APS

Palo Verde Nuclear
Generating Station

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U.S. Nuclear Regulatory Commission
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Reference: Letter 102-04294-JML/SAB/RKR, dated June 8, 1999, from J. M. Levine, APS, to NRC, "Request for Amendment to Technical Specification 3.7.15, Fuel Storage Pool Boron Concentration; 3.7.17, Spent Fuel Assembly Storage; and 4.3.1, Criticality."

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN 50-528/529/530
Response to NRC Request for Additional Information

In the referenced letter, Arizona Public Service Company (APS) requested an amendment to Technical Specification 3.7.15, Fuel Storage Pool Boron Concentration; 3.7.17, Spent Fuel Assembly Storage; and 4.3.1, Criticality, for each Palo Verde Nuclear Generating Station (PVNGS) Unit. In a phone call on November 18, 1999, the NRC staff requested additional information required to complete the review of the amendment request. The discussion identified changes to the dilution analysis provided in the referenced letter in enclosure 4, "Palo Verde Nuclear Generating Station Spent Fuel Pool Boron Dilution Analysis (13-NS-C44)." Attachment 1 provides responses to the NRC staff questions. Attachment 2 provides replacement pages for enclosure 4 to the referenced letter.

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No commitments are being made to the NRC by this letter.

Should you have any questions, please contact Scott A. Bauer at (623) 393-5978.

Sincerely,

Michael J. Wersin
for D Mauldin

CDM/SAB/RKR/mah

Attachments

cc: E. W. Merschoff (all w/Attachment)
M. B. Fields
J. H. Moorman
A. V. Godwin

ATTACHMENT 1

Response to NRC Request for Additional Information

Response to NRC Request for Additional Information

1. NRC Question: Page 24 of the referenced letter, enclosure 4, "Palo Verde Nuclear Generating Station Spent Fuel Pool Boron Dilution Analysis (13-NS-C44)," states that the spent fuel pool (SFP) volume is conservatively assumed to be 340,000 gallons. On pages 14, 25, and 27 the volume is given as 320,000 gallons. What is the correct volume?

   APS Response: 340,000 gallons is the nominal SFP volume. 320,000 gallons is the minimum operational volume. The volume of 320,000 gallons was used in the analysis in order to obtain the minimum volume of water needed to dilute the SFP to 900 ppm. The value on page 24 has been revised to 320,000 gallons and the revised page is included in attachment 2.

2. NRC Question: The volumes of non-borated water required to dilute the SFP from 2150 to 900 ppm boron are listed on page 25 for both normal conditions with the pool volume at the minimum level of 320,000 gallons and for post seismic conditions when the pool volume could be as low as 206,000 gallons. Are the listed volumes correct?

   APS Response: The volumes provided on page 25 are the total volumes of water, borated and non-borated that would result if non-borated water was added to the initial volume of water in each case until the 900 ppm boron concentration was reached. The volume of water that had to be added the pool to achieve this dilution is the difference between these values and the initial volume. The volume of water added should have been provided in both cases. The discussion on page 25 has been corrected and the revised page is included in attachment 2. This change also resulted in a change to page 29. The revised page 29 is also included in attachment 2.

3. <u>NRC Question:</u> In Table 4 on page 21, what does the NA mean?

<u>APS Response:</u> The "NA" indicates that there are no scenarios that would result in a discharge of non-borated water into the SFP. These system piping/components are located below the SFP normal water level and/or are isolated by manual valves. A note has been added to Table 4, resulting in a change to page 21. The revised page 21 is included in attachment 2.

4. <u>NRC Question:</u> Are the fire protection water tanks at a higher elevation than the SFPs? If they are, does this result in the fire protection system becoming a dilution source following a seismic event due to gravity draining of the fire protection water tanks?

<u>APS Response:</u> The top of the SFPs in all three units is lower than the maximum level in the fire protection water tanks. Due to site terrain, the Unit 3 SFP is at the lowest elevation. The top of the Unit 3 SFP is approximately 9 feet below the maximum water level in the fire protection water tanks. In order to get dilution flow to the SFP from the fire protection water tanks, a line break would have to occur in the fire protection riser on the 140 foot elevation of the spent fuel building in the space between the floor and 9 feet above the floor level with the worst case break being right at the floor level. This scenario would also depend on there being no other breaks in the fire protection lines between the 140 foot elevation and the fire protection water tanks. PVNGS does not consider this to be a credible scenario. Therefore, this scenario is not part of the PVNGS design basis.

