FENOC

FirstEnergy Nuclear Operating Company

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724-682-4862

March 11, 2008
L-08-100

10 CFR 50.90

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

SUBJECT:
Beaver Valley Power Station, Unit No. 2
Docket No. 50-412, License No. NPF-73
Responses to a Request for Additional Information in Support of License Amendment Request No. 204, Revision 1 (TAC No. MD2378)

By letter dated March 6, 2008, the U.S. Nuclear Regulatory Commission (NRC) issued a request for additional information (RAI) pertaining to License Amendment Request (LAR) No. 204, Revision 1. This LAR was submitted by FirstEnergy Nuclear Operating Company (FENOC) on December 21, 2007 by letter L-07-517 (Reference 1). The LAR proposes Technical Specification changes that incorporate the results of a new spent fuel pool criticality analysis that will permit utilization of vacant storage locations in the Beaver Valley Power Station Unit No. 2 spent fuel storage pool. The new criticality analysis was submitted by FENOC on July 26, 2007 by letter L-07-103 (Reference 2).

Attachment 1 contains the FENOC responses to the March 6, 2008 RAI. The regulatory commitments contained in this letter are listed in Attachment 2. Approval of the proposed amendment is requested by March 2008 to support the Unit No. 2 refueling outage scheduled for the spring of 2008. Once approved, the amendment shall be implemented within 30 days.

If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – FENOC Fleet Licensing, at 330-761-6071.

I declare under penalty of perjury that the foregoing is true and correct. Executed on March 11, 2008.

Sincerely,

Edward H. Hubley

A001
NRR

Attachments:
1. Response to RAI Items
2. Regulatory Commitment List

Reference:

1. FENOC Letter L-07-517, License Amendment Request Number 204, Revision 1 (TAC Nos. MD2377 and MD2378), dated December 21, 2007
2. FENOC Letter L-07-103, Supplemental Information for License Amendment Request Nos. 333 and 204, (Revision 2 of WCAP-16518) (TAC Nos. MD2377 and MD2378), dated July 26, 2007

cc: Mr. S. J. Collins, NRC Region I Administrator
Mr. D. L. Werkheiser, NRC Senior Resident Inspector
Ms. N. S. Morgan, NRR Project Manager
Mr. D. J. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

ATTACHMENT 1
L-08-100
Responses to RAI Items

By letter dated June 14, 2006, as supplemented by letters dated July 20, July 26, and December 21, 2007, FirstEnergy Nuclear Operating Company (FENOC, licensee) requested an amendment to the Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 and 2) Technical Specifications (TSs). The proposed changes to the TSs would incorporate the results of topical report, (WCAP)-16518, which will permit utilization of vacant storage locations dictated by the existing TS storage configurations in the BVPS-2 spent fuel storage pool. By letter dated December 21, 2007, the licensee withdrew their license amendment request (LAR) for BVPS-1. Based on previous RAI questions (References 1 and 2) and information obtained from the audit, the Nuclear Regulatory Commission (NRC) staff request further information on the following items:

RAI Item 1

On January 25, January 28, February 1, February 4, February 11, and February 12, 2008, the NRC staff conducted an audit of Westinghouse calculations associated with the BVPS-2 spent fuel pool criticality analysis. Those calculations were documented as calculations notes, CN-CRIT-224 and CN-CRIT-244. Please provide Section 7 of CN-CRIT-244 to support the NRC staff's safety evaluation (SE) for the BVPS-2 SFP criticality LAR. Also, identify any portions that are replaced due to response to questions listed below.

RAI Item 1 Response

The following response consists of a condensed non-proprietary version of Section 7 of Westinghouse Calculation Note Number CN-CRIT-244, Revision 0. The specific areas that were removed include the discussion of core operating conditions, burnup shape applicability less than 30 gigawatt day per metric ton uranium (GWd/MTU), the discussion of the SFP temperature bias, and the justification of the 5% assembly burnup uncertainty. These portions were removed from this response because they are addressed in the responses to the other RAI Items.

