Omaha Public Power District
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402/536-4000

February 8, 1984
LIC-84-038

50-285

Mr. James R. Miller, Chief
U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Division of Licensing
Operating Reactors Branch No. 3
Washington, D.C. 20555

Reference: Docket No. 50-285

Dear Mr. Miller:

Fort Calhoun Reload Core
Analysis Methods and Verification

Attached is additional information concerning the District's proficiency in using the CESEC-III computer code, as requested by members of your staff during a January 26, 1984 telephone conversation.

Sincerely,

W C Jones

W. C. Jones
Division Manager
Production Operations

WCJ/JJF:jmm

Attachment

cc: LeBoeuf, Lamb, Leiby & MacRae
1333 New Hampshire Avenue, N.W.
Washington, D.C. 20036

Mr. E. G. Tourigny, Project Manager
Mr. L. A. Yandell, Senior Resident
Inspector

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Attachment

The Cycle 8 Safety Analysis Report (SER) requested that the District submit reload methodology reports, while paying particular attention to Generic Letter 83-11 [Reference (1)]. The District committed to providing these reports in Reference (2), based on the report scope agreed to with members of your staff in a May 11, 1983 telephone conversation.

Generic Letter 83-11 requires licensees who intend to use a safety analysis computer code to demonstrate their proficiency in using the code by submitting code verification done by themselves. As discussed in Generic Letter 83-11, verification includes comparisons performed by the licensee of the code results to experimental data, plant operational data, or other benchmarked analyses.

As discussed in the District's Transient and Accident Methods and Verification report [Reference (3)], the purpose of the District's verification is to demonstrate our proficiency in using the CESEC-III code. This proficiency is demonstrated through comparisons of CESEC-III code results with calculations performed by Combustion Engineering (CE) and Exxon Nuclear Company (ENC) and with Fort Calhoun Station transient test data.

The District choose to compare Cycle 8 CESEC-III results with Cycle 6 CE and ENC results because the reactor physics parameters affecting the results of the Cycle 8 analyses were essentially the same as those of Cycle 6 for the events considered and no system changes were made between the Cycle 6 and Cycle 8 analyses. Although some differences do exist, they are small and their impact can be readily isolated. The Cycle 8 to Cycle 6 comparisons were previously presented to members of your staff and submitted in Reference (4).

To further demonstrate the validity of the Cycle 8 to Cycle 6 comparisons, the analysis input data given in Reference (3) has been expanded and clarified, where necessary. Each of the Cycle 8 to Cycle 6 comparisons is described below.

CEA Drop

As stated in Reference (3), a comparison was made between the Cycle 6 ENC analysis and the Cycle 8 OPPD analysis. Table 1 has been updated and expanded to show that:

(1) The effective moderator temperature coefficients used were -2.76×10^{-4} $\Delta\rho/°F$ and -2.7×10^{-4} $\Delta\rho/°F$ for Cycles 6 and 8, respectively.

(2) The effective doppler coefficients used were -2.556×10^{-5} $\Delta\rho/°F$ and -2.496×10^{-5} $\Delta\rho/°F$.

(3) The delayed neutron fractions were 0.0045 and 0.00476.

CEA Drop (Continued)

(4) The RCS flow rate, which is a third order effect, is increased for Cycle 8 by 7,000 gpm (approximately 3.68%). This change is insignificant.

(5) The dropped CEA worth for Cycle 6 is 0.06% $\Delta\rho$ more. This has little effect on the final power level calculated in the analysis.

(6) All other significant parameters are identical.

Based on the above comparisons, it may be concluded that the Cycle 6 and Cycle 8 moderator temperature coefficients, doppler coefficients, delayed neutron fractions, and dropped CEA worths are essentially the same, with all other first and second order parameters identical. Therefore, a direct comparison may be made between Cycle 6 and Cycle 8. The results of the comparison show excellent agreement.

Hot Zero Power (HZP) Main Steamline Break (MSLB)

The HZP MSLB cases considered in Reference (3) for comparison include the Cycle 6 ENC analysis, the Cycle 6 CE analysis for the control grade automatic auxiliary feedwater system, and the Cycle 8 OPPD analysis. Table 2, which has been expanded from Reference (3), summarizes the input parameters for each of the cases. This table shows that:

(1) All cases were initiated from the same power level, with the same inlet temperature.

