UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 13, 2020

Mrs. Maria L. Lacal
Executive Vice President/
Chief Nuclear Officer
Mail Station 7602
Arizona Public Service Company
P.O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 - REGULATORY AUDIT SUMMARY FOR THE NOVEMBER 7-8, 2019, AUDIT FOR THE LICENSE AMENDMENT AND EXEMPTION REQUESTS ASSOCIATED WITH FRAMATOME HIGH THERMAL PERFORMANCE FUEL (EPID L-2018-LLA-0194 AND EPID L-2018-LLE-0010)

Dear Mrs. Lacal:

By letter dated July 6, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18187A417), as supplemented by letters dated October 18, 2018, March 1, 2019, May 17, 2019, and October 4, 2019 (ADAMS Accession Nos. ML18296A466, ML19060A298, ML19137A118, and ML19277J457, respectively), Arizona Public Service Company (the licensee) requested changes to the technical specifications (TSs) to support the implementation of Framatome Advanced Combustion Engineering 16x16 High Thermal Performance (HTP™) fuel design with M5® as a fuel rod cladding material and gadolinia as a burnable absorber for Palo Verde Nuclear Generating Station (Palo Verde), Units 1, 2, and 3. In addition to this license amendment request, the licensee is requesting an exemption from certain requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46, “Acceptance criteria for emergency core cooling systems [ECCS] for light-water nuclear power reactors,” and 10 CFR Part 50, Appendix K, “ECCS Evaluation Models,” to allow the use of Framatome M5® alloy as a fuel cladding material. In addition, the proposed amendments would revise TS 2.1.1, “Reactor Core SLs [Safety Limits]”; TS 4.2.1, “Fuel Assemblies”; and TS 5.6.5, “Core Operating Limits Report (COLR).”

The proposed amendments would adapt the approved Palo Verde reload analysis methodology to address both Westinghouse and Framatome fuel, including the implementation of Framatome methodologies, parameters and correlations. The ability to use either Westinghouse or Framatome fuel will ensure security of the Palo Verde fuel supply by providing for multiple fuel vendors with reliable fuel designs and geographically diverse manufacturing facilities.

For better understanding of the license amendment, the U.S. Nuclear Regulatory Commission staff conducted the first audit at the Hilton Hotel, 1750 Rockville Pike, Rockville, Maryland 20852, on January 22-23, 2019. For preparing the final requests for additional information (RAIs), the second audit was conducted at the plant site in Arizona on June 17-20, 2019, to review all the calculation notebooks and relevant documents. A third audit was held on November 7-8, 2019, at the Westinghouse facility and Marriott Hotel in Bethesda,

Maryland, to review and resolve the outstanding issues, especially Westinghouse engineering calculations supporting the introduction of Framatome HTP^{TM} fuel, and some of the licensee's RAI responses in its letter dated October 4, 2019. The regulatory audit summary is enclosed with this letter.

If you have any questions, please contact me at 301-415-1564 or via e-mail at Siva.Lingam@nrc.gov.

Sincerely,

/RA/

Siva P. Lingam, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. STN 50-528, STN 50-529,
and STN 50-530