Soluble Boron Credit

The total soluble boron credit needed to maintain the k_{eff} less than 0.95 with 95% probability of a 95% confidence interval, including the worst case postulated accident, is determined using Equation 1, shown below. Separate terms are used to account for a 5% reactivity reduction, assembly reactivity uncertainties, and postulated accidents. The reactivity worth of each term is determined and then converted to a boron concentration using the calculated Beaver Valley Power Station Unit 2 (BVPS-2) soluble boron worth.

$$SBC_{Total} = SBC_{95/95} + SBC_{RE} + SBC_{PA} \qquad \text{Equation (1)}$$

Where:
- SBC_{Total} = total soluble boron concentration requirement,
- $SBC_{95/95}$ = soluble boron concentration required to lower SFP reactivity by 5%,
- SBC_{RE} = soluble boron concentration required to offset assembly reactivity uncertainties,
- SBC_{PA} = soluble boron concentration required to mitigate the limited postulated accident.

The first step in the soluble boron credit methodology is to determine the worth of the soluble boron in the spent fuel pool. The worth is conservatively determined by loading the entire pool with the "3x3" loading configuration with 5 w/o ^{235}U assemblies depleted to 55,000 MWd/MTU burnup. As discussed in Reference 1, this configuration is selected because the depleted fuel has a harder (higher energy) neutron spectrum, which is less sensitive to the primarily thermal neutron absorption from boron-10 in the soluble boron. In other words, using depleted fuel for this calculation minimizes the incremental reactivity worth of the soluble boron, conservatively maximizing the soluble boron requirement. Calculations are performed for a range of boron concentrations and a polynomial is fit to this data. This polynomial is used to translate the reactivity worth determined for each SBC term into boron concentrations.

The second step in the methodology is to determine the reactivity worth associated with each term in Equation 1.

The first term, $SBC_{95/95}$ is simply 5% (0.05 Δk_{eff} units). This value is derived from Reference 2, which states that the SFP must be subcritical with unborated water ($k_{eff} < 1.0$) and with soluble boron present, k_{eff} must not be more than 0.95 . This difference defines the 5% in reactivity.

The second term, SBC_{RE}, accounts for assembly reactivity uncertainties. The SBC_{RE} term was originally used to account for the reactivity penalty inherent in reactivity equivalencing, but this practice is no longer used. This term is currently used to account for two specific uncertainties:

- Burnup uncertainty - the burnup uncertainty is determined as the reactivity associated with a 5% decrease in assembly burnup. The reactivity impact of the 5% reduction in burnup is fuel storage configuration specific because of both the maximum credited burnup in that configuration and the reactivity response to the burnup change. The largest uncertainty is selected from all configurations analyzed.
- Depletion uncertainty - The depletion uncertainty is calculated as 1% reactivity per 30,000 MWd/MTU. The largest burnup credited in this analysis is used for determining this uncertainty.

The reactivity effects of the burnup and depletion uncertainties are combined algebraically to yield a bounding assembly reactivity uncertainty.

The third term, SBC_{PA}, is the boron concentration necessary to mitigate the worst postulated accident scenario. The double contingency principle, detailed in References 3 and 4, allows the use of soluble boron to mitigate these other accidents, since a boron dilution event and the postulated accident scenarios are separate low-probability events. The specific events considered are provided in Reference 1. Each accident is considered from unborated pool conditions as this produces the highest reactivity in the accident condition. The reactivity insertion of the accident is calculated as the difference between the accident k_{eff} and the base case unborated k_{eff}.

The final step is the summing of the three boron concentration terms.