(2) The CE and OPPD analyses were both initiated from the maximum permissible pressurizer pressure (during normal operation), while the ENC analysis was initiated from the lowest permissible pressure. The difference has a negligible effect on the thermal hydraulic response of the system.

(3) The CE and ENC analyses assumed the minimum RCS flow value from the FSAR. The OPPD analysis assumed the Cycle 8 Technical Specification limit which had been increased from the FSAR (and original Technical Specification) minimum guaranteed flow. This parameter has, at most, a second order effect on the transient, so the flow difference is not significant.

(4) The effective moderator temperature coefficient of reactivity is presented in Figure 1 as a plot of reactivity versus moderator temperature. This figure shows virtually identical cooldown curves for all three cases. Since this parameter is the single most important input to the event, justification for comparison of the analyses is provided by the essentially identical cooldown curves.

Hot Zero Power (HZP) Main Steamline Break (MSLB) (Continued)

(5) The doppler reactivity, as a function of fuel temperature, was identical for the CE and OPPD analyses which assume a bounding curve. The ENC doppler function is contained in Reference (5). Comparisons of physics data for Cycle 8 and Cycle 6 show that the doppler coefficient for Cycle 8 is essentially unchanged from Cycle 6.

(6) The doppler coefficient multipliers were both 1.15 for the CE and OPPD analyses, while a value of 0.8 was assumed for the ENC analysis.

(7) The ENC analysis assumed a shutdown margin of 3% $\Delta\rho$, while the OPPD analysis assumed a 4% $\Delta\rho$ shutdown margin. The CE analysis assumed a 4.2% $\Delta\rho$ scram worth for HZP, with the most reactive CEA stuck, because the purpose of this analysis was to verify acceptable return-to-power results for the auxiliary feedwater system. These differences were isolated in the analysis results, as discussed in Reference (3).

(8) The initial steam generator pressures assumed for the CE and OPPD analyses were essentially the same, while the ENC assumed value is not available. For Cycle 8, a higher initial steam generator mass inventory was assumed. This change results in a longer cooldown time (due to a longer time to steam generator dryout, particularly at HZP, as opposed to a relatively insignificant difference at HFP). This effect can be observed in Figure 4-5 of Reference (3).

(9) The delayed neutron fractions were identical for the CE and OPPD analyses, while the ENC assumed value was unavailable. This is a second order effect.

(10) The inverse boron worth was unavailable for the ENC analysis, while the CE and OPPD values used were -87 and -94 ppm/% $\Delta\rho$, respectively. This parameter is associated with the effects of safety injection, which provides additional shutdown margin. The larger, more negative value is more conservative. This small difference has no significant effect on the analysis.

(11) The values of the gap thermal conductivity were assumed to be the minimum values. The ENC and OPPD analyses assumed the same bounding values, while the CE analysis used a conservative value derived from fuel performance calculations. All three values are consistent, with no significant difference.

From the above input data comparisons, it can be observed that the CE analysis using CESEC-I and the OPPD analysis using CESEC-III should be most nearly the same. Some differences in the results will exist which are attributable to a different scram worth and

Hot Zero Power (HZP) Main Steamline Break (MSLB) (Continued)

to OPPD's use of the most sophisticated code version which includes modeling of wall heat, vessel upper head voiding, and the safety injection tanks, with the use of a core temperature tilt asymmetry option. With the purpose of the submittal of Section 6 of Reference (3) being a demonstration of the District's proficiency in the use of the CESEC-III computer code, as per Reference (1), the District's proficiency can be demonstrated by obtaining similar (but not necessarily identical) results for these comparisons, in addition to benchmarking against actual plant data, as shown in Section 6.2 of Reference (3). The results of the Reference (3) comparisons show excellent agreement between the thermal hydraulic responses of the CE and OPPD analyses with consistent results in the reactivity feedback responses of the ENC, CE, and OPPD analyses. Insufficient data was available from the ENC analysis to make the RCS pressure and steam generator pressure comparisons.