Enclosure:
Audit Summary

cc: Listserv

REGULATORY AUDIT SUMMARY PERFORMED AT WESTINGHOUSE FACILITY AND

MARRIOTT HOTEL IN NORTH BETHESDA MARYLAND ON

NOVEMBER 7-8, 2019, IN SUPPORT OF THE FRAMATOME HIGH

THERMAL PERFORMANCE FUEL LICENSE AMENDMENT AND EXEMPTION

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3

DOCKET NOS. 50-528, 50-529, AND 50-530

1.0 BACKGROUND

By letter dated July 6, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18187A417), as supplemented by letters dated October 18, 2018, March 1, 2019, May 17, 2019, and October 4, 2019 (ADAMS Accession Nos. ML18296A466, ML19060A298, ML19137A118, and ML19277J457, respectively), Arizona Public Service Company (APS, the licensee) requested changes to the technical specifications (TSs) to support the implementation of Framatome Advanced Combustion Engineering (CE) 16x16 High Thermal Performance (HTP™) fuel design with M5® as a fuel rod cladding material and gadolinia as a burnable absorber for Palo Verde Nuclear Generating Station (Palo Verde or PVNGS), Units 1, 2, and 3. In addition to this license amendment request (LAR), APS is requesting an exemption from certain requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46, "Acceptance criteria for emergency core cooling systems [ECCS] for light-water nuclear power reactors," and 10 CFR Part 50, Appendix K, "ECCS Evaluation Models," to allow the use of Framatome M5® alloy as a fuel cladding material. In addition, the proposed amendments would revise TS 2.1.1, "Reactor Core SLs [Safety Limits]"; TS 4.2.1, "Fuel Assemblies"; and TS 5.6.5, "Core Operating Limits Report (COLR)."

The proposed amendments would adapt the approved Palo Verde reload analysis methodology to address both Westinghouse and Framatome fuel, including the implementation of Framatome methodologies, parameters and correlations. The ability to use either Westinghouse or Framatome fuel will ensure security of the Palo Verde fuel supply by providing for multiple fuel vendors with reliable fuel designs and geographically diverse manufacturing facilities.

For better understanding of the LAR, the U.S. Nuclear Regulatory Commission (NRC) staff conducted the first audit at the Hilton Hotel, 1750 Rockville Pike, Rockville, Maryland 20852, on January 22-23, 2019 (ADAMS Accession No. ML19011A108). For preparing the final requests for additional information (RAIs), the second audit was conducted at the plant site in Arizona on June 17-20, 2019 (ADAMS Accession No. (ML19154A469), to review all the calculation notebooks and relevant documents. A third audit was held on November 7-8, 2019, at the Westinghouse facility and Marriott Hotel in Bethesda, Maryland (ADAMS Accession No. ML ML19154A469), to review the Westinghouse Palo Verde seismic analysis, loss-of-coolant accident (LOCA) analysis, and some of the licensee's responses in its letter dated October 4, 2019. This document provides a report on the deliberations during the third regulatory audit.

Enclosure

2.0 SCOPE AND PURPOSE

The audit was held on November 7–8, 2019, at the Westinghouse facility and Marriott Hotel in Bethesda, Maryland, and was conducted in accordance with the audit plan provided to the licensee. The purpose of the audit was to review the Westinghouse seismic analysis, LOCA analysis, and some of the licensee's responses in its letter dated October 4, 2019, in particular, RAIs BHTP RAI-03, BHTP RAI-05, BHTP RAI-06, CHF RAI-04, SNPB RAI-10, SNPB RAI-17, SNPB RAI-19, SNPB RAI-22, SNPB RAI-25, SNPB RAI-26, SNPB RAI-28, SNPB RAI-29, SNPB RAI-30, and SRXB RAI-3. Specifically, RAIs SNPB RAI-10, SNPB RAI-17, SNPB RAI-28, SNPB RAI-29, and SNPB RAI-30 are related to Westinghouse seismic and LOCA analyses. The details of the audit are discussed in Section 4.0 of this summary.

3.0 AUDIT TEAM

The following NRC staff members participated in the site audit:

- Paul Clifford
- Jennifer Dixon-Herrity
- Joseph Donoghue
- Ravi Grover
- Joshua Kaizer
- John Lehning
- Siva P. Lingam
- Robert Lukes
- Mathew Panicker
- Diana Woodyatt

The following APS personnel supported the audit:

- Michael DiLorenzo
- Ryan Gibbs
- Thomas Remick
- Thomas Weber

The following APS consultants also supported the audit:

- Eric Kjolsing
- Dave Medek

The following Westinghouse personnel supported the audit:

- Micah Bowen
- Andrew Bowman
- Jin Liu
- Mike Volodzko
- Tom Zalewski

4.0 AUDIT REPORT

4.1 Information Needs

The licensee was requested to have the presentations and documents related to the areas of focus listed. The documentation was provided by presentations, documents, and calculation details. The following were the planned major areas of focus for detailed discussion and document review.

