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

March 2, 2000

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

SUBJECT: PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2, AND 3 - ISSUANCE OF AMENDMENTS ON FUEL STORAGE POOL CAPACITY (TAC NOS. MA5685, MA5686 AND MA5687)

Dear Mr. Overbeck:

The Commission has issued the enclosed Amendment No. 125 to Facility Operating License No. NPF-41, Amendment No. 125 to Facility Operating License No. NPF-51, and Amendment No. 125 to Facility Operating License No. NPF-74 for the Palo Verde Nuclear Generating Station, Units 1, 2, and 3, respectively.

The amendments consist of changes to the Technical Specifications in response to your application dated June 8, 1999, as supplemented by letters dated July 20 and November 24, 1999. The amendments increase the storage capacity of spent fuel in the fuel storage pools by allowing credit for soluble boron and decay time in the safety analysis, and increase the maximum radially averaged fuel enrichment from 4.3 weight percent to 4.8 weight percent.

As you requested, the licenses are being issued with an implementation date of on or before May 31, 2000. We request that you submit a letter informing the staff when these amendments are fully implemented.

DF01

Palo Verde Generating Station, Units 1, 2, and 3

cc:

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A copy of the related Safety Evaluation is also enclosed. The Notice of Issuance will be included in the Commission's next biweekly *Federal Register* notice.

Sincerely,

/RA/

Mel B. Fields, Project Manager, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

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

Enclosures:
1. Amendment No. 125 to NPF-41
2. Amendment No. 125 to NPF-51
3. Amendment No. 125 to NPF-74
4. Safety Evaluation

cc w/encls: See next page

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

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

DOCKET NO. STN 50-528

PALO VERDE NUCLEAR GENERATING STATION, UNIT 1

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 125
License No. NPF-41

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by the Arizona Public Service Company (APS or the licensee) on behalf of itself and the Salt River Project Agricultural Improvement and Power District, El Paso Electric Company, Southern California Edison Company, Public Service Company of New Mexico, Los Angeles Department of Water and Power, and Southern California Public Power Authority dated June 8, 1999, as supplemented by letters dated July 20 and November 24, 1999, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act) and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 2.C(2) of Facility Operating License No. NPF-41 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 125 , and the Environmental Protection Plan contained in Appendix B, are hereby incorporated into this license. APS shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan, except where otherwise stated in specific license conditions.

3. This license amendment is effective as of the date of issuance, and shall be implemented on or before May 31, 2000.

FOR THE NUCLEAR REGULATORY COMMISSION

Stephen Dembek, Chief, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: March 2, 2000

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

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

DOCKET NO. STN 50-529

PALO VERDE NUCLEAR GENERATING STATION, UNIT 2

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 125
License No. NPF-51

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by the Arizona Public Service Company (APS or the licensee) on behalf of itself and the Salt River Project Agricultural Improvement and Power District, El Paso Electric Company, Southern California Edison Company, Public Service Company of New Mexico, Los Angeles Department of Water and Power, and Southern California Public Power Authority dated June 8, 1999, as supplemented by letters dated July 20 and November 24, 1999, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act) and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 2.C(2) of Facility Operating License No. NPF-51 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 125, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated into this license. APS shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan, except where otherwise stated in specific license conditions.

3. This license amendment is effective as of the date of issuance, and shall be implemented on or before May 31, 2000.

FOR THE NUCLEAR REGULATORY COMMISSION

Stephen Dembek, Chief, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: March 2, 2000

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

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

DOCKET NO. STN 50-530

PALO VERDE NUCLEAR GENERATING STATION, UNIT 3

AMENDMENT TO FACILITY OPERATING LICENSE

Amendment No. 125
License No. NPF-74

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by the Arizona Public Service Company (APS or the licensee) on behalf of itself and the Salt River Project Agricultural Improvement and Power District, El Paso Electric Company, Southern California Edison Company, Public Service Company of New Mexico, Los Angeles Department of Water and Power, and Southern California Public Power Authority dated June 8, 1999, as supplemented by letters dated July 20 and November 24, 1999, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act) and the Commission's regulations set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to the Technical Specifications as indicated in the attachment to this license amendment, and paragraph 2.C(2) of Facility Operating License No. NPF-74 is hereby amended to read as follows:

(2) Technical Specifications and Environmental Protection Plan

The Technical Specifications contained in Appendix A, as revised through Amendment No. 125, and the Environmental Protection Plan contained in Appendix B, are hereby incorporated into this license. APS shall operate the facility in accordance with the Technical Specifications and the Environmental Protection Plan, except where otherwise stated in specific license conditions.

3. This license amendment is effective as of the date of issuance, and shall be implemented on or before May 31, 2000.

FOR THE NUCLEAR REGULATORY COMMISSION

Stephen Dembek, Chief, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Attachment: Changes to the Technical Specifications

Date of Issuance: March 2, 2000

ATTACHMENT TO LICENSE AMENDMENT NOS. 125, 125, AND 125

FACILITY OPERATING LICENSE NOS. NPF-41, NPF-51, AND NPF-74

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

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

REMOVE	INSERT
3.7.15-1	3.7.15-1
3.7.17-1	3.7.17-1
3.7.17-2	3.7.17-2
--	3.7.17-3
--	3.7.17-4
4.0-2	4.0-2
4.0-3	4.0-3

3.7 PLANT SYSTEMS

3.7.15 Fuel Storage Pool Boron Concentration

LCO 3.7.15 The fuel storage pool boron concentration shall be ≥ 2150 ppm.