There are several conservatisms implicit to the Westinghouse soluble boron credit methodology, and these include the following:

1. The burnup uncertainty is included in the SBC_{RE} term (as described above), but is also included in the overall criticality analysis bias and uncertainty rackup. Since the uncertainty is already accounted for, adding it in the SBC_{RE} term is additional conservatism.
2. The algebraic treatment of the two portions of the SBC_{RE} term is conservative relative to a statistical root-sum-square (RSS) combination of two independent uncertainties.
3. Biases and uncertainties are not recalculated in the presence of soluble boron. Westinghouse experience is that the sum of biases and uncertainties is nearly invariant to the presence of soluble boron and, in most cases, decreases slightly, as shown in the current criticality safety analysis of record for BVPS-2. Thus, using the biases and uncertainties from unborated conditions provides a slight conservatism for most analyses.
4. Conservatism exists in using a single boron worth determined with fuel depleted to the maximum credited burnup of any configuration. Particularly for an accident condition, which is typically limited by a misloaded fresh 5 w/o assembly, this single soluble boron worth value can be higher than that calculated for the entire spent pool model. The mitigation of the accident will be driven by the boron within the misloaded assembly, which will respond more than the depleted fuel for which the worth was calculated. This is the largest source of conservatism in the Westinghouse soluble boron credit methodology. While the limiting Reference 1 accident occurs in the "1-out-of-4 5.0 w/o at 15,000 MWd/MTU" configuration, a conservatively low boron worth determined with the "3x3" configuration (requiring increased burnup) is used to calculate the boron concentration necessary to mitigate the accident. If the lower burnup requirements for "1-out-of-4 5.0 w/o at 15,000 MWd/MTU" configuration were used, then the soluble boron worth would increase and the soluble boron requirements would decrease.

   Table 1 presents a series of soluble boron worth calculations performed in a similar method as described in Reference 1, with the exception that the maximum concentration considered is increased to 1000 ppm and SCALE 4.4 is used. The differential boron worth varies from 0.00017 Δk_{eff}/ppm at 200 ppm to 0.00014 Δk_{eff}/ppm at 1000 ppm. Table 2 shows that the differential boron worth calculated in the limiting accident condition ("1-out-of-4 5.0 w/o at 15,000 MWd/MTU" configuration) is 0.00019 Δk_{eff}/ppm. Since a lower boron worth value was utilized in the Reference 1 analysis, the soluble boron requirements are conservatively higher than necessary.

Table 1. Soluble Boron Worth in the BVPS-2 Spent Fuel Pool

Boron Concentration (ppm)	k_{eff}	σ	Integral Boron Worth (Δk_{eff})	Differential Boron Worth (Δk_{eff}/ppm)
0	0.97081	0.00034	0	0
200	0.93619	0.00032	0.03462	0.00017
400	0.90586	0.00029	0.06495	0.00016
600	0.87832	0.00030	0.09249	0.00015
800	0.85389	0.00030	0.11692	0.00015
1000	0.83167	0.00027	0.13914	0.00014

5. The accident scenarios presented in Reference 1 were conservatively considered in a pool *with no soluble boron present.* The limiting postulated accident was determined in Reference 1 to be the misloading of a fresh 5 w/o assembly, and the reactivity of this assembly was maximized by considering it in the unborated condition. Table 2 presents analysis performed to demonstrate the conservatism inherent in this approach.

Table 2. Accident Condition k_{eff} at Different Soluble Boron Concentrations

Configuration	Boron Concentration (ppm)	k_{eff}	σ	Accident Δk_{eff}
3x3 - Base	0	0.97081	0.00034	
3x3 - Misload		1.02579	0.00031	0.05498
3x3 - Base	441.8	0.89942	0.00031	
3x3 - Misload		0.94910	0.00034	0.04968
1-out-of-4, 5 w/o, 15k - Base	0	0.95866	0.00025	
1-out-of-4, 5 w/o, 15k - Misload		1.02096 (1)	0.00033	0.06230
1-out-of-4, 5 w/o, 15k - Base	441.8	0.86213	0.00023	
1-out-of-4, 5 w/o, 15k - Misload		0.93692 (1)	0.00029	0.07479

