October 16, 2001

Mr. Gregg R. Overbeck
Senior Vice President, Nuclear
Arizona Public Service Company
P. O. Box 52034
Phoenix, AZ 85072-2034

SUBJECT: EXEMPTION FROM THE REQUIREMENTS OF 10 CFR 50.44, 50.46, AND PART 50, APPENDIX K - PALO VERDE NUCLEAR GENERATING STATION, UNIT 3 (TAC NO. MB1343)

Dear Mr. Overbeck:

The Commission has approved the enclosed exemption from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, Section 50.44, Section 50.46, and Part 50, Appendix K for the Palo Verde Nuclear Generating Station, Unit 3. This action is in response to your letter of March 2, 2001, as supplemented by letters dated August 28, 2001, and September 25, 2001, that submitted a temporary exemption to allow continued testing of a lead fuel assembly (LFA) fabricated of an advanced zirconium based cladding material.

A copy of the exemption and the supporting safety evaluation are enclosed. The exemption has been forwarded to the Office of the Federal Register for publication.

Sincerely,

/RA/

L. Raynard Wharton, Project Manager, Section 2
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. STN 50-530

Enclosures: 1. Exemption
2. Safety Evaluation

cc w/encls: See next page

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ARIZONA PUBLIC SERVICE COMPANY

PALO VERDE NUCLEAR GENERATING STATION, UNIT 3

DOCKET NO. STN 50-530

EXEMPTION

1.0 BACKGROUND

The Arizona Public Service Company (APS/licensee) is the holder of Facility Operating License No. NPF-74 which authorizes operation of the Palo Verde Nuclear Generating Station (PVNGS), Unit 3 . The license provides, among other things, that the facility is subject to all rules, regulations, and orders of the U.S. Nuclear Regulatory Commission (NRC, the Commission) now, or hereafter in effect.

The facility consists of a pressurized water reactor located in Maricopa County in Arizona.

2.0 REQUEST/ACTION

Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, discusses fuel performance requirements for fuel used in light water nuclear power reactors. The requirements refer specifically to cladding types of zircaloy or ZIRLO, and do not address other cladding material. Since advanced zirconium based cladding materials do not conform to the two designations specified in the code, an exemption is required.

APS requested a temporary exemption from the requirements of 10 CFR 50.44, 10 CFR 50.46, and 10 CFR Part 50, Appendix K, for PVNGS, Unit 3, by letter dated March 2, 2001, as supplemented on August 28, 2001, and September 25, 2001. The exemption would allow continued testing of a lead fuel assembly (LFA) containing fuel rods fabricated with an advanced zirconium based cladding material, designated as Alloy A. This cladding material has been previously approved for limited use and testing at PVNGS in letters dated July 17, 1992, and February 4, 1997. The requested exemption extension would allow the Unit 3 LFA to exceed the already approved operating cycles.

Part 50 of 10 CFR specifies standards and acceptance criteria only for fuel rods clad with zircaloy or ZIRLO. As noted above, APS was granted an exemption to use Alloy A in a limited number of pins starting in Cycle 4 and continuing through Cycle 6 in Unit 3. Based on the success of this advanced cladding, APS was granted an additional exemption to extend the burnup for a limited number of pins clad with Alloy A during Cycle 7. As part of the second exemption, APS was allowed to use a full assembly of the Alloy A clad in Unit 3 for three operating cycles, starting in Cycle 7. Based on the results of physical examination and measurements that have confirmed the superior performance of Alloy A, and NRC's prior approval for a limited number of pins, APS has requested an exemption to extend the burnup into Cycle 10 for the full assembly of Alloy A fuel rods.

Section 50.44 (a) of 10 CFR states, "Each boiling or pressurized light-water nuclear power reactor fueled with oxide pellets within cylindrical zircaloy or ZIRLO cladding, must, as provided in paragraphs (b) through (d) of this section, include means for control of hydrogen gas that may be generated, following a postulated loss-of-coolant accident (LOCA)."

Section 50.46(a)(1)(i) of 10 CFR states, "Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding

must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated."

Section 50.46 of 10 CFR continues on to delineate specifications for peak cladding temperature, maximum hydrogen generation, coolable geometry, and long-term cooling. Sections 50.44 and 50.46 of 10 CFR specifically refer to fuel with zircaloy or ZIRLO cladding; the use of fuel clad with zirconium-based alloys that do not conform to either of these two designations requires an exemption from this section of the Code.

Appendix K, paragraph I.A.5, of 10 CFR Part 50 states, "The rate of energy release, hydrogen generation, and cladding oxidation from the metal/water reaction shall be calculated using the Baker-Just equation." The Baker-Just equation presumes the use of zircaloy or ZIRLO cladding. The use of fuel with zirconium-based alloys that do not conform to either of these two designations requires an exemption from this section of the Code.