Hot Full Power (HFP) Main Steamline Break (MSLB)

The HFP MSLB cases considered in Reference (3) for comparison include the same analyses as for the HZP MSLB. Table 3 shows an expansion of the case input data presented in Reference (3). This table shows that:

(1) The same comments from the HZP MSLB items (1), (3), (5), (6), (9), and (11) apply to the HFP case.

(2) The CE and OPPD analyses were both initiated from the maximum permissible pressurizer pressure (during normal operation), while the ENC analysis was initiated from the nominal pressure minus the 22 psia uncertainty. This difference has a negligible effect on the system's thermal hydraulic response.

(3) The effective moderator temperature coefficient of reactivity is presented in Figure 2 as a plot of reactivity versus moderator temperature. This figure shows virtually identical cooldown curves for all three cases. Since this parameter is the single most important input to the event, justification for direct comparison of the Cycle 6 and Cycle 8 cases is provided.

(4) Both the CE and ENC analyses utilized a scram worth of 5.81% $\Delta\rho$, while a greater scram worth of 6.57% $\Delta\rho$ was available for the Cycle 8 OPPD case. The effect of this difference is discussed in Reference (3).

(5) The comments of item (8) of the HZP MSLB apply to steam generator input data, with the exception that the CE analysis used the steam generator pressure which was anticipated for Cycle 6 operation at 1500 MWt and 545°F inlet temperature which was changed from the previous cycle's power and

Hot Full Power (HFP) Main Steamline Break (MSLB) (Continued)

inlet temperature of 1420 MWt and 536°F. The Cycle 8 analysis used the steam generator pressure that would be observed for 1530 MWt and 547°F.

(6) The inverse boron worth used in the CE and OPPD analyses varied by 11 ppm/% $\Delta\rho$. This effect is seen in the results of safety injection which occurs after the peak return-to-power, thus having essentially no impact on the event. The input value for the ENC analysis was unavailable.

From the above input data comparisons, it can observed that the OPPD analysis more closely resembles that performed by CE. It should be again reiterated that the District employs CE methodology and codes, so the results of these two analyses should be consistent. The results of the Reference (3) comparisons show excellent agreement between the CE and OPPD analyses, as anticipated.

Conclusions

Section 6 of Reference (3) fulfills the requirements of Reference (1) for demonstrating the District's proficiency in using the CESEC-III code for performing safety analysis in support of reload licensing. This has been done by benchmarking the code against plant transient data in Section 6.2 of Reference (3) and showing that the same (but not identical) results are obtained in comparison of the OPPD Cycle 8 analyses of the CEA drop and MSLB to analyses performed by ENC and/or CE for Cycle 6, in which the physics and operating parameters are nearly identical. The input data assumed in the CEA drop analyses performed by OPPD and ENC are virtually identical, with the same analysis results obtained. The OPPD MSLB analyses at HZP and HFP show excellent agreement with those performed by CE, with less but still good agreement to those performed by ENC. The variance between the ENC and CE MSLB analyses, which have been approved by the staff, is greater than the OPPD to ENC or OPPD to CE analyses, providing further assurance of the correctness of the Cycle 8 analyses and confidence in the District's ability to correctly use the CESEC-III code.

References

(1) Generic Letter 83-11, "Licensee Qualification for Performing Safety Analysis in Support of Licensing Actions", February 8, 1983.

(2) Letter from W. C. Jones to R. A. Clark (LIC-83-184), July 28, 1983.

(3) OPPD-NA-8303-P, "Omaha Public Power District Transient and Accident Methods and Verification", September, 1983.

<u>References</u> (Continued)

(4) CEN-242(0)-P, "OPPD Responses to NRC Questions on Fort Calhoun Cycle 8", February 18, 1983.

(5) XN-NF-79-79, "Fort Calhoun Cycle 6 Plant Transient Analysis Report", October, 1979.

