APS

Palo Verde Nuclear
Generating Station

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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Dear Sirs:

Subject: **Palo Verde Nuclear Generating Station (PVNGS)**
Units 1, 2 and 3
Docket Nos. STN 50-528, 50-529, and 50-530
Discovery and Correction of Errors in Topical Report

The purpose of this submittal is to inform the NRC of recently-discovered and corrected errors in the analytical method described in topical report "Arizona Public Service Company PWR Reactor Physics Methodology Using CASMO-4/SIMULATE-3, September 1999." This report is listed in PVNGS Technical Specification 5.6.5.b as document no. 11 containing a description of analytical methods used to determine the core operating limits. This topical report was submitted to the NRC by APS in a Technical Specification amendment request, letter no. 102-04455, dated June 8, 2000, and approved for use at PVNGS by the NRC in Amendment No. 132 for Units 1, 2, and 3, dated March 20, 2001.

The topical report errors, caused by a data entry error, were the reported Doppler Power Coefficient (DOPC) bias, bias-based uncertainty, and unbiased uncertainty, and the Fuel Temperature Coefficient (FTC) bias and uncertainty. The DOPC bias-based 95/95 uncertainty went from 20.6% to a corrected value of 11.0%, while DOPC unbiased 95/95 uncertainty went from 23.12% to 26.93%. The FTC uncertainty, which is based on the unbiased DOPC, went from 16.4% to a corrected value of 19.0%. Corrected non-proprietary pages of the "Arizona Public Service Company PWR Reactor Physics Methodology Using CASMO-4/SIMULATE-3" topical report are attached. None of the redacted proprietary information on these pages is affected by the corrections.

A001

The DOPC bias and bias-based uncertainty are not used in any safety related analysis. The FTC bias and uncertainty are also not used in any safety related analysis. The DOPC unbiased uncertainty is one of the uncertainties currently used to calculate the minimum required boron concentration to satisfy lower mode shutdown margin requirements. Evaluation of the DOPC unbiased uncertainty error found that existing conservatism used in calculating the minimum required boron concentration bounded the DOPC unbiased uncertainty error, hence there have been no shutdown margin violations. Additionally, no core operating limits specified in the Core Operating Limits Report (COLR) were impacted by the error.

The data entry error that resulted in the topical report errors was made when inferring the Unit 1 Cycle 1 20% Rated Thermal Power (RTP) measured DOPC. To determine the measured DOPC, control rods are inserted to add negative reactivity which is then balanced by a corresponding decrease in reactor power. The reactivity change associated with the control rod movement is equal to the reactivity added by multiplying the change in reactor power with the DOPC, after accounting for slight changes in the moderator temperature distribution. When entering the data, the rod worth associated with a 120 inch withdraw was skipped causing a mismatch between rod position and worth. This data entry error lead to the formulation of incorrect DOPC and FTC bias and uncertainty. This condition has been entered in the PVNGS corrective action program as CRDR 2803384.

No commitments are being made to the NRC by this letter. If you have any questions, please contact Thomas N. Weber at (623) 393-5764.

Sincerely,

David Mauldin

CDM/TNW/GAM

Enclosure: Corrected Non-Proprietary Pages for Topical Report "Arizona Public Service Company PWR Reactor Physics Methodology Using CASMO-4/SIMULATE-3, September 1999"

cc:	B. S. Mallett	NRC Region IV Regional Administrator
	M. B. Fields	NRC NRR Project Manager
	G. G. Warnick	NRC Senior Resident Inspector for PVNGS

ENCLOSURE

Corrected Non-Proprietary Pages for Topical Report "Arizona Public Service Company PWR Reactor Physics Methodology Using CASMO-4/SIMULATE-3, September 1999"

Pages:
17
76
77
78
79

Table 1-2 List of 95/95 Tolerance Limits (Bias ±Uncertainty)

Parameter	Bias	95/95 Uncertainty	Units*
HFP Core Reactivity (pcm)	331.5	226.8	Absolute
HZP Core Reactivity (pcm) (BOC only)	Bias = (0.157 x α) - (60.136 x β) + 322.427 Where, α = Number of Fresh Erbium Rods β = BOC Core Average BU in GWD/MT	621.7	Absolute
Isothermal Temperature Coefficient (pcm/°F)	-0.28	1.52	Absolute
Control Rod Worth - Bank Worth - Total Worth - Dropped Worth - Ejected Worth - Net (N - 1) Worth	 0.8% 1.0% [ ]% -1.3% 1.0%	 8.3% 7.1% [ ] [ ] 7.1%	Relative
Inverse Boron Worth (ppm/ %Δk/k)	-3.16%	13.49%	Relative
Doppler Power Coefficient (pcm/% power)	~~Bias = -5.704 + 1.115*CAB(GWD/MT) + 3.87E-03*P(%);~~ Bias = -0.186 + 9.02E-03*CAB(GWD/ MT) + 1.65E-03*P(%) where CAB is the core average burnup	~~20.6%~~ 11.0%	Relative
Fuel Temperature Coefficient (pcm/°F)	~~-0.8%~~ -1.8%	~~16.4%~~ 19.0%	Relative
Local Pin Power (Pin-to-Box)	[ ]	[ ]	Relative
Calculated Assembly Peaking - F_q (box) - F_r (box) - F_{xy} (box)	 0% 0% 0%	 5.34% 3.25% 3.69%	Relative

Statistical Analysis

The *W* test for normality was performed on the DOPC observed differences, then a determination as to whether or not the DOPC is a function of power level or power level and core average burnup. Once that was determined a bias and uncertainty (K(95/95*S)) was calculated.