APS believes that special circumstances are present, pursuant to 10 CFR 50.12(a)(ii), to warrant granting the exemption request.

3.0 DISCUSSION

Pursuant to 10 CFR 50.12, the Commission may, upon application by an interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50 when (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security, and (2) when special

circumstances are present. These circumstances include the special circumstances as set forth in 10 CFR 50.12(a)(2)(ii), which states that special circumstances are present whenever, "Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule."

The underlying purpose of 10 CFR 50.44 is to ensure that there is an adequate means of controlling generated hydrogen. The hydrogen produced in a post-LOCA scenario comes from a metal-water reaction. In the previous exemptions, it was concluded that the use of the Baker-Just equation to determine the metal-water reaction rate is conservative for Alloy A cladding. Therefore, the amount of hydrogen generated by metal-water reaction in these materials will be within the design basis of Palo Verde Unit 3.

Section 50.46 of 10 CFR identifies acceptance criteria for ECCS system performance at nuclear power facilities. The effectiveness of the ECCS in Palo Verde Unit 3 will not be affected by the reinsertion of the LFA. Due to the similarities in the material properties of Alloy A to zircaloy, and the location of the LFA in a non-limiting location, it can be concluded that the ECCS performance in Palo Verde Unit 3 will not be adversely affected.

The intent of paragraph I.A.5 of Appendix K to 10 CFR Part 50 is to apply an equation for rates of energy release, hydrogen generation, and cladding oxidation from a metal-water reaction which conservatively bounds all post-LOCA scenarios. CEN-429-P, Rev. 00-P, "Safety Analysis Report for Use of Advanced Zirconium Based Cladding Material in PVNGS Unit 3 Lead Fuel Assemblies," August 1996, verifies that due to the similarities in the composition of the Alloy A cladding and zircaloy, the application of the Baker-Just equation will continue to conservatively bound all post-LOCA scenarios.

The staff examined the licensee's rationale to support the exemption requests and concluded that continued use of advanced zirconium based cladding materials would meet the underlying purpose of 10 CFR Part 50.

Based upon the considerations discussed in this exemption, the staff concludes that the information provided by APS and the actions described in the application form an acceptable basis for extending the exemption for another cycle.

The safety evaluation may be examined, and/or copied for a fee, at the NRC's Public Document Room, located at One White Flint North, 11555 Rockville Pike (first floor), Rockville, Maryland. Publicly available records will be accessible electronically from the ADAMS Public Library component on the NRC Web site, http://www.nrc.gov (the Public Electronic Reading Room).

Therefore, the staff concludes that pursuant to 10 CFR 50.12(a)(2)(ii), special circumstances exist as discussed in Section 3.0 above, and granting this exemption will not present an undue risk to the public health and safety and is consistent with the common defense and security.

4.0 CONCLUSION

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12(a), the exemption is authorized by law, will not endanger life or property or common defense and security, and is, otherwise, in the public interest. Also, special circumstances are present. Therefore, the Commission hereby grants Arizona Public Service Company, et al., an

exemption from the requirements of 10 CFR 50.44, 10 CFR 50.46, and 10 CFR Part 50, Appendix K, for Palo Verde Nuclear Generating Station, Unit 3.

Pursuant to 10 CFR 51.32, the Commission has determined that the granting of this exemption will not have a significant effect on the quality of the human environment (66 FR 52644).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 16th day of October 2001.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/
John A. Zwolinski, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO THE EXEMPTION TO FACILITY OPERATING LICENSE NO. NPF-74

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

PALO VERDE NUCLEAR GENERATING STATION, UNIT 3

DOCKET NO. STN 50-530

1.0 INTRODUCTION

By letter dated March 2, 2001, Arizona Public Service Company (APS), requested that the Nuclear Regulatory Commission (NRC) provide a temporary exemption from the requirements of 10 CFR 50.44, 10 CFR 50.46, and 10 CFR Part 50, Appendix K, for the Palo Verde Nuclear Generating Station (PVNGS), Unit 3. APS submitted this request on behalf of itself, the Salt River Project Agricultural Improvement and Power District, Southern California Edison Company, El Paso Electric Company, Public Service Company of New Mexico, Los Angeles Department of Water and Power, and Southern California Public Power Authority. This exemption will allow the continuation of testing of a lead fuel assembly (LFA) containing fuel rods fabricated with Alloy A, an advanced zirconium based cladding material. The LFA will continue testing through a fourth cycle of operation, achieving a peak rod average burnup of approximately 72 MWd/kgU. Discussions were held with the NRC staff to clarify some portions of the request and additional information was submitted in letters dated August 28 and September 25, 2001. Continued irradiation of this fuel assembly will provide data to support development of new cladding materials for use in pressurized water reactors (PWRs) and provide data for use in developing the basis of future regulatory changes to allow full batch implementation of this cladding material. In addition it will provide data for burnups beyond the current approved burnup limit of 60 MWd/kgU.