The deliberations during the audit, along with the original contents of the LAR, and the supplemental information will be used to generate a safety evaluation to complete the comprehensive review of the license amendment and exemption requests. The licensee's stated goal of the fuel transition is to increase security of fuel supply through reliable fuel designs and diverse manufacturing, to implement an improved fuel design, and to maintain existing methods to the extent practical.

4.2 Items Discussed during the Audit

- Fuel seismic and LOCA applied loads (SNPB RAIs-10/29/30).
- Westinghouse large-break and small-break LOCA analyses (SNPB RAIs-17/28).
- Continued applicability of validation for Framatome small-break LOCA evaluation model following an autonomously implemented modification (SNPB RAI-19).
- Fuel assembly description in TS 4.2.1 (SNPB RAI-22).
- Mixed batches of fresh fuel (SNPB RAI-25).
- Thermal conductivity for Westinghouse supplied fuel (SNPB RAI-26).
- Critical heat flux (BHTP RAIs-03/05/06, and CHF RAI-04).
- Departure from nucleate boiling (DNB) propagation (SRXB RAI-3).
- ABB fuel failure estimation calculation (ABB-FFEC) fuel failure predictions (SRXB RAI 5).

4.2.1 Fuel Seismic and LOCA Applied Loads (SNPB RAIs-10/29/30)

With respect to the Framatome methodology and application to the Palo Verde fuel transition, the response to SNPB RAI-29 describes the mixed-core configurations analyzed to encompass fuel transitions from CE16STD (Standard Fuel) to CE16HTP™ and CE16NGF (Next Generation Fuel) to CE16HTP™. The response to SNPB RAI-30 describes how the fuel design analyses addressed irradiation effects. Note that much of this material was discussed during the first regulatory audit. Based on the material presented in response to these two RAIs, the NRC staff does not require additional information at this time for Framatome CE16HTP™ fuel seismic and LOCA design analyses.

During the third regulatory audit, the NRC staff reviewed the draft responses to SNPB RAI-29 and RAI-30 pertaining to the Westinghouse fuel seismic analyses. The Westinghouse mixed-core configurations encompass the following fuel transitions: CE16STD to CE16HTP™, CE16NGF to CE16HTP™, and CE16HTP™ to CE16NGF. Mixed-core configurations were based on Palo Verde fuel management guidelines and controlled by restrictions related to other than seismic considerations. Hence, virtually all potential mixed fuel configurations were evaluated. During the audit, APS stated that cycle-specific verification would ensure that the upcoming fuel loading pattern is bounded by the analyzed Framatome and Westinghouse analyses. Otherwise, cycle-specific analyses would be performed using the approved methodologies.

All of the Westinghouse evaluations were performed at beginning of life (BOL) with still-water damping, consistent with the approved methodology. While irradiation impacts were not considered, flowing water damping has been shown to be a significant credit and is being credited in Pressurized-Water Reactor Owners Group (PWROG) topical report PWROG-16043-P, "PWROG Program to Address NRC Information Notice 2012-09: 'Irradiation Effects on Fuel Assembly Spacer Grid Crush Strength' for Westinghouse and CE PWR Fuel Designs," to offset irradiation effects. PWROG-16043-P also showed a reduction in CE-type grid strength at simulated end of life (EOL) conditions of 3 percent one-sided and 20 percent through grid. For comparison, the Westinghouse Robust Fuel Assembly (RFA)-2 fuel bundle exhibited a reduction of 30 percent.

For the CE16NGF to CE16HTP™ and CE16HTP™ to CE16NGF fuel transitions, positive margin is maintained for all assembly components, including grids (i.e., no grid deformation is predicted). This includes operating basis earthquake (OBE) and safe shutdown earthquake (SSE)+LOCA external loads.