APPLICABILITY: Whenever any fuel assembly is stored in the fuel storage pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Fuel storage pool boron concentration not within limit.	------------NOTE------------ LCO 3.0.3 is not applicable. ----------------------------	
	A.1 Suspend movement of fuel assemblies in the fuel storage pool.	Immediately
	AND	
	A.2 Initiate action to restore fuel storage pool boron concentration to within limit.	Immediately

3.7 PLANT SYSTEMS

3.7.17 Spent Fuel Assembly Storage

LCO 3.7.17 The combination of initial enrichment, burnup, and decay time of each fuel assembly stored in each of the four regions of the fuel storage pool shall be within the acceptable burnup domain for each region as shown in Figures 3.7.17-1, 3.7.17-2, or 3.7.17-3, and described in Specification 4.3.1.1.

APPLICABILITY: Whenever any fuel assembly is stored in the fuel storage pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Requirements of the LCO not met.	A.1 --------NOTE--------- LCO 3.0.3 is not applicable. --------------------- Initiate action to move the noncomplying fuel assembly into an appropriate region.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.17.1	Verify by administrative means the initial enrichment, burnup, and decay time of the fuel assembly is in accordance with Figures 3.7.17-1, 3.7.17-2, or 3.7.17-3, and Specification 4.3.1.1.	Prior to storing the fuel assembly in the fuel storage pool.

Figure 3.7.17-1
ASSEMBLY BURNUP VERSUS INITIAL ENRICHMENT
for
Region 2

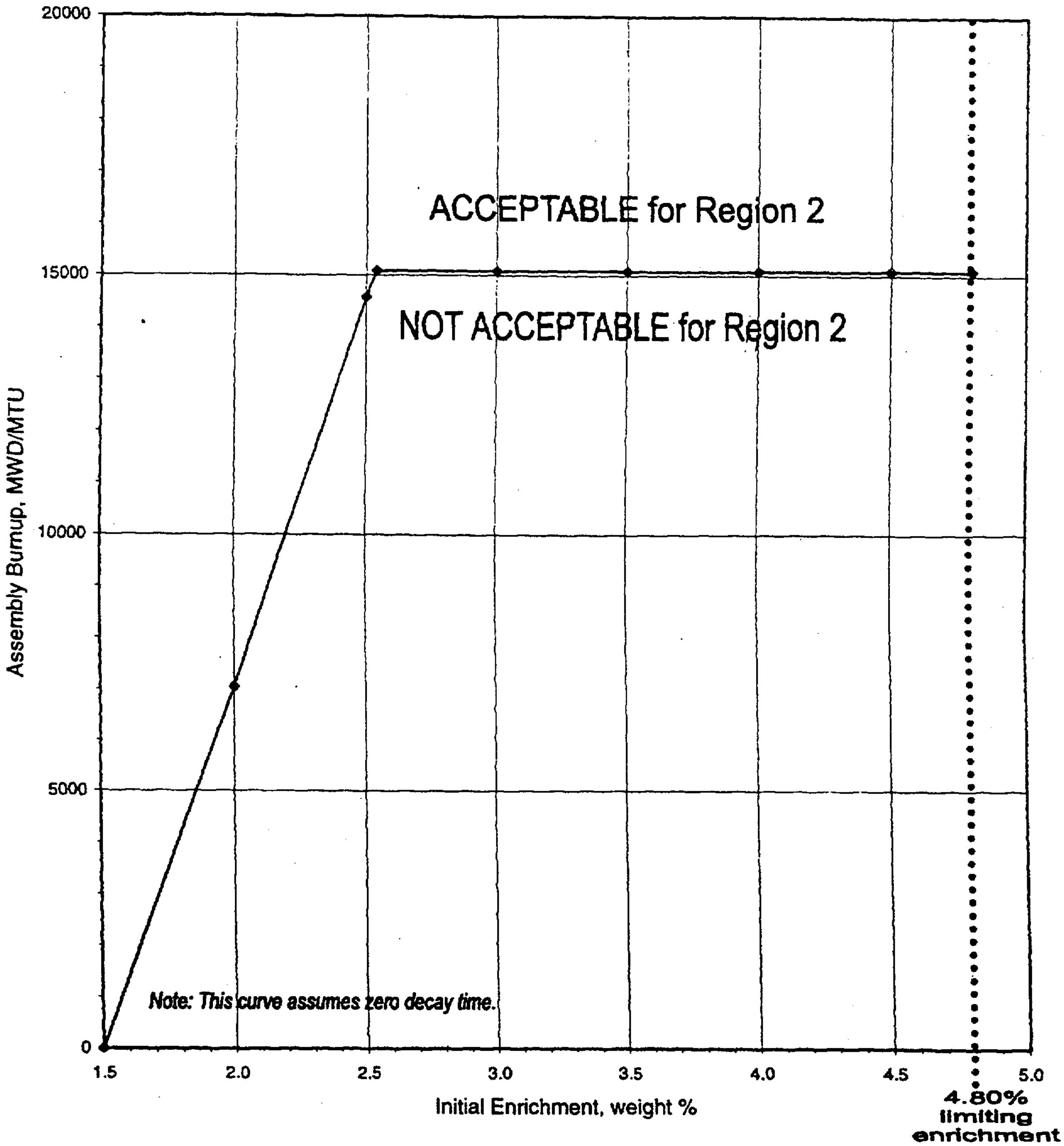


Figure 3.7.17-2
ASSEMBLY BURNUP VERSUS INITIAL ENRICHMENT
for
Region 3
(at decay times from 0 to 20 years)