Section 50.44 of Title 10 of the Code of Federal Regulations (10 CFR) contains requirements for the control of hydrogen gas that may be generated after a postulated loss-of-coolant accident (LOCA) in light-water reactors (LWRs) fueled with uranium oxide pellets within cylindrical Zircaloy cladding. Section 50.46 of Title 10 of the Code of Federal Regulation contains acceptance criteria for emergency core cooling systems (ECCS) for LWRs fueled with uranium oxide pellets within cylindrical Zircaloy cladding. Further, 10 CFR 50.46 states that ECCS cooling performance following a postulated LOCA must be calculated in accordance with an acceptable evaluation model. Finally, Appendix K to 10 CFR Part 50 contains the required and acceptable features for ECCS evaluation models. All of these regulations reference the use of conventional Zircaloy-4 or ZIRLO cladding materials. Therefore, use of a different cladding material requires an exemption from these regulations for use in LWRs.

This LFA will provide data on fuel and materials performance that will support industry goals of extending the current fuel burnup limits and will provide data to address NRC questions related to fuel performance behavior at high burnups. The data will also help confirm the applicability of nuclear design and fuel performance models at high burnups.

2.0 APPLICABLE REGULATIONS

The licensee requested an exemption from 10 CFR 50.44, 10 CFR 50.46, and 10 CFR 50, Appendix K, for PVNGS Unit 3. This exemption will allow the continued irradiation of a LFA which uses Alloy A, an advanced zirconium based cladding material, for an additional cycle of operation.

Section 50.12(a) of 10 CFR states: "The Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of the regulations of this part, which are - (1) Authorized by law, will not present an undue risk to the public health and safety, and are consistent with the common defense and security. (2) The Commission will not consider granting an exemption unless special circumstances are present. Special circumstances are present whenever - ... (ii) Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule."

Section 50.44 of 10 CFR contains the standards for control of hydrogen gas generated in part by Zircaloy or ZIRLO clad fuel following a LOCA. The intent of this rule is to ensure that adequate means of controlling hydrogen gas following a LOCA are provided.

Section 50.46 of 10 CFR states: "Each boiling or pressurized light-water nuclear power reactor fueled with uranium oxide pellets within cylindrical Zircaloy or ZIRLO cladding must be provided with an emergency core cooling system (ECCS) that must be designed so that its calculated cooling performance following postulated loss-of-coolant accidents conforms to the criteria set forth in paragraph (b) of this section. ECCS cooling performance must be calculated in accordance with an acceptable evaluation model and must be calculated for a number of postulated loss-of-coolant accidents of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated loss-of-coolant accidents are calculated." The intent of this rule is to ensure adequate core cooling following an accident and that facilities have adequate ECCS systems to provide the necessary cooling.

Part I.A.5 of 10 CFR Part 50, Appendix K, states: "The rate of energy release, hydrogen generation, and cladding oxidation from the metal/water reaction shall be calculated using the Baker-Just equation..." The Baker-Just equation assumes the use of Zircaloy cladding material; therefore, strict application of the equation would be invalid for other cladding materials. The intent of this requirement is to provide a conservative bounding calculation for all post LOCA scenarios.

3.0 EVALUATION

3.1 Non-Zircaloy, Non-Zirlo Cladding

The LFA used in PVNGS Unit 3 was fabricated by Westinghouse using a new cladding material called Alloy A, which has improved corrosion resistance and dimensional stability. Alloy A was previously tested in PVNGS Unit 3 by irradiating lead fuel rods which used this cladding material. These lead fuel rods were irradiated for four cycles and received burnups in the range of 70 MWd/kgU. These fuel rods were examined at intermediate steps through the burnup cycle and after being discharged so that the cladding characteristics could be quantified.

Similarly, the LFA which uses Alloy A cladding has been irradiated for three cycles of operation. During this irradiation period, the assembly has been inserted into the core in the same location as the assembly containing the lead fuel rods, providing a similar irradiation history. The interim evaluations of the LFA demonstrate that it is performing as expected based on data from the lead fuel rods.

Hydrogen produced following a LOCA scenario is generated by a metal-water reaction which oxidizes the cladding. The majority of this oxidation occurs during the beta phase of the reaction since the diffusion coefficient for oxygen in the beta phase is significantly greater than in the alpha phase for zirconium. Alloy A is anticipated to have improved resistence to oxidation as demonstrated through the oxidation rate of the material during normal operation. Therefore, the beta phase oxidation of Alloy A is anticipated to be comparable to or lower than the hydrogen generated following a LOCA from a Zircaloy-4 assembly. This clad oxidation coefficient was previously demonstrated in the exemption request allowing PVNGS to irradiate the LFA for three cycles. A strict interpretation of 10 CFR 50.44 would preclude the use of any advanced zirconium based alloys. However, the intent of 10 CFR 50.44 is met and special circumstances exist to grant an exemption to allow the use of this assembly for an additional cycle.