For the CE16STD to CE16HTP™ fuel transition, positive margin is maintained for all assembly components, excluding grids within CE16STD assemblies located on the core peripheral under SSE+LOCA loads. During the audit, the NRC and Westinghouse staff discussed the extent of grid deformation and its potential impact on control rod insertion and coolability. Below are some observations:

- For OBE, positive margin maintained for all components, including grids.
- For SSE+LOCA:
    - Inboard CE16STD maintain positive grid margin;
    - Peripheral CE16STD predict grid deformation;
    - Full core CE16STD cores experience higher loads and more predicted plastic strain than proposed CE16STD to CE16HTP™ transition;
    - Transition core CE16STD to CE16NGF cores experience higher loads and more predicted plastic strain than proposed CE16STD to CE16HTP™ transition;
    - These higher levels of applied loads and plastic strain were found to be acceptable with respect to approved criteria;

- Hence, the proposed CE16STD to CE16HTP™ transition is in the positive direction (lower loads and deformation) and acceptable.

During the audit, the NRC staff reviewed Westinghouse Calculation CN-NFPE-19-34, Revision 0, "Fuel Assembly Seismic/LOCA Stress Analysis for the Full Core Implementation of Framatome HTP™ Fuel in APS." The following guide tube calculated stresses were obtained from this Westinghouse calculation.

Guide Tube	OBE Allowable	SSE+LOCA Calculated	SSE+LOCA Allowable
CE16STD			
Pm	30.2 ksi[1]	14.5 ksi	45.1 ksi
Pm[2]+Pb[3]	41.9 ksi	26.8 ksi	62.6 ksi
CE16NGF			
Pm	30.2 ksi	16.7 ksi	45.1 ksi
Pm+Pb	41.9 ksi	28.2 ksi	62.6 ksi

One of the NRC staff's concerns with the legacy Westinghouse fuel seismic methodology is the use of American Society of Mechanical Engineers Boiler and Pressure Vessel Code Service Level D criteria for guide tubes. This would allow local yielding and potentially buckling of the guide tubes. Given that Palo Verde has rodded core locations along the perimeter, this concerned the NRC staff. The results of the guide tube stress analysis above indicate that the maximum predicted local guide tube stress under SSE+LOCA loads remained below the allowable stress for OBE. Hence, predicted stress remained within the elastic region.

During the audit, the NRC staff reviewed Westinghouse Calculation CN-NFPE-16-17, Revision 1, "Seismic/LOCA Grid Strength Margins for Full Cores of Standard Fuel and Westinghouse Fuel Transition to CE16NGF Fuel at Palo Verde with BOL Properties and Still Water Damping." Section 6.3.4 described the assessment for control element assembly (CEA) insertion:

- Grid testing of HID-1L grid (CE16STD) shows that "even at energy inputs much greater than the energy required to fail the grid, there was no resultant interior deformation of the grid."

- "That is, the CEA guide thimble tube pattern was maintained because the failure mechanism of the grid was on the exterior at the core shroud contact area."

This Westinghouse evaluation provides further evidence supporting the ability to insert control rods at the peripheral locations.

After reviewing the draft responses to SNPB RAI-29 and SNPB RAI-30 and discussing these matters during the audit, the NRC staff identified the following additions needed to close remaining open items. These additions were reflected in the final RAI responses.

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[1] Kilos per square inches.
[2] General primary membrane stress intensity.
[3] Bending stress intensity.

1. For Westinghouse mixed-core evaluations, all STD and NGF assembly components satisfy existing, approved acceptance criteria.

2. For Westinghouse mixed-core evaluations, STD and NGF maximum calculated guide tube stresses remain below more restrictive OBE acceptance criteria.

3. For STD fuel on the core periphery, maximum calculated loads (and associated plastic deformation) for the CE16STD → CE16HTP™ fuel transition are less than those predicted for a full core of CE16STD and CE16STD → CE16NGF transition.

