC staff requested clarification regarding the storage of used fuel assemblies in the spent fuel pool that are missing fuel pins (rods) and how biases and uncertainties are addressed for such assemblies.

This enclosure contains the clarifying information, within the context of the original SNPB RAI-1 response. This response supersedes the previous response provided as SNPB RAI-1, of Reference 4. Changes in the SNPB RAI-1 response are indicated with margin bars in this enclosure. The clarifications relate primarily to Subpart d of the SNPB RAI-1 response, but the entire SNPB RAI-1 response is provided for completeness. Editorial changes were also made to Subparts a, b, and f, as indicated with margin bars. The responses to SNPB RAIs-2 through 12 of Reference 4 remain unchanged.

SNPB RAI-1

WCAP-18030-P, Revision 0, "Criticality Safety Analysis for Palo Verde Nuclear Generating Station Units 1, 2, and 3 (Proprietary)," dated September 2015, fuel assembly reconstitution as normal condition is described as follows, "Fuel assembly reconstitution is defined as either pulling damaged fuel rods [pins] out of an assembly and reinserting intact rods with less reactivity than the damaged rod, or as removing undamaged rods from a damaged assembly for insertion in a new assembly. In most cases damaged rods will be replaced with stainless steel rods. Natural uranium rods may also be used. Additional information is provided in Section 5.4.2 of WCAP-18030-P." Please provide a full description of the fuel assembly reconstitution process, which includes at least the following:

a. The description initially seems to be saying that damaged fuel pins could be replaced with fuel pins from another assembly, but then states that damaged fuel pins would only be replaced with either stainless steel or natural uranium pins. Provide clarification.
b. If the intention is to allow damaged fuel pins to be replaced with intact fuel pins with less reactivity from another assembly, provide the methodology that will be used to identify the replacement fuel pins. Please clarify what will replace the intact fuel pins being moved.
c. Please clarify where in the SFP does the fuel assembly reconstitution activity take place.
d. What is the maximum number of fuel pins that can be missing for a given reconstituted assembly at one time? Please justify any limitation or lack thereof.
e. Please clarify whether or not there is any limitation on the number of pins in any fuel assembly that are not part of its initial construction. Please justify any limitation or lack thereof.
f. In WCAP-18030 Section 5.4.2 it states, "If a fuel assembly has a rod removed and the lattice location is left empty, that fuel assembly shall be treated as fresh fuel until the location is filled or analysis is performed demonstrating that the fuel assembly is bounded by the design basis assembly at the same burnup and initial enrichment levels." Please provide the methodology that will be used to perform the analysis. Please provide the analysis that demonstrates it is acceptable to store fuel with missing fuel pins as fresh. Please justify any limitations or lack thereof.
g. Please provide a licensing commitment to incorporate requirements, resulting from reconstitution limitations, into the licensee's procedures.

APS Response:

SNPB RAI-1, Subpart a:

The NRC has approved the use of inert stainless steel rods (pins) as replacements for the failed fuel pins with the restrictions identified in Reference 5. The currently NRC approved methodology (Reference 5) for replacement of failed fuel pins by inert stainless steel rods prohibits stainless steel replacement rods from being inserted in specific locations within the fuel assembly (i.e., next to guide tubes, on the assembly periphery, adjacent to other inert stainless steel rods). If a failed fuel pin is located in a position which has not been approved for replacement with an inert stainless steel rod, the failed fuel pin can be replaced or 'swapped' with an intact fuel pin based on specific limitations associated with the initial uranium enrichment, depletion, and burnable absorber loading from the same or a different fuel assembly. An inert stainless steel rod can then be placed in the original location of the 'swapped' intact fuel pin so that the replacement restrictions established in Reference 5 are satisfied. Natural uranium pins may be used for fuel storage.

SNPB RAI-1, Subpart b:

The PVNGS currently approved methodology for replacing damaged fuel pins does not allow stainless steel rods in all locations. When a fuel pin is damaged in a location where stainless steel rods are disallowed, a fuel pin 'swap' must be performed. In order to avoid placing an inert stainless steel replacement rod in a prohibited location, for example, on the assembly periphery, a failed fuel pin located there would be replaced with an intact fuel pin of identical mechanical design, with specific limitations for initial enrichment, burnup, and initial burnable absorber loading from the interior. The inert stainless steel rod would be placed in the vacant interior location. Such fuel pin 'swap' guidelines have been used in fuel assembly reconstitutions as a means of complying with the NRC approved inert rod replacement guidelines. These guidelines do not specifically require that the replacement intact fuel pins from another assembly be less reactive. The resulting reconstituted assembly will be stored consistent with the methodology described in the response to SNPB RAI-1, Subpart e, or Subpart f.