(1) The differential boron worth of the misload accident case is 0.00019 Δk_{eff}/ppm

- The misload accident was considered for the two limiting fuel storage configurations identified in Reference 1 – "3x3" and "1-out-of-4 5.0 w/o at 15,000 MWd/MTU".
- For each configuration, the base case and accident k_{eff} were determined at both 0 ppm and 441.8 ppm soluble boron concentration. Per Reference 1, 441.8 ppm is the required minimum concentration not accounting for any accidents.
- For the "3x3" configuration, *the accident Δk_{eff} decreases in the presence of soluble boron.*
- For the "1-out-of-4 5.0 w/o at 15,000 MWd/MTU" configuration, the accident Δk_{eff} increases in the presence of soluble boron; however, the *accident condition k_{eff} is more than 6% subcritical.*
- These calculations demonstrate that while *in some cases* it is more conservative to consider the accident condition initiating from the required boron concentration, the resulting accident k_{eff} is significantly subcritical.

6. The three SBC terms are determined first as reactivities and then each is individually ("parallel" application) translated into boron concentrations. It has been commented that since the differential boron worth is reduced as boron concentration increases that a more conservative approach would be to sum the Δk_{eff} for each of the three terms ("serial" application), and then translate this overall worth into a boron concentration.

   Table 3 presents a series of calculations performed in the limiting accident condition ("1-out-of-4 5.0 w/o at 15 GWd/MTU" configuration) at varying boron concentrations. The results show that at the total soluble boron requirement identified in Reference 1 (determined using the "parallel application" of boron worths), the SFP is *subcritical by almost 12% Δk_{eff}.* Table 3 also shows that with "serial application" of the soluble boron worth the SFP is subcritical by more than 14% Δk_{eff}. While more conservative, this clearly represents an unnecessary level of conservatism in this case.

Table 3. "1-out-of-4 5.0 w/o at 15 GWd/MTU" Accident Condition k_{eff} at Different Soluble Boron Concentrations

Boron Concentration (ppm)	k_{eff}	σ
0	1.02096	0.00033
382.3 (accident mitigation)	0.94664	0.00030
441.8 (required without accident)	0.93692	0.00029
836.3 (parallel application)	0.88099	0.00030
1005.6 (serial application)	0.85965	0.00030

In summary, there are conservatisms in the soluble boron concentration requirement that provides more than 10% Δk_{eff} conservatism.

Burnup Profile

The burnup profile used in the Reference 1 analysis is obtained from Reference 5. As elaborated below, the profile selected for use is very conservative and obviates the need for consideration of plant specific burnup shapes above 30 GWd/MTU. The profile is applied to every depleted fuel assembly modeled in the Reference 1 analysis.

A series of 12 bounding profiles are presented in Reference 5, derived from the DOE burnup shape database (Reference 6). Each profile represents the axial burnup distribution which yields the largest calculated k_{eff} in the burnup range considered in that group. The profile for Group 5 covers the burnup range from 30 – 34 GWd/MTU, and per Reference 5 can be conservatively applied to all higher burnups as well. The reason for this is that the burnup profiles become flatter (i.e. higher relative burnup levels near the ends of the fuel) as fuel burnup is increased, thereby reducing the reactivity near the ends of the fuel. Therefore, the profile is conservatively applied in the Reference 1 analysis for each fuel storage configuration at 30 GWd/MTU and higher. This profile is also applied in the Reference 1 analysis for each fuel storage configuration from 0 to 30 GWd/MTU; additional information demonstrating that this is conservative for BVPS-2 is provided in RAI Response to Items 2 and 5.