4. Fuel bundles along core periphery are restricted to assembly powers well below limiting, interior core locations.

5. NGF intermediate flow mixing (IFMs) will not impact adjacent STD or HTP™ fuel rods.

4.2.2 Westinghouse Large-Break and Small-Break LOCA analyses (SNPB RAIs-17/28)

SNPB RAI-17 addressed the general topic of LOCA analysis for mixed cores involving Framatome HTP™ fuel at Palo Verde. The question requested further information concerning whether the Framatome and Westinghouse LOCA analyses adequately address envisioned mixed-core configurations, and clarification as to the conditions under which a given mixed-core configuration would be deemed either inside or outside the bounds of the existing analysis.

SNPB RAI-28 requested a description of the Westinghouse large- and small-break LOCA analyses for mixed-core configurations containing Framatome HTP™ fuel, the results of the analyses, and confirmation that the acceptance criteria of 10 CFR 50.46(b) remain satisfied.

The NRC staff's audit focused upon the Westinghouse LOCA analyses. Previous audits and the NRC staff's review of docketed information had already addressed the Framatome LOCA analyses.

During the audit, the NRC staff audited several Westinghouse calculations for the large- and small-break LOCA events that are listed below in Section 4.3 of this audit report.

The Westinghouse mixed-core LOCA analyses for Palo Verde considered four mixed-core transition scenarios:

- From a full core of Westinghouse NGF to a full core of Framatome HTP™ fuel (except for the hot assembly)

- From a full core of Westinghouse STD fuel to a full core of Framatome HTP™ fuel (except for the hot assembly)

- From a full core of Framatome HTP™ fuel (except for the hot assembly) to a full core of Westinghouse NGF

- From a mixed core of Westinghouse NGF and STD fuel to a full core of Framatome HTP™ fuel (except for the hot assembly)

The large-break LOCA analysis for the above mixed-core configurations was performed explicitly using the Westinghouse CE large-break LOCA evaluation model currently licensed at Palo Verde (i.e., the 1999 evaluation model). The effects of the same mixed-core configurations on the small-break LOCA analysis were assessed qualitatively, since the Westinghouse CE small-break LOCA evaluation model currently licensed at Palo Verde (i.e., supplement to model) is a single-channel model that cannot explicitly simulate effects associated with multiple fuel assembly designs in the core.

The results of the vendor's calculations using the large-break LOCA evaluation model showed that the predicted results for the analyzed mixed-core configurations would be bounded by the existing analysis of record. This result appears consistent with physical expectations considering that the pressure drop associated with Framatome HTP™ fuel is between that of Westinghouse NGF and STD fuel. Full cores of Westinghouse NGF, as well as mixed cores of Westinghouse NGF and STD fuel have been accounted for in the existing analysis of record.

The vendor qualitatively dispositioned the impacts of the postulated mixed-core configurations on the small-break LOCA event and reached a similar conclusion that they would also be bounded by the existing analysis of record. This result also appears consistent with physical expectations given the relative pressure drop behavior cited above, as well as the fact that differences in fuel assembly design are typically less important for the small-break LOCA event as compared to the large-break LOCA event. Large-break LOCA scenarios tend to be dominated more by inertial effects; whereas, small-break LOCA scenarios tend to depend more on gravitational forces, liquid static heads, and the overall reactor coolant system design.

The NRC staff found the audit of the Westinghouse LOCA calculations beneficial to promote an understanding of how impacts of mixed-core configurations were taken into account. Discussion of the calculations with cognizant vendor and licensee personnel significantly assisted the NRC staff's understanding of the calculational methods and results.

The licensee stated it would submit a summary description of the Westinghouse large- and small-break LOCA analyses for mixed-core configurations involving Framatome HTP™ fuel in response to SNPB RAI-17 and -28.

4.2.3 Modification to Framatome Small-Break LOCA Evaluation Model (SNPB RAI-19)

In SNPB RAI-19, the NRC staff requested that the licensee justify that a modification Framatome implemented to its small-break LOCA evaluation model following the NRC staff's review of topical report EMF-2328P, Supplement 1, "PWR [Pressurized Water Reactor] Small Break LOCA Evaluation Model, S-RELAP5 Based," Framatome, December 2016 (ADAMS Accession No. ML12065A391), would not adversely affect the validation of the approved evaluation model.