Nonetheless, the volume of water in the top nine feet of the fire protection water tanks is approximately 2.4 E+5 gallons. As discussed in section 7.0 of the dilution analysis it would take 2.8 E+5 gallons of non-borated water to dilute the SFP from 2150 ppm to 900 ppm boron following a seismic event. Therefore, gravity drainage from the fire protection water tanks to the Unit 3 SFP could not deliver sufficient water to dilute the SFP to 900 ppm.

ATTACHMENT 2

Replacement Pages for the Referenced Letter, Enclosure 4, "Palo Verde Nuclear Generating Station Spent Fuel Pool Boron Dilution Analysis (13-NS-C44).

Replace pages 21, and 24 through 29 in reference 1, enclosure 4, "Palo Verde Nuclear Generating Station Spent Fuel Pool Boron Dilution Analysis (13-NS-C44)," with the attached replacement pages 21, and 24 through 29. Section 7.0 "Spent Fuel Pool Dilution Evaluation" is being replaced in its entirety. The changes include the changes discussed in Attachment 1 and editorial changes that do not change the meaning or conclusions.

Table 4 - Summary of Dilution Sources for Spent Fuel Pool

	Normal	Event Related	Pipe Break
Condensate transfer system	100 (gpm)	NA *	NA *
Liquid radwaste recycle monitor tank	150 (gpm)	NA*	NA*
Fire Protection Supply Lines	NA*	45 - 500[1] (gpm) (Fires)	85 (gpm)
Demineralized Water System			
- Decon / Utility station	NA*	50 (gpm) (Operator error)	23 (gpm)
- Spent Fuel Pool Clean up System resin change out	850 Gal / change	NA*	NA*
Domestic water Utility Station	NA*	50 (gpm) (Operator error)	4 (gpm)
Nuclear cooling / Essential cooling	1 (gpm)	85 (gpm) (tube rupture)	NA*
De-boration by pool clean up Ion Exchange	7 – 10 PPM / change	NA*	NA*

* Note: "NA" indicates that there are no scenarios that would result in discharge of non-borated water into the SFP. These system piping / components are located below the SFP normal water level and / or are isolated by manual valves.

6.0 INSTRUMENTATION

6.1 Loss of Offsite Power and Impact on the Spent Fuel Pool Level Instrumentation

Instrumentation is provided which monitors the temperature and the water level in both the refueling and spent fuel pools. Spent fuel pool alarms are annunciated locally and in the control room. Refueling pool computer alarms are annunciated in the control room only. Additional instrumentation, monitored locally, is provided to check inlet and outlet temperatures on the heat exchangers, and to determine the pressure of the cooling pump discharge. The power source for instrumentation is provided by normal 120 VAC (Panel E- NNN–D015). Automatic transfer to back up reliable power source is available. Additionally, in the event that the distribution panel E-NNN-D15 is lost due to shedding of MCC E-NHN-M19 in a loss of all power event, provisions are made to enable operators to load key instruments on emergency diesels (Ref. 55 through 58). Procedures 40AO-9ZZ15 and 40AO-9ZZ12 provide instruction for the implementation of the design and to ensure that loss of annunciators, and degraded electrical power conditions are addressed (Ref. 59 and 60).

1 500 gpm is the maximum flow of a fire hose station. 45 gpm, is estimated flow for sprinkler system.

E-NNN-D11 & D12 similar to the BAMP and RWMP instrumentation described previously (Ref. 68 & 70).

Flow indicators SIA-FI-338 & SIB-FI-348 provide Control Room flow indication for the CS pump "A" and "B" Trains respectively (Ref. 75). These instrument loops are designed to Quality Class Q and Seismic Category I requirements (Ref. 75). The Class 1E Instrumentation Distribution Panels, PNA-D25 & PNB-D26 respectively power these flow-monitoring loops (Ref. 62 & 74). These indicators are located on Control Boards B02E and B02D in the Control Room.

The pump discharge pressure is available in the Control Room for the LPSI pump makeup flow path to the SFP. The indicators SIN-PI-306 & PI-307, described above for the CS pumps, provide pressure indication for this alignment also. There is no flow indication either locally or in the Control Room for the LPSI pump makeup flow path to the SFP.

6.3 Loss of Offsite Power and Impact on Other Systems Instrumentation

Instrumentation on all non-quality systems such as nuclear cooling water, liquid radwaste, Domestic water, and Demineralized water could be lost during total loss of power. These systems instrumentation are not critical during mitigation of boron dilution event.