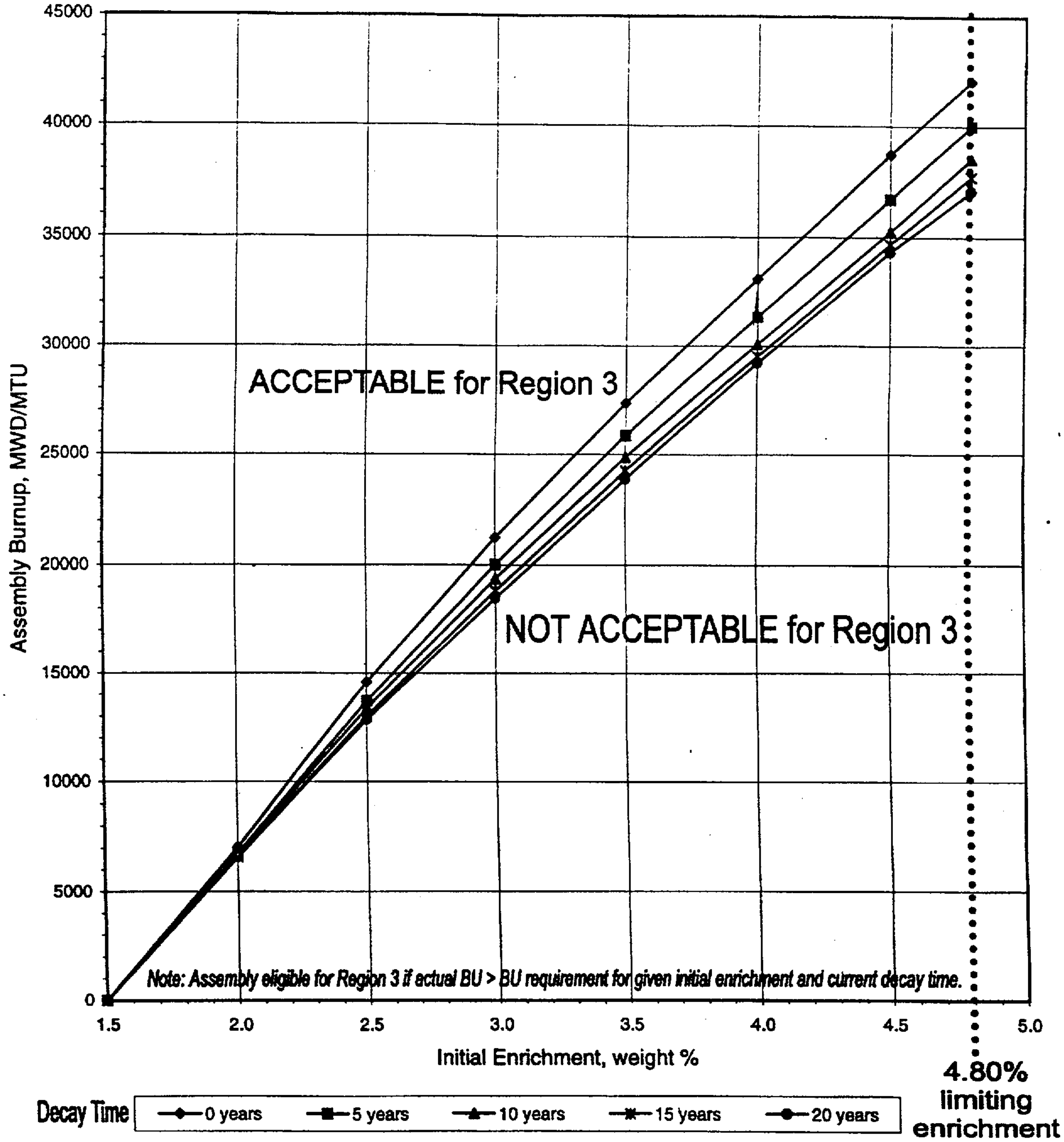
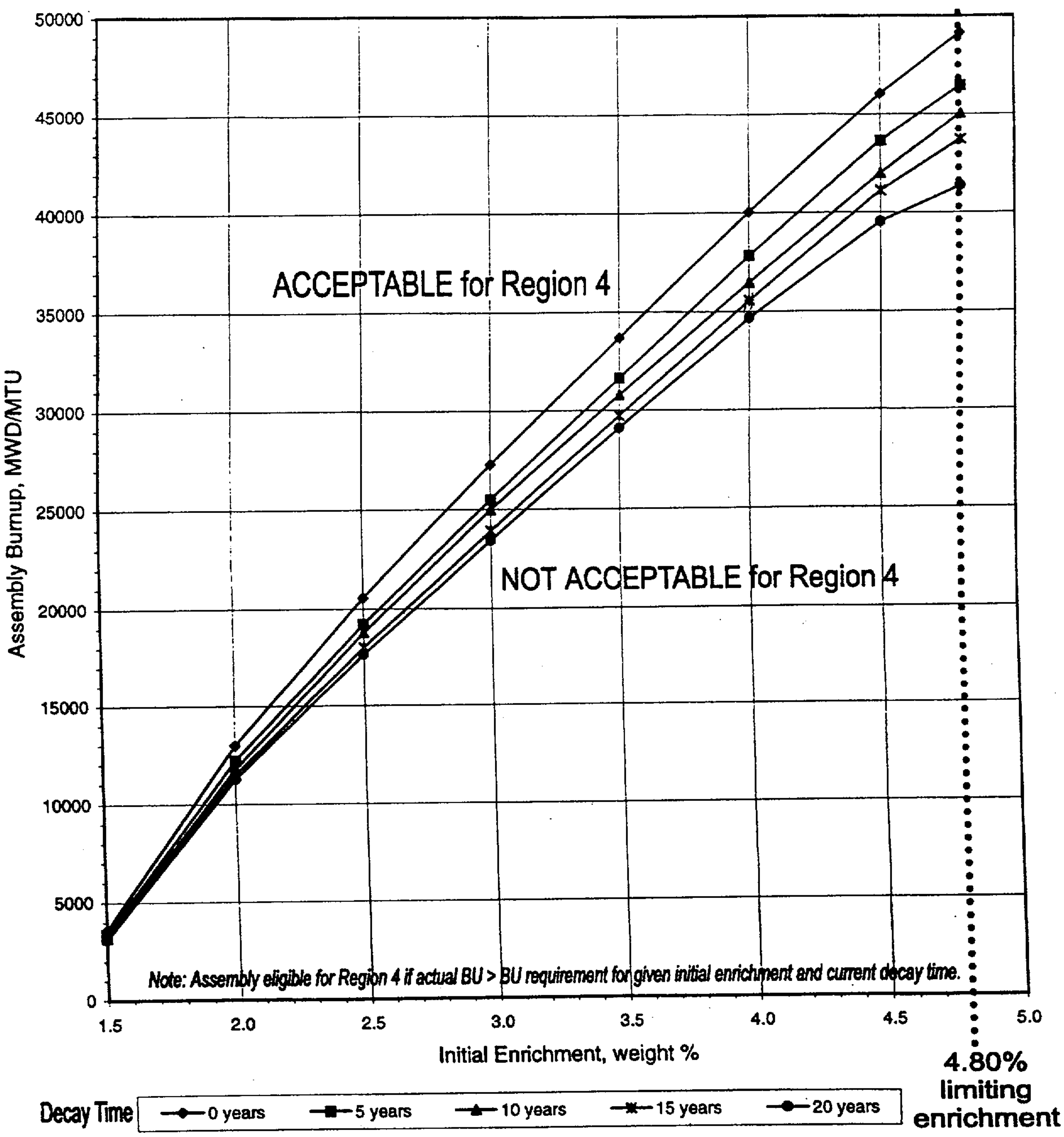