In particular, Framatome implemented an evaluation model modification to address observations of unexpected liquid holdup in intact cold-leg discharge piping following the clearing of the loop seal in the broken loop. Framatome deemed this effect non-physical and, with the intent of ameliorating it, implemented an evaluation model change to reduce interfacial condensation in the intact cold legs around the time-of-loop seal clearing.

During the audit, Framatome personnel discussed the basis for deeming the observed liquid holdup non-physical. Framatome further pointed out that its method of correction was implemented via input changes and did not involve actual code modifications. Framatome

personnel also identified that the loop seal biasing scheme from Supplement 1 to EMF-2328P, which Framatome associated with the liquid holdup issue, was only implemented in sample plant calculations and was not applied in the comparison calculations used for evaluation model validation. As such, Framatome personnel stated that validation of the approved evaluation model would not be affected by correction of the identified liquid holdup issue.

Framatome's discussion of the issue enhanced the NRC staff's understanding. However, the NRC staff made several additional observations regarding the subject of SNPB RAI-19:

- Some changes to input parameters may be regarded as changes to an approved evaluation model (e.g., activation of an existent, alternative decay heat or critical flow modeling option in lieu of the approved modeling option). Therefore, the presence or absence of code modifications does not appear to be directly relevant to the determination of whether evaluation model changes may screen out from, among other things, assessment to ensure the continuity of the existing evaluation model validation.

- Although the loop seal biasing scheme from Supplement 1 to EMF-2328P may exacerbate liquid holdup in intact cold legs, existing evidence and physical insights do not appear sufficient to reasonably infer that liquid holdup may be precluded when the biasing scheme is absent.

- Examination of existing validation calculations supporting the Framatome small-break LOCA evaluation model should provide evidence as to whether liquid holdup occurred in the intact cold legs for relevant cases. Assessment of the existing evidence would either support application of the existing validation basis to the modified evaluation model (i.e., no liquid holdup identified) or indicate further evaluation (i.e., liquid holdup identified).

Based upon audit discussion, the licensee agreed to evaluate further the NRC staff's observations and assess whether a supplement to its response to SNPB RAI-19 would be appropriate.

4.2.4 Fuel Assembly Description in TS 4.2.1 (SNPB RAI-22)

In SNPB RAI-22, the NRC staff requested that the licensee define the term "zirconium-alloy clad" that it proposed to use in the description of fuel assemblies in TS 4.2.1 in lieu of naming specific fuel cladding alloys (e.g., Zircaloy, ZIRLO, M5®). The NRC staff further requested that the licensee justify that omission of the specific cladding materials is not necessary to satisfy the requirement in 10 CFR 50.36(c)(4), "Design features," that the TSs shall include design "features of the facility such as materials of construction… which if altered or modified, would have a significant effect on safety."

Audit discussion did not identify a definition for the term "zirconium-alloy clad."

Instead, audit discussion turned to whether the regulatory requirement expressed in 10 CFR 50.36(c)(4), could be satisfied by incorporating wording that would require cladding materials used at Palo Verde to have been approved by the NRC staff. The idea being that a change from one NRC staff-approved cladding material to another would not be expected to have a significant effect on safety.

The licensee stated it would consider submitting a revised version of TS 4.2.1 containing wording consistent with the audit discussions.

4.2.5 Mixed Batches of Fresh Fuel (SNPB RAI-25)

In SNPB RAI-25, the NRC staff requested that the licensee clarify whether the proposed license amendment would permit operation with mixed batches of fresh fuel. The RAI further requested that, if operation with mixed batches of fresh fuel would be permitted following implementation of the license amendment, that the licensee either (1) provide justification for its acceptability or (2) propose a binding restriction to forbid such operation. If operation with mixed batches of fresh fuel would be prohibited after implementation of the proposed license amendment, the NRC staff requested that the licensee identify specific, existing regulatory requirement(s) that would preclude such operation.