Fuel rods clad with Alloy A are identical in design and dimension to fuel rods clad with conventional cladding materials. The advanced Alloy A was chosen because it demonstrated improved corrosion resistence and performance characteristics. The mechanical properties of the Alloy A cladding meet the mechanical requirements of conventional Zircaloy-4 cladding. Thus, the cladding and structural integrity of the fuel assemblies fabricated using Alloy A will be maintained and clad performance of Alloy A will be consistent with conventional clad performance. Since the cladding parameters are similar, the ECCS systems will be able to perform their functions as intended following a LOCA. Therefore, a strict application is not necessary to achieve the purpose of the regulation. The intent of 10 CFR 50.46 is met and special circumstances exist to grant an exemption to allow the use of this assembly.

Use of the Baker-Just equation is specified in Part I.A.5 of 10 CFR Part 50, Appendix K. This equation assumes the use of Zircaloy or ZIRLO cladding material. Alloy A is similar to Zircaloy; therefore, use of the Baker-Just equation in the analysis will conservatively bound post-LOCA scenarios. Since the intent of the regulation is to conservatively predict the scenario response, use of the Baker-Just equation for Alloy A calculations will meet the intent of the regulation and special circumstances exist to grant an exemption to allow the use of this assembly.

3.2 Burnup Beyond 60 MWd/kgU

Since the rods in the LFA are anticipated to reach average burnups of up to 72MWd/kgU, irradiation of the fuel rods above the approved burnup of 60 Mwd/kgU was also addressed in this review. The NRC has recently been working with the industry to develop guidelines for lead test assemblies (LTAs) including fuel assemblies such as the one under review. The intention is to develop a set of guidelines which provides a structured process for LTAs while maintaining safety. These guidelines will be consistent with the NRC performance goals which are: maintain safety, maintain public confidence, improve efficiency and effectiveness of regulation and reduce unnecessary burden. Many different aspects will be addressed in LTA guidelines, including: characterization of the fuel assembly both pre- and post-irradiation, which poolside

examinations will be performed, the number of LTAs allowed in any given core, the location or placement of LTAs within the core, what the safety analysis should cover and reporting requirements. This review was performed in accordance with the proposed LTA guidelines.

Pre- and post-irradiation testing of LFAs or LTAs are essential to the value of the program. At the end of the current cycle, Cycle 9, poolside examinations will be performed on the LFA to verify the characteristics of the fuel assembly. If unsatisfactory performance of the cladding material is observed, the fuel assembly will not be reinserted into the core for Cycle 10. The poolside examinations to be performed include: oxide thickness, axial fuel rod growth and/or shoulder gap, ovality, and cladding diameters over the length of the rods. Visual inspections to evaluate the surface conditions and look for defects will also be performed. Following irradiation in Cycle 10, these same measurements will be performed.

The test program proposed by the licensee is in agreement with the proposed LTA guidelines. The NRC staff considers the test program to be appropriate and APS has committed to send the results to the NRC after completion of the program.

The LFA will be located in the center location of the core. It will be the only assembly with burnup higher than the approved limit. The Cycle 10 reload analysis demonstrates that all relevant design limits for the design basis events for the LFA have been met. Evaluations of the performance of the LFA are currently underway in the areas of fuel performance, mechanical design, transient analysis and fuel rod corrosion. Standard Westinghouse codes are being used for the evaluations and are based on the power history of the LFA. The most limiting design requirement is the requirement not to exceed 1 percent total strain during a transient above a burnup of 52MWd/kgU. The LFA will not be used if all limits are not met.

APS has developed an alternate core design in the event that the LFA will not be used. Reasons for not using the LFA include unacceptable poolside inspection results and unacceptable results from the necessary analyses and evaluations in areas such as fuel performance, mechanical design, corrosion and accidents. The alternate core replaces the LFA with an assembly with comparable reactivity that has the standard OPTIN cladding and will not exceed 60 Mwd/kgU burnup. The alternate design has been fully evaluated.

Based on the pre- and post-irradiation test program, agreement to report the test results, location and limited number (only one) of LFAs, the results of design evaluation and the statement that the LFA will not be used if the design criteria are not met, the staff finds it acceptable to irradiate the LFA to peak rod burnups in excess of the 60 Mwd/kgU approved limit.

4.0 CONCLUSIONS

Based on our review, the staff concludes that the proposed exemption is acceptable because the intent of the regulations is met and special circumstances exist. Furthermore, it is acceptable to irradiate the LFA to burnups in excess of the approved limit of 60MWd/kgU.

Principal Contributor: M. Chatterton

Date: October 16, 2001