Figure 3.7.17-3
ASSEMBLY BURNUP VERSUS INITIAL ENRICHMENT
for
Region 4
(at decay times from 0 to 20 years)



4.0 DESIGN FEATURES (continued)

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum radially averaged U-235 enrichment of 4.80 weight percent;

b. $k_{eff} < 1.0$ if fully flooded with unborated water, which includes an allowance for biases and uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.95$ if fully flooded with water borated to 900 ppm, which includes an allowance for biases and uncertainties as described in Section 9.1 of the UFSAR.

d. A nominal 9.5 inch center-to-center distance between adjacent storage cell locations.

e. Region 1: Fuel shall be stored in a checkerboard (two-out-of-four) storage pattern. Fuel that qualifies to be stored in Regions 1, 2, 3, or 4 in accordance with Figures 3.7.17-1, 3.7.17-2, or 3.7.17-3, may be stored in Region 1.

f. Region 2: Fuel shall be stored in a repeating 3-by-4 storage pattern in which Region 2 (two-out-of-twelve) assemblies and Region 4 (ten-out-of-twelve) assemblies are mixed as shown in Section 9.1 of the UFSAR. Only fuel that qualifies to be stored in Regions 2, 3, or 4, in accordance with Figures 3.7.17-1, 3.7.17-2, or 3.7.17-3, may be stored in Region 2.

g. Region 3: Fuel shall be stored in a four-out-of-four storage pattern. Only fuel that qualifies to be stored in Regions 3 or 4, in accordance with Figures 3.7.17-2 or 3.7.17-3, may be stored in Region 3.

(continued)

4.0 DESIGN FEATURES (continued)

h. Region 4: Fuel shall be stored in a repeating 3-by-4 storage pattern in which Region 2 (two-out-of-twelve) assemblies and Region 4 (ten-out-of-twelve) assemblies are mixed as shown in Section 9.1 of the UFSAR. Only fuel that qualifies to be stored in Region 4 in accordance with Figure 3.7.17-3 shall be stored in Region 4.

4.3.1.2 The new fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum radially averaged U-235 enrichment of 4.80 weight percent;

b. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for biases and uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.98$ if moderated by aqueous foam, which includes an allowance for biases and uncertainties as described in Section 9.1 of the UFSAR; and

d. A nominal 17 inch center to center distance between fuel assemblies placed in the storage racks.

4.3.2 Drainage

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 137 feet - 6 inches.

4.3.3 Capacity

The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1329 fuel assemblies.

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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 125 TO FACILITY OPERATING LICENSE NO. NPF-41,

AMENDMENT NO. 125 TO FACILITY OPERATING LICENSE NO. NPF-51,

AND AMENDMENT NO. 125 TO FACILITY OPERATING LICENSE NO. NPF-74

ARIZONA PUBLIC SERVICE COMPANY, ET AL.

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

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

1.0 INTRODUCTION

By application dated June 8, 1999, as supplemented by letters dated July 20 and November 24, 1999, Arizona Public Service Company (APS or the licensee) requested changes to the Technical Specifications (TSs) for the Palo Verde Nuclear Generating Station (Palo Verde), Units 1, 2, and 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.

The proposed amendments would increase the storage capacity of spent fuel in the fuel storage pools by allowing credit for soluble boron and decay time in the safety analysis, and would increase the maximum radially averaged fuel enrichment from 4.3 weight percent (w/o) to 4.8 w/o uranium-235 (U-235).

The July 20 and November 24, 1999, supplements provided clarifying information that was within the scope of the original *Federal Register* notice and did not change the staff's initial proposed no significant hazards consideration determination.