The NUREG guidance (Reference 5) notes that the database presented in Reference 6 is an adequate representation of all spent nuclear fuel from U.S. PWRs. This database includes profiles from Westinghouse plants and fuel as well as other vendor plants and fuel types. The bounding Group 5 profile is 4.5 standard deviations (or approximately 0.03 Δk_{eff}) more reactive than the average assembly profile within the Group 5 database. The profile is described as a statistical outlier that causes "a considerable increase in reactivity." This limiting profile is from a B&W 15x15 fuel assembly that is likely to have experienced control rod shadowing for a substantial portion of its depletion. The most reactive Group 5 profile presented in Reference 6 for Westinghouse 17x17 fuel is only about 0.015 Δk_{eff} more reactive than the average assembly profile. This demonstrates that actual Westinghouse 17x17 fuel assembly burnup profiles are significantly less skewed than the profile used in the Reference 1 analysis, reflecting the fact that Westinghouse PWRs such as BVPS-2 have traditionally operated at baseload conditions with (near) all-rods-out, and continue to do so.

The nodalization used for the Reference 1 analysis is a 4-zone model that has three 6-inch nodes at the top of the assembly to capture the end effect. The remaining 126 inches of the fuel assembly is represented as a single node. Benchmarking calculations show that the 4-zone model is statistically identical to a 7-zone model that has three 6-inch zones at both the top and bottom of the fuel assembly. The reason for this is that the slightly less depleted bottom end of the fuel assembly does not contribute to the overall assembly reactivity. This reactivity is largely driven by the top portion of the assembly where the presence of lower moderating conditions creates a harder neutron spectrum and consequently more plutonium production.

Physical Fuel Rod Tolerances

The two physical fuel rod tolerances considered here are on the fuel pellet diameter and the cladding thickness. The tolerance on pellet diameter has been evaluated to determine its reactivity effect, though only the positive tolerance is considered because it adds fissile mass. The tolerance on cladding thickness has also been evaluated, and is considered in both directions. The reactivity impact of these tolerances is shown in Table 4, although only the minimum cladding thickness result is provided because it results in a positive reactivity uncertainty. The overall impact on the bias and uncertainty rackup would be 0.00004 Δk_{eff}, and is not included in the Reference 1 analysis. This impact is consistent with Westinghouse experience that has shown the net effect of these physical fuel rod tolerances on the bias and uncertainties to be less than 0.00005 Δk_{eff}.

Table 4. Fuel Rod Physical Tolerance Results for the "All-Cell" Configuration

Configuration	k_{eff}	σ	Δk_{eff}
Nominal	0.97346	0.00011	
Maximum diameter fuel pellet	0.97371	0.00011	0.00047
Minimum cladding thickness	0.97434	0.00011	0.00110

One source of conservatism available to offset the small impact of the physical fuel rod tolerances is the assumption on fuel pellet theoretical density. The Reference 1 analysis assumes a 97.5% theoretical density in a right circular cylinder with no fuel pellet dishing or chamfering. However, if the actual bounding theoretical density of all manufactured BVPS-2 fuel is considered, at least a 1% reduction in theoretical density is realized. A further reduction in fissile mass and reactivity would be realized if the 1.1% nominal pellet dishing and chamfering were explicitly considered.

Table 5 presents analysis to quantify the reactivity decrease associated with a 1% reduction in pellet density only, from 97.5% to 96.5%. The reactivity decrease varies from 0.00081 to 0.00145 Δk_{eff} depending on fuel storage configuration. If one adjusts the Table 5 k_{eff} values for the Monte Carlo uncertainties, then the reactivity decrease varies from 0.00035 to 0.00120 Δk_{eff} depending on fuel storage configuration. In either case, this reactivity decrease is more than sufficient to compensate for the very small reactivity increase associated with physical fuel rod tolerances.