Therefore essential instrumentation on this system could be available. Instrumentation for Condensate Storage and Transfer System and Essential Cooling Water system are available during total loss of power and backup by a 1E power source.

7.0 SPENT FUEL POOL DILUTION EVALUATION

For the purposes of evaluating spent fuel pool dilution times and volumes, the total pool volume available for dilution is conservatively assumed to be 320,000 gallons (Ref. 76), for normal plant operation (operator error), fire event and pipe breaks. The volume of the transfer canal and cask loading pit are 34,000 and 82,000 gallons respectively. During normal plant operation the cask-loading pit is filled with borated water and the transfer canal may be filled. They are both isolated from the main pool by pneumatic sealed gates. The normal configuration of the spent fuel pool is to have all of the gates in place. In this configuration, any dilution of the pool, the transfer canal or cask loading pit is assumed to affect only the body of water that non-borated water is introduced in.

During a seismic event, the total pool volume available for dilution is conservatively assumed to be 206,000 gallons (Ref. 77). During this event, due to the failure of non-quality pool gates and pool clean up system, all bodies of water would reach equilibrium at elevation 133ft. The initial conditions for the event are assumed to be as follows; spent fuel pool water level is at 137 ft, the cask loading pit is only filled to the 133 ft elevation, and the transfer canal is empty prior to the event. In this configuration, any dilution in the spent fuel pool, the transfer canal or cask loading pit is assumed to affect all bodies of water that non-borated water is introduced.

The boron concentration currently maintained in the spent fuel pool is 4,000 – 4,400 ppm for plant Modes 1 through 6. In addition, the boron concentration is maintained at greater than

2,150 ppm when irradiated fuel is stored in the spent fuel pool. Based on newly proposed Technical Specification, LCO 3.7.15, the minimum allowable soluble boron concentration required to maintain the spent fuel boron concentration at $K_{eff} < 0.95$, including uncertainties and burnup, with a 95% probability at a confidence level (95/95) is 900 ppm.

For the purposes of evaluating dilution times and volumes, the initial spent fuel pool boron concentration is assumed to be at the current Technical Specification Limit of 2,150 ppm. The evaluations are based on the spent fuel pool boron concentration being diluted from 2,150 ppm to 900 ppm. To dilute the spent fuel pool volume of 320,000 gallons during normal operation, from 2,150 ppm to 900 ppm, it would conservatively require 4.4E+5 gallons of non-borated water. Following a seismic event, the volume of water in the pool would be approximately 206,000 gallons. To dilute the spent fuel pool from 2,150 ppm to 900 ppm, it would conservatively require 2.84E+5 gallons of non-borated water.

This analysis assumes thorough mixing of all the non-borated water added to the spent fuel pool. It is likely, with cooling flow and convection from the spent fuel decay heat, that thorough mixing would occur. However, if mixing were not adequate, it would be conceivable that a localized pocket of non-borated water could form somewhere in the spent fuel pool. This possibility is addressed by the criticality calculation, which shows that the spent fuel K_{eff} will be less than 1.0 on a 95/95 basis with the spent fuel pool filled with non-borated water. Thus, even if a pocket of non-borated water formed in the spent fuel pool, K_{eff} would not be expected to exceed 1.0 anywhere in the pool.

The time to dilute ($T_{dilution}$) depends on the initial volume of the pool and the postulated rate of dilution. The dilution volumes and times for the dilution scenario discussed in Sections 3.2 and 3.3 are calculated based on the following equation:

$$T_{dilution} = (V/Q)^* \, Ln\,(C_o/C_{end}) \qquad \text{(Equation 1)}$$

Where:

C_o = the boron concentration of the pool volume at the beginning of the event (2,150 ppm)

C_{end} = the boron endpoint concentration (900 ppm)

Q = dilution rate (gallons of water/minute)

V = volume (gallons) of spent fuel pool.

7.1 Spent Fuel Dilution During Seismic Event (Power Operation / Refueling)

7.1.1 Description of Event

In the hypothetical event of a SSE with loss of offsite power, the spent fuel pool water level could drop due to the failure of non-seismic pool clean up system and gates. The minimum elevation reached during this event is adequate to maintain pool cooling and provide more than 10-ft. of shielding above the fuel assemblies. Post seismic, the spent fuel pool, cask loading pit and transfer canal reach equilibrium. The design leakage due to evaporation is less than 2 gpm.