2.0 BACKGROUND

The fuel storage racks in each Palo Verde spent fuel pool have a total of 1329 storage cells, each capable of holding a spent fuel assembly. The TSs currently limit the maximum number of fuel assemblies that can be stored in a spent fuel pool to no more than 1034 fuel assemblies in the Unit 1 and 3 spent fuel pools, and no more than 1033 fuel assemblies in the Unit 2 spent fuel pool. For normal operating conditions, no credit is currently taken for soluble boron in the spent fuel pools even though the pools are always filled with borated water.

The licensee is planning on implementing dry cask storage in the second half of 2002. However, the spent fuel pools will lose the capacity to fully offload the reactor core during refueling outages prior to that time. To increase the spent fuel pool allowable capacity to 1205 assemblies, the licensee is requesting credit for soluble boron, credit for fuel assembly burnup, and for fuel assembly configuration in the spent fuel criticality analysis.

The proposed amendments would also increase the maximum radially averaged fuel enrichment from 4.3 w/o to 4.8 w/o U-235. This change would allow additional flexibility in future core designs.

3.0 EVALUATION

3.1 Criticality Analyses

The licensee evaluated the Palo Verde spent fuel storage racks using criticality methodology analogous to that developed by the Westinghouse Owners Group (WOG) and described in WCAP-14416-NP-A, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology," (Ref.1) which has been reviewed and approved by the NRC. This methodology takes partial credit for soluble boron in the fuel storage pool criticality analyses and requires conformance with the following NRC acceptance criteria for preventing criticality outside the reactor:

1) k_{eff} shall be less than 1.0 if fully flooded with unborated water, which includes an allowance for uncertainties at a 95 percent probability, 95 percent confidence (95/95) level; and

2) k_{eff} shall be less than or equal to 0.95 if fully flooded with borated water, which includes an allowance for uncertainties at a 95/95 level.

The analysis of the reactivity effects of fuel storage in the Palo Verde spent fuel racks was performed with SCALE-PC, a personal computer version of the SCALE-4.3 code package (which includes KENO-Va, NITAWL, CSAS-2, and BONAMI), with the updated 44-group Evaluated Nuclear Data File Version 5 (ENDF/B-V) cross section library. Since the KENO-Va code package does not have burnup capability, depletion analyses were made with the two-dimensional integral transport theory code, DIT, which uses an 89-group structure collapsed from the Version 6 ENDF/B-VI library. The NRC staff has accepted the use of a DIT cross section library based on ENDF/B-VI (Ref. 2). The SCALE-PC models used in the reactivity analysis have been benchmarked against experimental data for fuel assemblies similar to those for which the Palo Verde racks are designed and have been found to adequately reproduce the critical values. The selected critical experiments included the Babcock & Wilcox experiments carried out in support of close proximity storage of power reactor fuel and the Pacific Northwest Laboratory program carried out in support of the design of fuel shipping and storage configurations. This experimental data is sufficiently diverse to establish that the method bias and uncertainty will apply to the Palo Verde storage rack conditions. The DIT code and its cross section set have been used in the design of reload cores and extensively benchmarked against operating reactor history and test data. The staff concludes that the analysis methods used are acceptable and capable of predicting the reactivity of the Palo Verde storage racks with a high degree of confidence.

The Palo Verde spent fuel storage racks are designed to store either fresh (unirradiated) fuel assemblies or burned (irradiated) fuel assemblies in a borated water pool. The storage racks have previously been qualified for storage of fuel assemblies with maximum radially averaged enrichments up to 4.3 w/o U-235. Assemblies are currently stored within the racks in 2-out-of-4, 3-out-of-4, and 4-out-of-4 (all cells) configurations depending on the initial average enrichment and the burnup of the assembly. Cell blocking devices are inserted to prevent inadvertent assembly storage in cells that are required to be empty. The racks contain no absorber materials for reactivity holddown (e.g., Boraflex or boral).

The proposed four-region fuel storage configuration is shown in Figures 3.1 and 3.2 of CENPD-395 (Ref. 3). Several nomenclatures are associated with the proposed configuration:

(1) Region 1 is comprised of two 9x8 storage racks and one 12x8 storage rack. Fresh fuel assemblies enriched to a maximum of 5.0 w/o U-235 are stored in a 2-out-of-4 checkerboard configuration alternating with empty cells. The fresh assembly locations contain a stainless steel L-insert for reactivity and position control. The empty cells contain a cell blocking device to prevent the accidental insertion of any fuel assembly. The empty locations are referred to as Region 0. The fresh fuel assembly locations are referred to as Region 1. There are 120 empty locations and 120 fresh assembly locations. The final 95/95 k_{eff} for the Regions 0 and 1 checkerboard configuration was 0.93999 with no soluble boron.

(2) Regions 2 and 4 are mixed and are comprised of seven 9x8 storage racks and three 12x8 storage racks. Regions 2 and 4 are mixed in a repeating 3x4 storage pattern in which 2-out-of-12 cell locations are designated Region 2 and 10-out-of-12 cell locations are designated Region 4. Lightly burned assemblies (4.8 w/o U-235 initial enrichment irradiated to 15,086 megawatt-days/metric ton of uranium (MWD/MTU)) are designated as Region 2 and heavily burned assemblies are designated as Region 4. There are 132 storage locations allocated for Region 2 assemblies and 660 storage locations allocated for Region 4 assemblies. Since fuel assemblies may be stored in every Region 2 and Region 4 cell location, no cell blocking devices are installed in Region 2 and Region 4. Reactivity equivalencing (discussed below in more detail) was used to determine the burnup versus initial enrichment pairs required for Region 4 fuel to achieve a 95/95 k_{eff} of 0.999 with no soluble boron.