Table 5. Conservatism Determined from 1% Reduction in Theoretical Density

Configuration	97.5% Theoretical Density		96.5% Theoretical Density		Δk_{eff}
	k_{eff}	σ	k_{eff}	σ	
All-Cell	0.97346	0.00011	0.97211	0.00011	0.00135
3x3	0.95866	0.00025	0.95785	0.00021	0.00081
1-out-of-4 5 w/o 15,000	0.96894	0.00016	0.96786	0.00017	0.00107
1-out-of-4 3.85 w/o IFBA	0.95404	0.00013	0.95259	0.00012	0.00145

RAI Item 2

After considering the information in CN-CRIT-244 and NUREG/CR-6801 (Reference 5), it appears the axial burnup profile used in WCAP-16518 under predicts k_{eff} for any case run at 15 gigawatt day per metric ton uranium (GWD/MTU) or 25 GWD/MTU. Provide a site-specific analysis that demonstrates that BVPS-2 retains reactivity margin with the burnup profile used in the WCAP-16518 analysis.

RAI Item 5

During the depletion phase of the analysis, core operating parameters should be selected to maximize ^{241}Pu production and increase the reactivity of the spent fuel. WCAP-16518 did not use core operating parameters which would maximize ^{241}Pu production. NUREG/CR-6665, Reference 4, provides some indication of the impact of the core operating parameters. The information in CN-CRIT-244 indicated that the axial burnup profile used in WCAP-16518 provides sufficient margin to accommodate this issue above, but not below 30 GWD/MTU. Provide a site-specific analysis that demonstrates that BVPS-2 retains reactivity margin with the burnup profile used in the WCAP-16518 analysis.

Response to Items 2 and 5

An analysis has been performed to investigate the reactivity effects of the use of limiting BVPS-2 burnup profiles, between 10 GWd/MTU and 30 GWd/MTU, and the use of limiting core operating temperatures on the criticality safety conclusions presented in Reference 1. This analysis has considered specific depletion effects from BVPS-2 core operation and the actual geometry and pool conditions in the spent fuel pool. The burnup profiles investigated in this analysis considered:

- *all* non-blanketed fuel assembly discharge burnup profiles that have less relative burnup in the top two zones than the burnup profile utilized in Reference 1.
- *all* natural-enriched blanket fuel assembly end-of-cycle burnup profiles from applicable cycles.
- *all* mid-enriched blanket fuel assembly end-of-cycle burnup profiles from applicable cycles.

Note that nearly all blanketed fuel assembly burnup profiles have less relative burnup in the top three zones than the burnup profile utilized in the Reference 1 analysis, as expected. The analysis explicitly demonstrates that the reduced reactivity resulting from the lower blanket enrichments is more than sufficient to offset the reactivity effects of the most severe BVPS-2 burnup profiles identified. This axial blanket reactivity benefit conservatively bounds less severe blanketed fuel assembly burnup profiles.

The limiting BVPS-2 burnup profiles were explicitly analyzed using a limiting temperature profile that bounds uprated core conditions and all previous cycles' operating conditions. Reactivity comparisons are made relative to the Reference 1 conditions.

The following conclusions are drawn from the analysis of these burnup profiles and operating conditions.

- The reactivity of all non-blanketed BVPS-2 fuel assemblies, including the effects of bounding core operating temperatures, is demonstrated to be less than that of the associated minimum burnup requirement contained in Reference 1.
- The reactivity resulting from the most severe blanketed (natural and mid-enriched) fuel assembly burnup profiles, including the effects of bounding core operating temperatures, is demonstrated to be less than that of the Reference 1 burnup profile and conditions.

The results demonstrate that the Reference 1 analysis is conservative with respect to the use of limiting BVPS-2 burnup profiles and bounding core operating temperatures.

The following conditions are required to be met, prior to, or concurrent with, amendment implementation, for any new BVPS-2 fresh fuel assemblies in order to remain bounded by the Reference 1 analysis conclusions.

- Fresh fuel assemblies with nominal center-zone enrichments of 3.6 w/o to 4.95 w/o must contain a blanket with a minimum nominal length of 6 inches and with a nominal enrichment that does not exceed 2.6 w/o.
- Fresh fuel assemblies with nominal center-zone enrichments less than 3.6 w/o must contain a blanket with a minimum nominal length of 6 inches and with a nominal enrichment that does not exceed 1.0 w/o.