Liner and boundary valve leakage is limited to less than 5 gpm during plant modes 1 through 5. During modes 5 and 6 the design leakage from the pool boundary is limited to less than 30 gpm when valve PCN–V118 is in the closed position and refueling pool level is less than 133 ft. The normal source of make up during this mode of operation is the gravity feed from the refueling tank as discussed in section 4.1 of this report.

7.1.2 Calculation of Boron Dilution Times and Volumes

Based on the design bases of PVNGS (Ref. 78): non-safety systems are assumed to be not available to mitigate accident conditions and are not considered to operate in a manner which increases the severity of the accident. Therefore, it is assumed all non–seismic systems such as domestic, demineralized water, fire protection, condensate transfer, and liquid radwaste will fail. These systems would not contribute to the event since the motive force of the supply sources (i.e. supply pumps and tanks [2]) would fail as result of seismic event. As described in section 5 of this report, the lines providing water to the utility / decontamination and fire hose stations terminate at elevation 144 ft. There would be a minimum amount of water spilled due to failure of seismic IX piping. The volume of water spilled during the event from non-borated sources is estimated to be less than 15 gallons (100 ft. of 1 ½ inch piping).

The makeup source for this event is the Refueling Water Storage Tank. As stated in section 7.1.1, the gravity feed would be able to makeup for system and boundary leakage in all modes of operation. It should be noted that during modes 5-6 operation when refueling pool level is less than 133 ft., there will be more than 400,000 gal of borated water available to compensate for the design leakage.

7.1.3 Evaluation of Boron Dilution Event

It can be concluded from the above discussion that a seismic event would not result in a boron dilution event. The addition of 15 gallons of non-borated water in 206,000 gallons of borated inventory at a minimum of 2150-ppm is insignificant. Additional safety margin has been added to the design by administrative requirements of the procedure 4XA1-XRK7C. The control room operators would identify and isolate sources of leakage in a timely manner a once valid seismic alarm is received.

7.2 Moderate Energy Line Break

7.2.1 Description of Event

The plant design for protection against piping failures in the fuel building is reviewed to assure that such failures would not cause de-boration of the spent

[2] Note: All supply lines are isolated by manual root valves in the fuel building. The CST and liquid radwaste system are designed to seismic category II, and would retain their pressure boundary integrity up to OBE event.

fuel pool and to assure that the spent fuel pool boron concentration will remain above the minimum required. The review includes moderate energy fluid system piping located within the fuel building. It is assumed for this analysis that a hypothetical random pipe break would occur within the fuel building.

The pipe break is the initiating event, and it does not coincide with any other design bases events. As discussed in section 5 of this report all lines within the fuel building can be classified as moderate energy lines. Per ANS/ANSI 58.2–1980, through–wall crack opening shall be assumed as a circular orifice of cross-section flow area equal to that of rectangle with length of ½ the pipe inside diameter and width of ½ the pipe thickness. Table 4 shows a summary of calculated leakage for different systems. The hypothetical pipe break does not result in loss of equipment power or flooding of SSC. Therefore, no loss of offsite power is required for this event.

7.2.2 Calculation of Boron Dilution Times and Volumes

As described in section 5 and shown on Table 3, the most limiting pipe leakage is due to a failure in the fire protection piping. The fire protection hose station is located at elevation 140 ft. (pool operating deck). It is conservatively assumed that all 85-gpm discharged from the crack would be added to the pool (due to the geometry of the fuel building, a large portion of the leakage will spill on to lower floors). Since the initiating condition would happen during normal operation, the total volume of the spent fuel pool is available for dilution.

Therefore based on equation one:

- C_o = the boron concentration of the pool volume at the beginning of the event = 2150 ppm (assuming smallest pool concentration)
- C_{end} = the boron endpoint concentration = 900 ppm
- Q = dilution rate (gallons of water/minute) = 85 gpm
- V = volume (gallons) of spent fuel pool = 320,000 gals

Using equation one, the time to dilution time is calculated to be approximately 55 hrs. This would provide adequate time for operators to respond to the event. The pool Hi-Hi level alarm is currently set at 138' 4". Assuming the initiation event accurs at the time the pool has minimum possible Technical Specification elevation, i.e. 137' 4", the time for the operator to get an indication in control room is approximate 1.1 hr and the pool concentration at time of alarm would be greater than 2,050 ppm. Isolation of the header is easily achievable since the isolation valve is located outside the fuel building (PIV-014).