(3) Region 3 is comprised of three 9x8 storage racks and one 9x9 storage rack. Since fuel assemblies may be stored in every Region 3 cell location, no cell blocking devices are installed in Region 3. Medium burned fuel assemblies are designated as Region 3 in Figures 3.1 and 3.2 of CENPD-395. Reactivity equivalencing was also used to determine the burnup versus initial enrichment required for Region 3 fuel to achieve a 95/95 k_{eff} of 0.999 with no soluble boron.

The following assumptions were used in the rack reactivity calculations to support an increase in the number of fuel assemblies that may be stored in the Palo Verde fuel pools. The fuel assemblies contain uranium oxide (UO_2) over the entire length of each fuel rod and a uniform distribution of enrichments. Reactivity calculations for a given radially averaged enrichment with uniform fuel enrichments were found to bound those with zoned fuel enrichment distributions (Ref. 3). All fuel assemblies contain 236 fuel rods in a 16x16 fuel rod array with a nominal pitch of 0.5065 inch between fuel rods, a fuel pellet diameter of 0.3255 inch, and a UO_2 density of 10.31 grams/cubic centimeter (g/cc). A methodology bias (determined from benchmark calculations) as well as a reactivity bias to account for the effect of the normal range of spent fuel pool water temperatures (68 °F to 150 °F) were included. Uncertainties due to tolerances in fuel enrichment and density, module wall and L-insert thickness, storage cell pitch, assembly position, calculational uncertainty, and methodology bias uncertainty were accounted for. These uncertainties were appropriately determined at the 95/95 probability/confidence level. These biases and uncertainties meet the previously stated NRC requirements and are, therefore, acceptable.

A detailed KENO-Va model was then developed for the entire Palo Verde spent fuel pool to analyze the interfaces between the different modules and to determine the soluble boron requirements to satisfy the criterion that k_{eff} be less than or equal to 0.95, including biases and uncertainties. The fuel assemblies in the KENO-Va simulation had the following characteristics by region:

Region	Description of Fuel Assemblies in Region
0	None. Empty water location containing a cell blocking device
1	Fresh fuel assemblies enriched to 5.0 w/o U-235
2	Depleted fuel assemblies initially enriched to 4.80 w/o U-235 and depleted to 15,086 MWD/MTU
3	Burned fuel assemblies with a fresh fuel equivalent enrichment equal to 1.55 w/o U-235
4	Burned fuel assemblies with a fresh fuel equivalent enrichment equal to 1.35 w/o U-235

k_{eff} values were calculated for the entire spent fuel pool at 0, 200, 400, and 600 ppm of soluble boron assuming both fresh fuel equivalent enrichments for Regions 3 and 4 and burned fuel descriptions. The soluble boron worth using burned fuel assembly descriptions resulted in a smaller soluble boron worth and therefore was conservatively used to determine the boron concentration required to maintain $k_{eff} \leq 0.95$ and to compensate for accident scenarios that could increase the reactivity of the spent fuel pool. The amount of soluble boron required to maintain $k_{eff} \leq 0.95$ (including biases and uncertainties) was found to be 374 ppm. This boron value is well below the minimum spent fuel pool boron concentration value of 2150 ppm required by TS 3.7.15 and is, therefore, acceptable.

The concept of reactivity equivalencing due to fuel burnup was used to define the conditions under which fresh and irradiated fuel assemblies are interchangeable on an overall reactivity basis. The NRC has previously accepted the use of reactivity equivalencing to equate an array of fresh fuel assemblies and their enrichments, that have been shown to be acceptable for storage, into an array of irradiated assemblies with different initial enrichments, decay times, and burnable absorber concentrations. To determine the amount of soluble boron required to maintain $k_{eff} \leq 0.95$ for storage of fuel assemblies with enrichments higher than those acceptable for storage of fresh assemblies, a series of reactivity calculations were performed to generate a set of enrichment versus fuel assembly discharge burnup ordered pairs which all yield an equivalent k_{eff} when stored in the spent fuel storage racks.

The analysis also included spent fuel decay time credit, which results from the radioactive decay of isotopes in the spent fuel to daughter isotopes. The loss in reactivity due to the radioactive decay of the spent fuel results in reducing the minimum burnup needed to meet the reactivity requirements. The reactivity of an irradiated fuel assembly will decrease following its discharge from the reactor and the decay of short lived fission products due to the decay of actinides and long half-life fission products. For long cooling periods, the decay of plutonium-241 (Pu-241), with a half-life of approximately 14 years, to americium-241 (Am-241) is the most important contribution to a reduction in fuel assembly reactivity. The minimum required burnup for initial assembly enrichments between 1.5 and 4.8 w/o U-235 are shown in TS Figure 3.7.17-2 for Region 3 fuel and Figure 3.7.17-3 for Region 4 fuel. These burnup-enrichment pair data also include credit for actinide decay from 0 to 20 years.

Uncertainties associated with burnup credit include a reactivity uncertainty of 0.005 Δk at 30,000 MWD/MTU applied linearly to the burnup credit requirement to account for calculational and depletion uncertainties. Benchmarking of the design codes for several operating cycles demonstrated a small reactivity bias which is bounded by the bias of 0.005 Δk per 30,000 MWD/MTU. An uncertainty of 5 percent was also applied to the calculated burnup to account for burnup measurement uncertainty. The NRC staff concludes that these uncertainties conservatively reflect the uncertainties associated with burnup calculations and are acceptable. The soluble boron credit required for reactivity equivalencing methodologies was determined by converting the uncertainty in fuel assembly reactivity and the uncertainty in absolute fuel assembly burnup values to a soluble boron concentration (parts per million, ppm) necessary to compensate for these two uncertainties. The required soluble boron concentration was determined to be 126 ppm. Adding this to the soluble boron credit of 374 ppm required for k_{eff} to be less than or equal to 0.95 results in a total soluble boron credit of 500 ppm. This value is well below the minimum spent fuel pool boron concentration value of 2150 ppm required by TS 3.7.15 and is, therefore, acceptable.