Additionally, fuel pin 'swaps' have been performed in the past as part of fuel cladding demonstrations, where individual fuel pins were burned in multiple cycles in different assemblies to achieve a high burnup.

In cases where the reconstituted fuel assembly was returned to the core, stainless steel rods were inserted such that the fuel assembly would contain 236 pins. In some cases, such as the cladding demonstrations where it was known the fuel assembly would not be returned to the core, those pin positions were left vacant. Fuel assemblies with less than 236 pins will be stored in Region 1, consistent with the methodology described in SNPB RAI-1, Subpart f. Fuel assemblies that have non-original pins, but contain 236 pins will be stored consistent with the methodology described in SNPB RAI-1, Subpart e.

SNPB RAI-1, Subpart c:

Fuel reconstitution activities are restricted to Region 1. Region 1 is defined as any combination of Array A and Array B from Figure 5-1 of WCAP-18030. The response to SNPB RAI-1, Subpart f, provides more specific information with regard to fuel reconstitution activities and analyses.

SNPB RAI-1, Subpart d:

There are no administrative limitations on the number of fuel pin locations that are permitted to be empty. Alternatively, the response to SNPB RAI-1, Subpart f, and this SNPB RAI-1, Subpart d response, describe the methodologies that will be used to demonstrate that it is acceptable to store fuel assemblies with missing pins in the spent fuel pool.

No storage restrictions will be applied to fuel assemblies with less than or equal to 10 pins as the small amount of fissile material in these assemblies provides adequate sub-criticality safety margin, without specific assessment of biases and uncertainties. There are currently four grid cages that contain no special nuclear material (SNM) stored in the PVNGS spent fuel pools. APS performed 'pin swaps' in past operating cycles as described in greater detail in the response to RAI-1, Subpart b. A complete listing of the fuel assemblies containing less than 236 pins is provided in Table 1.

Table 1: Palo Verde Fuel Assemblies Containing <236 pins

PVNGS Unit	Fuel Assembly	Initial Enrichment (weight percent)	Burnup (MWD/MTU)	Discharge Cycle	Discharge Date	# of Missing Pins	Region Qualification per WCAP-18030
1	PXXU01[1]	3.23	14010	2	3/5/1989	232	1
1	P1D002	3.89	49618	4	9/4/1993	6	6
1	P1E001	4.01	42402	6	9/21/1996	6	5
2	P2L510	4.23	26013	9	10/4/2000	2	3
2	P2L401[2]	4.23	25997	9	10/4/2000	235.5	3
3	P3F101	3.81	51446	6	2/22/1997	2	6
3	P3F322	3.45	56312	7	9/19/1998	10	6

Notes:

1. PXXU01 was originally P1D128. 232 pins were moved to a new host cage in their corresponding locations; however, four pins could not be removed due to the potential for further damage and remained in the original grid cage. The original cage was renamed PXXU01 and the new cage named P1D128. The four pins that remained in PXXU01 were replaced with stainless steel pins in the renamed assembly P1D128, such that it has 236 pins.
2. The pins from P2L401 were moved to a new host cage, PXXU08. One pin was broken during this pin movement with a portion of the pin remaining in P2L401. The remaining portion of the pin cannot be removed without unacceptable risk of additional damage. PXXU08 contains 236 pins, three of which are stainless steel.

By design, fuel assembly lattices are under-moderated. Removing pins from the lattice decreases the fissile content of the assembly but increases the amount of moderator present in the lattice. Depending on the enrichment, burnup, and geometry the increase in reactivity from the additional moderator may be greater than the decrease in reactivity due to the removal of fissile content from the lattice.

The Region 1 design basis assembly has more moderator and higher density uranium compared to the legacy fuel assemblies itemized in Table 1. Additionally, the design basis fuel assembly has an initial enrichment of five percent and no burnup. Other than PXXU01 which contains only four pins, each of the fuel assemblies in Table 1 qualify for at least Region 3, without crediting decay, confirming that these fuel assemblies are significantly less reactive than a Region 1 design basis fuel assembly at an initial enrichment of five percent. The significantly higher reactivity of the design basis fuel assembly in Region 1 sufficiently bounds the fuel assemblies identified in the Table 1 such that the biases and uncertainties do not need to be recalculated for these legacy assemblies to be stored only in Region 1, unless an assembly specific analysis is performed as described below.