7.2.3 Evaluation of Boron Dilution Event

It can be concluded, from the above discussion, that a pipe break event would not result in a boron dilution event which could reduce the margin of safety. The addition of 85 gpm non-borated water to the spent fuel pool is at a flow rate that can be identified and isolated by control room operators in a reasonable time period.

7.3 Normal Operation, Operator Error and Fire

The scenarios evaluated in this section can be categorized into three categories;

1. Normal operational occurrences which include normal replacement of ion exchanges in the pool cooling system, normal evaporation makeup, and normal inter-system leakages (ruptures),

2. Operator error which include misuse of decontamination / utility station and

3. Fire in the fuel building

   a. Detail discussions of each system and normal parameters associated are provided in section 5. During normal operation the pool clean up system ion exchangers need to be replenished. This process would result in de-boration of the fuel pool. Since the normal boron concentration in the spent fuel pool is usually greater then 4,000 ppm. The effect of de-boration due to introduction of 850 gallons of demineralized water or de-boration due to ion-exchanger (7-10 ppm) would be insignificant.

      The inter-system leakage from nuclear cooling / essential cooling system into the pool cooling system adds an insignificant amount of non-borated water into the pool. At a rate of 1 gpm, the leakage would be almost undetectable and could be masked by evaporation from the spent fuel pool. However, control room operators would observe excessive demand on makeup water required for the nuclear cooling / essential cooling water system. In event of inter-system tube rupture, the flow initially would be approximately 85 gpm; however, the closed loop-cooling system would lose pressure rapidly and the control room would have an indication due to Low-Low level alarms produced by surge tank levels. Such event is bounded by the evaluation performed for pipe break (see section 7.2).

   b. It is possible to assume that a single operator using the decontamination station / utility station would mistakenly discharge a portion of hose flow into the spent fuel pool during maintenance activities or decontamination of casks or adjacent areas around the pool. The flow from these stations are limited to approximately 50 gpm. At this flow rate, the discharge from the hose is less than in the case evaluated for a pipe break, therefore, it would be bounded by the evaluation in section 7.2. However, it is highly improbable that the flow would be continuous for a long duration of time. Therefore, the consequences of such an event are much less than a moderate energy line break event.

c. The probability of fire at the fuel building at elevation 140 ft. is very small due to the lack of combustible loading. In case of a fire at this elevation, the fire team has to utilize the fire hose station HS 100, located at the southeast corner of the operating floor. The maximum flow for this hose station is 500 gpm and assuming that the fire can be terminated within an hour, the total water discharge to elevation 140-ft. would be 30,000 gal. If all flow is discharged directly into the pool, the pool concentration would be reduced from 2,150 to 1,900 ppm (note: normal concentration for spent fuel pool is greater than 4,000 ppm). Because of the limited flow into the spent fuel pool enclosure, and because of the awareness of control room and fire crews, the discharge to the pool would be terminated long before the spent fuel pool boron concentration could be reduced to 900 ppm.

7.4 Conclusions

It is concluded that an unplanned or inadvertent event, which would result in the dilution of the spent fuel pool boron concentration from 2,150 ppm to 900 ppm is not a credible event. This conclusion is based on the following:

1. In order to dilute the spent fuel pool ($K_{eff} > 0.95$), a substantial amount of water is needed. Most sources of water at PVNGS site would be exhausted and it would take continued manual actions on the part of plant personnel to assure that enough water would be available to support such a dilution.

2. Since such a large water volume turnover is required, a spent fuel pool dilution event would be readily detected by plant personnel via alarms, sump flooding in the fuel and / or auxiliary building, or by normal operator rounds through the spent fuel pool area.

3. Evaluations indicate that based on the design flow rates of non-borated water normally available to the spent fuel pool, sufficient time is available to detect and respond to such an event.

It should be noted that this boron dilution evaluation was conducted by evaluating the time and water volumes required for diluting the spent fuel pool from 2,150 ppm to 900 ppm. The 900-ppm end point was utilized to ensure that K_{eff} for the spent fuel would remain less than or equal to 0.95. However, the PVNGS technical requirements manual requires the spent fuel pool to be maintained at a concentration of 4,000 to 4,400 ppm boron. This requirement would provide additional design margin, which is not credited for in this study. In conclusion, the design and administrative procedures in place at PVNGS provide solid design bases for crediting soluble boron in the spent fuel pool and the plant design provides ample margin against an inadvertent dilution event.