Table 1

COMPARISON OF PARAMETERS INCLUDING UNCERTAINTIES USED IN THE CEA DROP ANALYSES FOR CYCLES 6 AND 8

Parameter	Units	ENC Cycle 6	OPPD Cycle 8
Initial Core Power Level	MWt	102% of 1500	102% of 1500
Core Inlet Temperature	°F	547	547
Pressurizer Pressure	psia	2053	2053
RCS Flow Rate	gpm	190,000	197,000
Moderator Temperature Coefficient	10^{-4} $\Delta\rho/°F$	-2.76*	-2.7
Doppler Coefficient	10^{-5} $\Delta\rho/°F$	-2.13	-2.17
Doppler Coefficient Multiplier		1.20	1.15
Dropped CEA Worth	% $\Delta\rho$	-0.34	-0.28
Delayed Neutron Fraction		0.0045	0.00476

*OPPD-NA-8303-P reported a value of -2.3×10^{-4} which did not include the 1.20 multiplier used.

Table 2

COMPARISON OF PARAMETERS INCLUDING UNCERTAINTIES USED IN THE HZP MSLB ANALYSIS FOR CYCLES 6 AND 8

Parameter	Units	ENC Cycle 6	CE Cycle 6 AFW	OPPD Cycle 8
Initial Core Power Level	MWt	0.0	1.0	1.0
Core Inlet Temperature	°F	532	532	532
Pressurizer Pressure	psia	2053	2175	2172
RCS Flow Rate	gpm	190,000	190,000	197,000
Effective Moderator Temperature Coefficient	10^{-4} $\Delta\rho/°F$	----------See Figure 1----------		
Doppler Coefficient	10^{-5} $\Delta\rho/°F$	***	****	****
Doppler Coefficient Multiplier		0.8	1.15	1.15
Minimum CEA Scram Worth (Shutdown Margin)	% $\Delta\rho$	-3.0	-4.2	-4.0
Initial Steam Generator Pressure	psia	*	905**	895
Initial Steam Generator Mass Inventory (Level)	% Narrow Range Scale	63	63	70
Delayed Neutron Fraction		*	0.0058	0.0058
Inverse Boron Worth (For Safety Injection)	$\frac{ppm}{\% \Delta\rho}$	*	-87	-94
H_{gap}	$\frac{Btu}{hr\ ft^2\ °F}$	500	868	500