Although most accidents will not result in a reactivity increase, two accidents can be postulated that could increase reactivity beyond the analyzed conditions. The first would be a boron dilution event, which is discussed in Section 3.2 of this safety evaluation. The second accident would be a misload of an assembly into a cell for which the restrictions on location, enrichment, or burnup are not satisfied. Calculations have shown that the misloading of a fresh 5.0 w/o fuel assembly into a cell location required to contain a less reactive fuel assembly results in the highest reactivity increase. However, for such events, the double contingency principle can be applied. This states that the assumption of two unlikely, independent, concurrent events is not required to ensure protection against a criticality accident. The reactivity increase requires an additional 400 ppm of soluble boron to maintain $k_{eff} \leq 0.95$. Therefore, the minimum amount of boron required by TS 3.7.15 (2150 ppm) is more than sufficient to cover any accident and the presence of the additional boron above the concentration required for normal conditions and reactivity equivalencing (500 ppm maximum) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

The licensee's July 20, 1999, letter contained similar calculations which were performed for the new fuel elevator, the fuel upender and transfer machine, and the intermediate fuel storage rack. The results show that $k_{eff} \leq 0.95$ (including all biases and uncertainties) in unborated water. Therefore, the fuel in the new fuel elevator, the fuel upender and transfer machine, and the intermediate fuel storage rack will continue to remain subcritical with the proposed increase in radially averaged enrichment to 5.0 w/o U-235.

The licensee proposes to modify TS 3.7.15, "Fuel Storage Pool Boron Concentration," to make it applicable whenever any fuel assembly is stored in the fuel storage pool. TS 3.7.17, "Spent Fuel Assembly Storage," would be revised to include decay time along with modified initial enrichment and burnup requirements to determine the region in which each fuel assembly can be stored. In addition, the maximum radially averaged enrichment allowed in the figures would be increased from 4.3 to 4.8 w/o U-235. TS 4.3.1, "Criticality," would be revised to require a k_{eff} less than 1.0 (including all biases and uncertainties) with the spent fuel pool fully flooded with unborated water and a $k_{eff} \leq 0.95$ (including all biases and uncertainties) with the spent fuel pool flooded with water borated to 900 ppm. These proposed TS changes are consistent with the revised criticality analysis evaluated above. Based on this consistency and on the use of approved methodology, the staff finds these TS changes acceptable.

TS 4.3.1.2, which requires the new (fresh) fuel storage racks be designed and maintained with a $k_{eff} \leq 0.95$ when fully flooded with unborated water and $k_{eff} \leq 0.98$ if moderated with aqueous foam (including all biases and uncertainties), would be modified to increase the maximum radially averaged enrichment from 4.3 to 4.8 w/o U-235. The licensee's July 20, 1999, letter contained a new analysis which was performed to determine that the proposed increase in maximum radially averaged enrichment to 4.8 w/o U-235 would still meet these limits. The new analysis conservatively assumed a radially averaged enrichment of 5.0 w/o U-235 and confirmed that the k_{eff} for the new fuel storage racks would continue to be $\leq$ 0.95 when fully flooded with unborated water and $\leq$ 0.98 if moderated by aqueous foam (including all biases and uncertainties). Therefore, the increased radially averaged enrichment will not affect the requirements of TS 4.3.1.2.b and c and the proposed change to TS 4.3.1.2 is acceptable.

Although the Palo Verde TSs have been modified to specify the above-mentioned fuel as acceptable for storage in the new and spent fuel racks, evaluations of reload core designs using any enrichment will continue to be performed on a cycle-by-cycle basis as part of the reload safety evaluation process. Each reload design is evaluated to confirm that the cycle core design adheres to the limits that exist in the accident analyses and in the TSs to ensure that reactor operation is acceptable.

Based on the review described above, the staff finds the criticality aspects of the proposed license amendments requesting credit for soluble boron and an increase in radially averaged enrichment for fuel storage are acceptable and meet the requirements of General Design Criterion 62 for the prevention of criticality in fuel storage and handling. The criticality analysis conforms to the NRC guidance for the assurance of criticality safety in spent fuel storage pools (Ref. 4).

3.2 Boron Dilution Analysis

The licensee performed a boron dilution analysis based on the NRC-approved Westinghouse Owners Group generic methodology for crediting soluble boron given in Topical Report WCAP-14416-NP-A (Ref. 1). The objective of the analysis is to ensure that sufficient time is available to detect and mitigate the dilution prior to exceeding the 0.95 k_{eff} design basis. The analysis applies to all three spent fuel pools since they are essentially identical. Potential events were quantified to show that sufficient time will be available to enable adequate detection and suppression of any dilution event.

Deterministic dilution event calculations were performed to define the dilution times and volumes necessary to dilute the spent fuel pool from an initial boron concentration of 2150 ppm to a soluble boron concentration of 900 ppm. The current TS limit for the minimum boron concentration is 2150 ppm. Currently, the licensee administratively maintains the boron concentration at 4000 to 4400 ppm in the spent fuel pool. The licensee conservatively chose a boron concentration of 2150 ppm as the initial concentration for the boron dilution event. Based on the licensee's criticality analysis, the soluble boron concentration required to maintain the spent fuel pool at k_{eff} less than 0.95 is less than the minimum boron concentration of 900 ppm used by the licensee in the boron dilution analysis. The staff's acceptance of this boron concentration value is contained in Section 3.1 of this safety evaluation. As such, the boron dilution analysis is considered acceptable as long as the evaluated dilution events do not reduce the spent fuel pool boron concentration to less than 900 ppm.