During the audit discussion, the licensee stated that operation with mixed batches of fresh fuel was no longer requested under the license amendment. The licensee further stated that an evaluation in accordance with 10 CFR 50.59, “Changes, tests, and experiments,” would have to be performed prior to loading a core with mixed batches of fresh fuel, and, presuming that the evaluation determined that operation with mixed fresh batches required prior NRC approval, a license amendment would be submitted at that time.

The NRC staff did not attain sufficient confidence from the audit discussion that future determinations performed by the licensee in accordance with 10 CFR 50.59 would necessarily reach an appropriate conclusion, lacking a binding requirement forbidding operation with mixed batches of fresh fuel. The existing analytical methods used by Palo Verde to determine core operating limits were developed to address traditional core designs involving full batch reloads. Application of these methods to cores loaded with mixed batches of fresh fuel was not envisioned at the time the analytical methods were developed, and the analytical methods have not been evaluated for use under those conditions. Nevertheless, precisely because the possibility of such applications was envisioned, these methods do not contain explicit prohibitions against application to cores with mixed batches of fresh fuel. Thus, significant potential for misinterpretation of the scope of methods applicability is apparent, which, absent a license condition, could result in the generation of inadequate core operating limits.

Based upon audit discussions, the licensee stated it would consider submitting a license condition to provide a binding restriction to prohibit operation with mixed batches of fresh fuel absent prior NRC staff review and approval.

4.2.6 Thermal Conductivity for Westinghouse-Supplied Fuel (SNPB RAI-26)

In SNPB RAI-26, the NRC staff requested that the licensee consider revising the license condition implemented in Amendment No. 205 concerning the modeling of thermal conductivity degradation when using FATES3B to analyze Westinghouse NGF. Because the present license amendment proposes to genericize several specific or restrictive statements in the current TS, thereby providing additional flexibility in the licensing of new fuel designs, the NRC staff questioned whether similarly generic language should also be incorporated into the existing license condition concerning thermal conductivity degradation, in lieu of mentioning the specific fuel design (i.e., Westinghouse NGF).

The licensee stated its initial position that a revision such as discussed in SNPB RAI-26 would not be necessary or appropriate. The licensee stated its view that, while it would intend to apply

corrections to account for thermal conductivity degradation for future Westinghouse fuel designs analyzed with FATES3B, a license condition would not be necessary to grant the current license amendment. The licensee also stated that it viewed the proposed license amendment as addressing Framatome HTP™ fuel and did not perceive the proposed license amendment as affecting the licensing of future Westinghouse fuel designs. Hence, the licensee did not perceive a nexus to the license condition implemented in Amendment No. 205.

The NRC staff did not attain sufficient confidence from the audit discussion that (1) the license amendment would not affect the licensing of future Westinghouse fuel designs and (2) thermal conductivity degradation would be modeled in an appropriate manner for future Westinghouse fuel designs. Because the proposed license amendment would grant additional regulatory flexibility to all fuel designs loaded in the future, including those supplied by Westinghouse, the NRC staff perceived a clear nexus between the proposed amendment and the license condition implemented in Amendment No. 205. Furthermore, absent a revision to the license condition implemented in Amendment No. 205, the NRC staff noted the existence of a potentially reasonable interpretation that the NRC staff had considered a thermal conductivity degradation correction necessary only for Westinghouse NGF, and not any other Westinghouse fuel designs (e.g., Westinghouse STD fuel). Whereas, without a correction for thermal conductivity degradation, safety analyses performed using inputs from FATES3B for future Westinghouse fuel designs could result in unacceptably nonconservative predictions.

Based upon audit discussions, the licensee stated it would consider revising the license condition implemented in Amendment No. 205 or submitting a new license condition to address thermal conductivity degradation for future Westinghouse fuel designs introduced to Palo Verde that are analyzed with FATES3B.

4.2.7 Critical Heat Flux

The NRC staff had brief discussions on BHTP RAI-03, BHTP RAI-05, BHTP RAI-06 and CHF RAI-04. These discussions were focused on confirming that the NRC staff understood the responses provided. No changes to the RAI responses were made due to the discussions during the audit.