Table 4-20 shows the average, standard deviation (S), and K(95/95)*S.

Table 4-20 shows that the normally distributed DOPC relative difference data has a K(95/95)*S of ~~23.12%~~ 26.93%. Since this is quite large a determination was made as to whether or not the DOPC is a function of power level or power level and core average burnup.

The data showed that the functionalization with the smallest uncertainty is against core average burnup, but it won't be used since the data is basically made up of beginning-of-life (BOL) data and is not entirely appropriate for reload cycles.

The next best was a combination of power and core average burnup. This one will be used since [ ]. Table 4.21 shows the statistical results for DOPC.

By using the combination of power and core average burnup the uncertainty is reduced from ~~23.1%~~ 26.9% to ~~20.6%~~ 11.0%.

Statistical Results

The DOPC tolerance limits (from Table 4.21) are:

~~-5.704 + 1.115*CAB(GWD/MT) + 3.87E-03*P(%) ± 20.6%~~,
-0.186 + 9.02E-03*CAB(GWD/MT) + 1.65E-03*P(%) ± 11.0%,
where CAB is the core average burnup

Table 4-19 Doppler Power Coefficient Comparisons

Unit	Cycle	Core Average Burnup (GWD/MT)	Power (% HFP)	Measurement (pcm/%power)	SIMULATE-3 Calculation (pcm/%power)	% Difference 100*(M - C)/C
1	1	0.125	18.4	~~-15.13~~ -12.82	-15.01	~~0.799%~~ -14.590%
1	1	0.255	53.3	-11.60	-12.52	-7.348
1	1	0.988	80.5	-10.15	-10.56	-3.883
1	1	2.142	95.3	-9.11	-9.17	-0.654
1	2	12.718	95.0	-10.98	-9.86	11.359
2	1	0.541	50	-10.89	-12.61	-13.640
2	1	1.080	96.3	-7.86[a]	-9.71	-19.053
2	2	9.543	94.4	-10.46	-10.29	1.652
3	1	0.658	96.0	-9.28	-9.43	-1.591

a.This point is abnormally low. Compare -7.86 to the other two Cycle 1 HFP data points of -9.11 and -9.28. This point is not negative enough and is eliminated from the data base.

Table 4-20 Doppler Power Coefficient Statistics for Relative Differences

	pcm/%power
Mean 100*(Meas - Calc)/Calc	~~-1.663%~~ -3.587%
Standard Deviation (S)	~~7.254~~ 8.450%
Number of Data Points	8
Degrees of Freedom	7
***W* Value**	~~0.964~~ 0.954
Critical Value(s)	0.818
Normal Distribution?	Yes
$K_{95/95}$[a] (95/95 Tolerance Factor)	3.187
$K_{95/95}$*S	~~23.12%~~ 26.93%

a. Reference 27 for n = 8 and 95/95 ~~confidence~~ tolerance interval.

Table 4.21 Functionalization for the DOPC Relative Differences

Functionalization	R^2	Standard Error (%)	Degrees of Freedom	K(95/95)[a]	Uncertainty 95/95 (%)
Power and Core Average Burnup[b]	~~0.58~~ 0.91	~~5.56~~ 2.97	5	3.708	~~20.6%~~ 11.0%

a.Reference 27

~~b.Bias (%) = -5.704 + 1.115*CAB(GWD/MT) + 3.87E-03*P(%)~~

Bias (%) = -0.186 + 9.02E-03*CAB(GWD/MT) + 1.65E-03*P(%)

4.7 FUEL TEMPERATURE COEFFICIENT

Statistical Analysis

The fuel temperature coefficient (FTC) is related to the DOPC by the relationship:

$$\frac{d\rho}{dP} = \frac{d\rho}{dT_f} \times \frac{dT_f}{dP}$$

where

$\rho =$ core reactivity

$T_f =$ fuel temperature

$P =$ core power

The term $d\rho/dP$ has been assigned a bias and an uncertainty, but neither $d\rho/dT_f$ nor dT_f/dP can be evaluated separately. One way of assigning biases and uncertainties is to assign biases and uncertainties equally to $d\rho/dT_f$ and dT_f/dP. The data base of DOPCs is used, without regression analysis versus power and core average burnup. The bias and uncertainty become:

FTC Bias = Average / 2

FTC Uncertainty = K(95/95)*S / $\sqrt{2}$

Another method is to assign a bias to dT_f/dP and uncertainty to $d\rho/dTf$ (FTC) using the fit of (Meas - Calc)/Calc with respect to power and core average burnup. The FTC bias becomes zero and the uncertainty becomes K(95/95)*S of the fit.

Assigning biases and uncertainties equally to $d\rho/dT_f$ and dT_f/dP is slightly more conservative, and [ ]. Therefore biases and uncertainties were assigned equally to $d\rho/dT_f$ and dT_f/dP.

Assigning biases and uncertainties equally to $d\rho/dT_f$ and dT_f/dP yields the following:

FTC Bias = Average / 2 = ~~-1.66~~ -3.59[1] / 2 = ~~-0.83%~~ -1.80%

FTC Uncertainty = K(95/95)*S / $\sqrt{2}$ = ~~23.12~~ 26.93[1] / $\sqrt{2}$ = ~~16.35%~~ 19.04%

Statistical Results

The tolerance limits for fuel temperature coefficient are:

~~-0.8 ± 16.4%~~
-1.8 ± 19.0%

1. From Table 4-20.