While APS does not plan on creating additional fuel assemblies with <236 pins, other non-conformances, or future operating events, such as damage to a fuel assembly grid cage or operation with lead test pins, may necessitate performing fuel assembly reconstitution with resulting fuel assemblies that could be stored with <236 pins.

A fuel assembly discovered to be not in conformance with WCAP-18030-P, Revision 1, can be stored in compliance with Technical Specification 3.7.17 if an assembly specific analysis is performed using the codes and methodologies described in WCAP-18030-P, Revision 1, demonstrating that the k_{eff} of the non-conforming assembly is less than the target k_{eff} limit of the desired storage array. The target k_{eff} limit is identified for each array in Tables 5-6 through 5-11 of WCAP-18030-P, Revision 1.

Alternatively, to ensure that the reconstituted fuel assembly with non-original pins remains bounded by the design basis fuel assembly, the reconstituted fuel assembly will be controlled as described in Section 5.4.2 of WCAP-18030, Revision 1, and in SNPB RAI-1, Subpart e, below.

Table 2 describes one fuel assembly in the Unit 2 spent fuel pool, P2F003, which was damaged during Unit 2 Cycle 6 in 1996 (legacy corrective action number 260049 and APS letter 102-03728, dated July 3, 1996, ADAMS Accession Number 9607100042). The damage to the fuel assembly caused some of the pins to move axially downward in the lower end fitting. There are 236 fuel pins in the assembly and the cladding is considered intact. The fuel assembly is provided with special rigging to prevent axial separation, which causes the fuel assembly to sit about 2.5 inches higher in the spent fuel rack. The special rigging consists of hardware on the upper and lower end fittings attached with 3/32 inch thick aircraft wire. This fuel assembly has resided in the Unit 2 spent fuel pool in location A-38 since its discharge from the core.

Based on burnup, enrichment and decay time, P2F003 requires 36297 MWD/MTU to qualify for storage in Region 6 of the spent fuel pool. Fuel assembly P2F003 exceeds this burnup requirement by 1854 MWD/MTU. In addition to the excess burnup, uncredited neutron leakage reduces the reactivity of the A-38 storage location which is on the pool periphery. Fuel assembly P2F003 can remain stored in spent fuel pool location A-38 as part of Array F, as the excess burnup and uncredited neutron leakage offset any potential reactivity impacts from the structural damage or special rigging. Figure 3-1 of WCAP-18030-P, Revision 1, contains a map of the spent fuel pool for Palo Verde Units 1, 2, and 3.

Table 2: Technical Description of P2F003

PVNGS Unit	Fuel Assembly	Initial Enrichment (weight percent)	Burnup (MWD/MTU)	Discharge Cycle	Discharge Date	Missing Pins
2	P2F003	3.970	38151	6	03/16/1996	0

Finally, an administrative error was identified in WCAP-18030-P, Revision 1, Section 5.2.3.1.4, *Fission Product and Minor Actinide Worth Bias*, subsequent to submittal by Reference 6. This administrative error has been entered into the Westinghouse corrective action program and is being tracked by PVNGS corrective action number 17-02936. Specifically, page 5-12 includes a uranium isotope (^{236}U) in a list of major actinides and O-16 assessed in establishing the fission product and minor actinide worth bias. This is an administrative error only. Isotope ^{236}U is treated consistently with the guidance in NUREG-7109. Only the text description is incorrect. The final results, conclusions, and storage requirements are not affected. The only correction would be to remove ^{236}U from the list of isotopes itemized in the first paragraph on page 5-12 of WCAP-18030-P, Revision 1. The calculations were performed using the methodology described in the guidance of NUREG-7109 which excludes ^{236}U as part of the applicable calculation step.

SNPB RAI-1, Subpart e:

The design basis described in Section 4.3 of WCAP-18030 is representative of no specific fuel at PVNGS but, rather, bounds the actual and currently anticipated fuels. Because of the bounding nature of the proposed design basis, assembly pin 'swaps' can be performed without resulting in a new fuel design that is more reactive than the design basis assembly.