4.2.8 DNB Propagation (SRXB RAI-3)

During the audit, NRC and APS staff discussed the initial response to SRXB RAI-3. The NRC staff had concerns that the response suggested a new bases for the proposed 5.0 second allowable time-in-DNB for M5® cladding. Based upon discussions during the second regulatory audit, the NRC staff expected that the existing bases for the 4.5 seconds allowable time-in-DNB would be adopted for M5® cladding, with appropriate justification. After discussions at the third audit, it was agreed that the response to SRXB RAI-3 would be supplemented to provide the justification for applying the existing screening criteria (4.5 seconds in DNB) to M5® cladding.

The NRC staff reviewed the EDGAR data and additional justification, and does not require further information at this time.

4.2.9 ABB-FFEC calculation Fuel Failure Predictions (SRXB RAI-5)

The response to SRXB RAI-5 describes the DNB fuel failure methods for mixed cores. It concludes that the methods are different for control rod ejection, as detailed in SRXB RAI-6. However, SRXB RAI-6 does not address DNB fuel failure methods. During the audit, NRC and

APS staff discussed the methodology used for control rod ejection to predict the total number of DNB failed rods. As a result of these discussions, SRXB RAI-5 was updated to capture the methods for control rod ejection. The NRC staff has reviewed the supplement and requires no additional information at this time.

4.3 Supporting Information from the Licensee

The licensee was requested to make the appropriate personnel or contractors, who are familiar with the proposed LAR, available for the audit (either in person or on the phone). The NRC staff also requested the licensee to have the supporting documents related to the above topics available and be prepared to discuss them with the staff during the audit.

List of Documents Reviewed during the Audit

Fuel Seismic Structural

1. Westinghouse Calculation CN-NFPE-19-34, Revision 0, "Fuel Assembly Seismic/LOCA Stress Analysis for the Full Core Implementation of Framatome CE16HTP™ Fuel in APS."

2. Westinghouse Calculation CN-NFPE-16-17, Revision 1, "Seismic/LOCA Grid Strength Margins for Full Cores of Standard Fuel and Westinghouse Fuel Transition to CE16NGF Fuel at Palo Verde with BOL Properties and Still Water Damping."

LOCA

3. Westinghouse Calculation CN-LIS-19-10, R0, "Evaluation and Analysis for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3, Loss of Coolant Analyses to Support the Arizona Public Service (APS) Vendor Qualification Program (VQP) for the Full Core Transition to Framatome Fuel Assemblies," October 10, 2019.

4. Westinghouse Calculation CN-LIS-19-18, R0, "Small Break Loss-of-Coolant Accident (SBLOCA) Evaluation to Support a Full Core Transition to Framatome Fuel Assemblies for Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2, and 3," October 10, 2019.

5. Westinghouse Calculation CN-TLA-14-014, R3, "ECCS Performance Analysis Comprehensive Checklist for PVNGS, Units 1, 2, and 3, with NGF," October 17, 2019.

5.0 CONCLUSION

Through the audit, the NRC staff obtained an enhanced understanding of the licensee's submittals and the details of the included safety analyses and their results. There was open communication throughout the audit, and this helped the NRC staff to communicate concerns about the submittals and have them answered by APS and Westinghouse. The licensee provided draft RAI responses for Westinghouse seismic analysis for mixed-core (SNPB RAIs-10/29/30) and Westinghouse large-break and small-break LOCA analyses (SNPB RAIs-17/28) before the audit took place so that the licensee can provide the draft responses for the NRC review before the site audit. Because of the discussions that were conducted at this audit, the NRC staff is able to primarily focus on the preparation of the safety evaluation.

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 - REGULATORY AUDIT SUMMARY FOR THE NOVEMBER 7-8, 2019, AUDIT FOR THE LICENSE AMENDMENT AND EXEMPTION REQUESTS ASSOCIATED WITH FRAMATOME HIGH THERMAL PERFORMANCE FUEL (EPID L-2018-LLA-0194 AND EPID L-2018-LLE-0010) DATED FEBRUARY 13, 2020

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