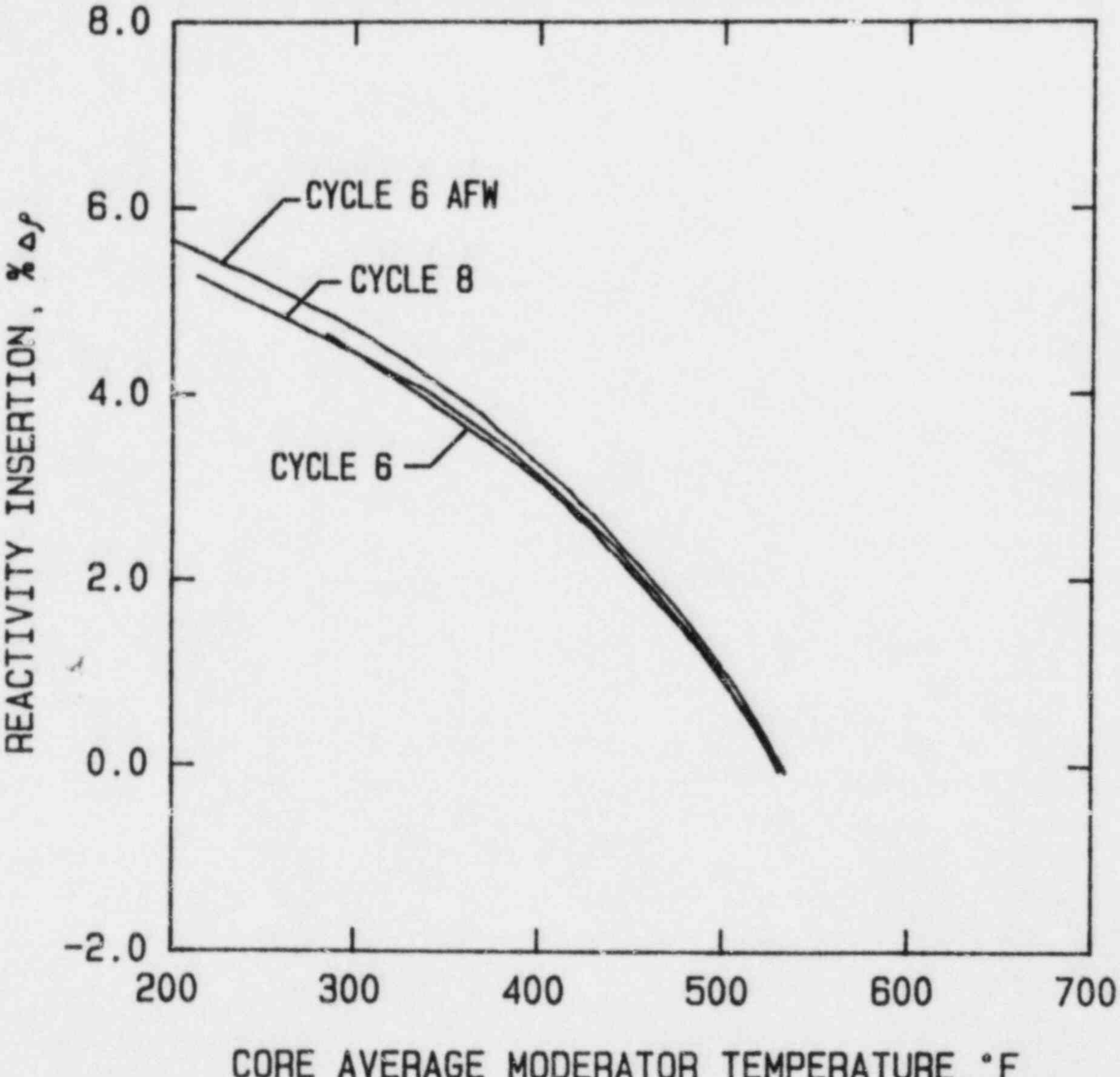
* Data used in analysis unavailable.
** Revised from OPPD-NA-8303-P.
*** Curve supplied in XN-NF-79-79, "Fort Calhoun Cycle 6 Reload Plant Transient Analysis Report", October, 1979.
****Same bounding doppler curve used.