As described in Section 4.2.5 of WCAP-18030, a number of radial enrichment zoning patterns were analyzed as a function of burnup. The largest observed reactivity increase, due to radial enrichment zoning, was found to be 52 pcm. This was conservatively increased to a 100 pcm bias, and applied to all arrays as a bias. This conservative treatment provided confidence that other zoning patterns will be bounded by the 100 pcm bias.

To ensure that fuel assemblies with non-original fuel pins remain bounded by the design basis fuel assembly, they will be treated as described in Section 5.4.2 of WCAP-18030, which required the following two, parallel criteria:

1. The fuel assembly enrichment will be assumed to be the higher of the inserted fuel pin or reconstituted fuel assembly's initial enrichment; and
2. The fuel assembly burnup will be assumed to be the lower of the reconstituted fuel pin or reconstituted fuel assembly's burnup.

SNPB RAI-1, Subpart f:

Fuel reconstitution is an infrequently performed procedure. In this process the fuel assembly is placed on a spacer that is up to 22 inches tall, which elevates the fuel assembly. The fuel assembly is then partially disassembled to allow fuel pins to be removed and/or replaced. In a re-cage activity, all 236 pins are removed from one grid cage and placed in a different grid cage. During this re-cage process both assembly cages will be on a spacer.

Fuel reconstitution is not a storage configuration. Performance of this maintenance activity is restricted to Region 1 of the spent fuel pool. Assurance of conformance to the requirements of 10CFR 50.68 is provided by performing this activity in Region 1, elevating the fuel assembly on a spacer, and restrictions on any other activity in the pool. An analysis, therefore, will not be performed for the large number of permutation of pin arrangements that may exist during a reconstitution campaign. An assessment will be performed of the fuel assembly or fuel assemblies involved prior to placing the fuel in a storage condition to ensure that the resulting assemblies meet each of the assumptions and criteria of WCAP-18030-P, Revision 1, and Technical Specification 3.7.17.

Some inspection activities are performed on individual fuel pins. These activities include movement of a single fuel pin from a fuel assembly or the rod storage basket to an inspection location and interfaces with inspection equipment. Movement and inspection of an individual fuel pin is a normal condition as described in WCAP-18030, Section 5.4.2, and does not result in a new or different storage configuration and does not require additional analysis. These inspection activities are limited to Region 1.

The non-proprietary version of the response to SNPB RAI-1, Subpart f, is provided in Attachment 2 of this enclosure and the proprietary version is provided in Attachment 3 of this enclosure. Attachment 1 provides the basis for the elements of the response to be withheld from public disclosure pursuant to the criteria of 10 CFR 2.390.

SNPB RAI-1, Subpart g:

APS commits to incorporate fuel reconstitution limitations described in the APS response to the NRC staff Nuclear Performance and Code Review Branch (SNPB) RAI-1, into PVNGS procedures prior to reconstituting fuel, following implementation of the criticality license amendment.

References:

1. APS letter number 102-07149, *License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated November 25, 2015, (ADAMS Accession Numbers ML15336A251 and ML15336A087)
2. APS letter number 102-07181, *Supplemental Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated January 29, 2016 (ADAMS Accession Number ML16043A361)
3. APS letter number 102-07275, *Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated June 30, 2016 (ADAMS Accession Number ML16182A519)
4. APS letter number 102-07342, *Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis,* dated October 6, 2016 (ADAMS Accession Number ML16286A240)
5. CE Topical Report CENPD-289-P-A, Use *of Inert Replacement Rods in ABB CENF Fuel Assemblies*, dated July 1999
6. APS letter number 102-07360, *Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis – Revised Technical Specifications and Bases and WCAP-18030, Revision 1,* dated November 9, 2016 (ADAMS Accession Number ML16321A002)
7. APS letter number 102-07384, *Response to Request for Additional Information Regarding License Amendment Request to Revise Technical Specifications to Incorporate Updated Criticality Safety Analysis – Revised Technical Specification Page***,** dated November 23, 2016 (ADAMS Accession Number ML16328A426)
8. NRC document *Palo Verde 1, 2, and 3 – Official RAIs from SNPB for LAR that Requested Revision of TSs to Incorporate Updated Criticality Safety Analysis,* dated July 14, 2016 (ADAMS Accession Number ML16197A006)