Each spent fuel pool has a nominal water inventory of 340,000 gallons. The minimum operational volume for each spent fuel pool is 320,000 gallons. The minimum operational volume was conservatively used in the boron dilution analysis. The staff calculated the volume required to dilute the spent fuel pool from 2150 ppm to 900 ppm. Using the methodology described in WCAP-14181-NP (Ref. 5), the volume required is approximately 278,700 gallons of non-borated water. This calculation assumed that the spent fuel pool was well mixed and had a constant volume.

The licensee considered various events that have the potential to dilute the spent fuel pool. These included dilution from the demineralized water system, fire protection system, domestic water system, nuclear cooling water and essential cooling water systems, and pool clean up ion exchangers. Most of these dilution events take longer than 12 hours to reach the minimum boron concentration. These events would be detected by plant personnel during required rounds every 12 hours. Other events that may affect the boron concentration of the spent fuel pool such as pipe cracks and loss of offsite power were also evaluated. The licensee stated that all pipes in the vicinity of the spent fuel pool are moderate energy lines, seismic category IX. As such, a random pipe break was not considered in their analyses. However, at the request of the staff, the licensee did evaluate the consequences of a break in the fire protection line in the spent fuel area (discussed below in more detail). The licensee followed the guidance of ANS/ANSI 58.2-1980 for through wall crack opening of the postulated pipe cracks.

Both the condensate transfer system and the fire protection system have tanks large enough to dilute the spent fuel pool without replenishment. The usable volume of the condensate storage tank is approximately 528,000 gallons. The condensate transfer system is directly connected to the spent fuel pool through a line that is isolated by a closed manual valve. The largest dilution rate would be 260 gallons per minute (gpm) (130 gpm per pump), which would take over 17 hours to dilute the spent fuel pool to 900 ppm. The fire protection system has two tanks large enough to dilute the spent fuel pool without replenishment. The volume of a fire protection tank is approximately 500,000 gallons. The fire protection system piping is in the vicinity of the spent fuel pool. In accordance with ANS/ANSI 58.2-1980, the licensee postulated a crack developing in the 4-inch fire protection system line. For this case, the approximate dilution rate would be 85 gpm and would take over 2 days to dilute the spent fuel pool to 900 ppm.

In response to the staff's request for additional information, the licensee considered a break of the fire protection line in the spent fuel pool area. The licensee does not consider the scenario to be credible and does not assume it to be part of the Palo Verde design basis. Due to the terrain at Palo Verde, the top of all three spent fuel pools is below the maximum level in the fire protection water tanks. In particular, there is approximately 9 feet difference between the top of the Unit 3 spent fuel pool and the maximum level of the fire protection water tanks. The volume of water in the top 9 feet of the fire protection water tank is approximately 240,000 gallons of non-borated water. As discussed above, approximately 278,700 gallons of non-borated water is required to dilute the spent fuel pool to 900 ppm. Therefore, a random break of the fire protection riser on the 140-foot elevation of the spent fuel pool is not sufficient to dilute the pool to the minimum boron concentration.

Other evaluated dilution events take longer than 12 hours to reach the minimum boron concentration. These events would be detected by plant personnel during required rounds. Additionally, spent fuel pool level instrumentation alarms in the control room. If a dilution event caused the level in one spent fuel pool to increase from the low level setpoint to the high level alarm point (1-foot span), approximately 1.1 hours would pass before an alarm is received in the control room. This is equivalent to a reduction of boron concentration of 100 ppm from 2150 ppm. To detect low flow, long-term dilution events, the TSs require that the spent fuel pool be sampled every 7 days. Additionally, the licensee has administratively isolated all non-borated sources to the spent fuel and refueling pools. The licensee will impose additional requirements to administratively estimate and verify the boron content of the spent fuel pool each time non-borated sources are used to add inventory to the pool.

The licensee concluded that an unplanned or inadvertent event that would dilute the spent fuel pool boron concentration from 2150 ppm to 900 ppm would be readily detectable by plant personnel via alarms or by normal operator rounds through the spent fuel pool area.

The staff finds that the combination of the large volume of water required for a dilution event, TS-controlled spent fuel pool concentration and 7-day sampling requirement, and plant personnel rounds would adequately detect a dilution event prior to k_{eff} reaching 0.95 (900 ppm). Therefore, the analysis and proposed TS controls are acceptable for the boron dilution aspects of the request.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Arizona State official was notified of the proposed issuance of the amendments. The State official had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.21, 51.32, and 51.35, an environmental assessment and finding of no significant impact was published in the *Federal Register* on March 1, 2000 (65 FR 11097) for this amendment. Accordingly, based upon the environmental assessment, the Commission has determined that issuance of this amendment will not have a significant effect on the quality of the human environment.

6.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above, that (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

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Date: March 2, 2000

7.0 REFERENCES

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3. "Palo Verde Spent Fuel Pool Criticality Analysis," CENPD-395, Rev. 0, January 1999.

4. L. Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," NRC Memorandum to T. Collins, August 19, 1998.

5. Cassidy, B., et al., Westinghouse Owners Group, "Westinghouse Owners Group Evaluation of the Potential For Diluting PWR Spent Fuel Pools," WCAP-14181-NP, July 1995.