Table 3

COMPARISON OF PARAMETERS INCLUDING UNCERTAINTIES USED IN THE HFP MSLB ANALYSES FOR CYCLES 6 AND 8

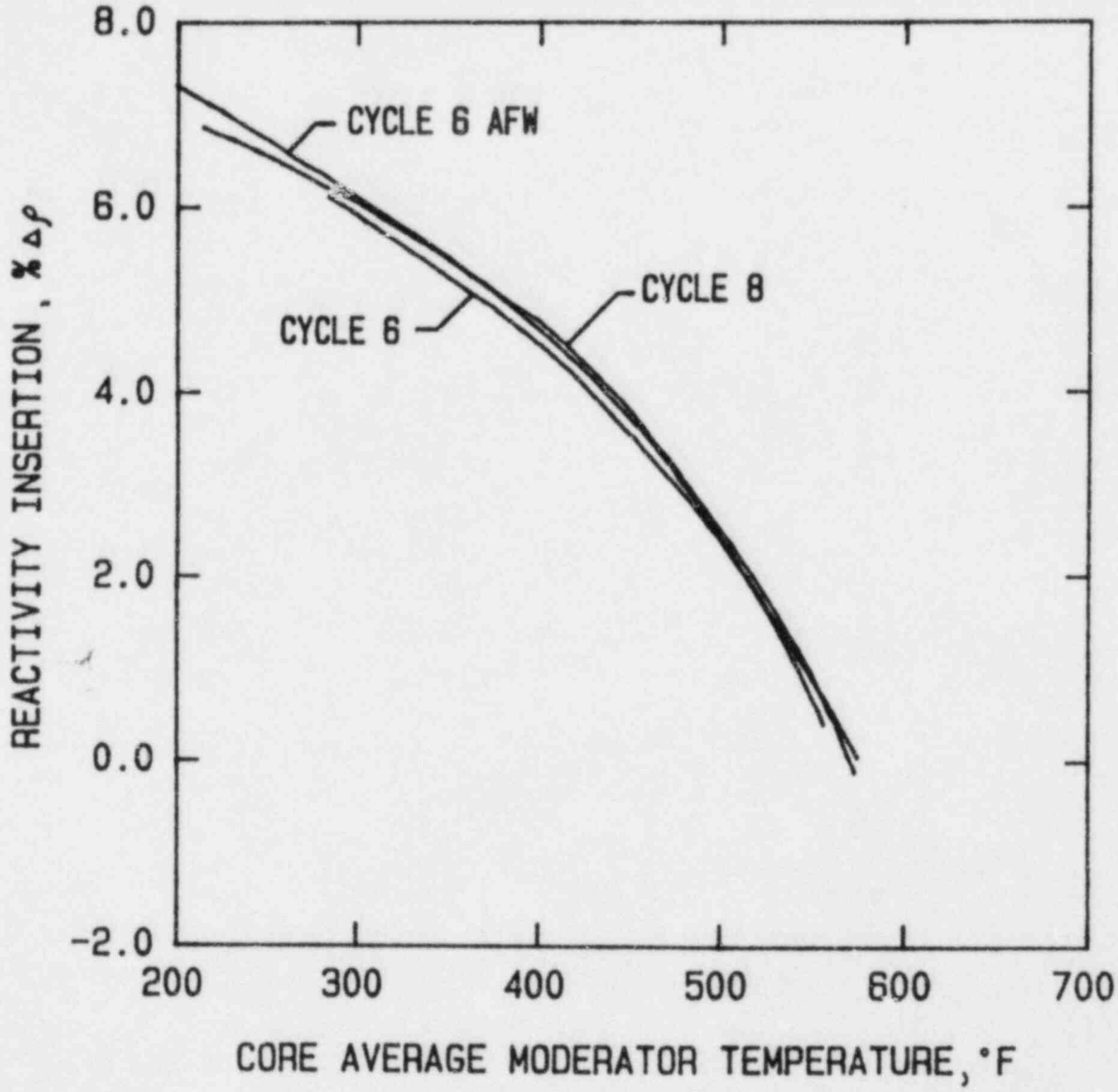
Parameter	Units	ENC Cycle 6	CE Cycle 6 AFW	OPPD Cycle 8
Initial Core Power Level	MWT	102% of 1500	102% of 1500	102% of 1500
Core Inlet Temperature	°F	547	547	547
Pressurizer Pressure	psia	2078	2175	2172
RCS Flow Rate	gpm	190,000	190,000	197,000
Moderator Temperature Coefficient	10^{-4} $\Delta\rho$/°F	----------See Figure 2----------		
Doppler Coefficient	10^{-5} $\Delta\rho$/°F	***	****	****
Doppler Coefficient Multiplier		0.8	1.15	1.15
Minimum CEA Scram Worth	% $\Delta\rho$	-5.81	-5.81	-6.57
Initial Steam Generator Pressure	psia	*	858**	890
Initial Steam Generator Mass Inventory (Level)	% Narrow Range Scale	63	63	70
Delayed Neutron Fraction		*	0.0058	0.0058
Inverse Boron Worth		*	-87	-98
H_{gap}	$\frac{Btu}{hr\ ft^2\ °F}$	500	568	500

* Data used in analysis unavailable.
** Revised from OPPD-NA-8303-P.
*** Curve supplied in XN-NF-79-79, "Fort Calhoun Cycle 6 Reload Plant Transient Analysis Report", October, 1979.
****Same bounding doppler curve used.



NOTE: CYCLE 6: ENC ANALYSIS
CYCLE 6 AFW: CE ANALYSIS
CYCLE 8: OPPD ANALYSIS

Steam Line Break Incident (HZP) Reactivity vs. Moderator Temperature	Omaha Public Power District Fort Calhoun Station-Unit No. 1	Figure 1



NOTE: CYCLE 6: ENC ANALYSIS
CYCLE 6 AFW: CE ANALYSIS
CYCLE 8: OPPD ANALYSIS

Steam Line Break Incident (HFP) Reactivity vs. Moderator Temperature	Omaha Public Power District Fort Calhoun Station-Unit No. 1	Figure 2