Deviations from these conditions will require evaluation/analysis to demonstrate that the Reference 1 conclusions remain applicable.

Description of Analysis

The analysis is separated into three categories of depletion calculations: non-blanketed fuel assemblies, natural-enriched blanket assemblies, and mid-enriched blanket assemblies. All BVPS-2 burnup profiles evaluated in the analysis consider a limiting temperature profile that is specified in Table 6. The Reference 1 burnup profile evaluated in the analysis considers the temperature profile from Reference 1 (values shown in Table 6).

Table 6. Moderator Temperature Profiles

Axial Zone	*Reference 1 Temperature Profile (°F)*	*Limiting Temperature Profile (°F)*
1 (6 inches)	612.86	619.23
2 (6 inches)	608.99	614.88
3 (6 inches)	605.12	610.53
4 (126 inches)	574.14	577.36

Non-Blanketed Fuel Assemblies

Non-blanketed fresh fuel was only inserted into BVPS-2 Cycle 1; the last of these assemblies were discharged at end of Cycle 5, and there is no plan to use these fuel assemblies again in BVPS-2. The analysis considers the discharge burnup profiles from all non-blanketed fuel assemblies used in the BVPS-2 core. Most of these discharge burnup profiles were found to be bounded by the burnup profile used in Reference 1; however, five of these discharge burnup profiles were found to be not bounded by the profile used in Reference 1, in that these profiles had less relative burnup in the top two zones of the assembly than the Reference 1 burnup profile. Since the axial burnup profile reactivity effect is dominated by the relative burnups in the top two zones, these particular profiles will be limiting. These five limiting non-blanketed assembly burnup profiles are shown in Table 7.

Table 7. Bounding Non-Blanketed Assembly Burnup Profiles

Axial Zone	*Reference 1 Profile*	**Profile 1(1)** **Cycle 3**	**Profile 2(2)** **Cycle 1**	**Profile 3(2)** **Cycle 1**	**Profile 4(2)** **Cycle 1**	**Profile 5(2)** **Cycle 1**
1	0.462	0.443	0.471	0.496	0.511	0.487
2	0.738	0.698	0.703	0.724	0.737	0.719
3	0.971	0.860	0.836	0.847	0.855	0.845
4	1.039	1.048	1.047	1.044	1.043	1.045

(1) Profile used for Table 9 analysis.
(2) Profile used for Table 10 analysis.

For each of the five fuel assemblies with limiting burnup profiles, the following steps were performed.

- A depletion calculation was performed using that assembly's initial enrichment, and using the limiting operating temperatures defined in Table 6.
- The isotopics resulting from this depletion calculation were then used in a spent fuel pool storage configuration calculation that also used the actual fuel assembly burnup and that assembly's limiting burnup profile.

The results of this calculation were then compared against a similar calculation that used the actual fuel assembly enrichment, and fuel assembly isotopics obtained from a depletion using the Reference 1 operating temperature profile, the Reference 1 burnup profile, and the minimum required burnup for the storage configuration in question. The minimum required burnup for each storage configuration was determined from the burnup versus enrichment polynomials in Reference 1.

If the reactivity from the first calculation was less than that from the second calculation, then margin existed within the Reference 1 analysis to permit storage of that limiting burnup shape. This set of calculations was repeated for each storage configuration that was permissible for the combination of enrichment and burnup represented by the actual fuel assembly.

Table 9 shows the results of these calculations for the single assembly (at 3.099 w/o^{235}U) discharged from Cycle 3 that is lower than the Reference 1 burnup profile in zones 1 and 2. These results demonstrate that this actual profile is less reactive than that based upon the Reference 1 profile in all spent fuel pool storage configurations in which this fuel assembly is allowed to be stored in accordance with the Reference 1 requirements. This supports the conclusion that while a single Cycle 3 burnup shape has less burnup in the top two zones than the Reference 1 burnup profile, the reactivity determined in the Reference 1 analysis is conservative. Note that the "RSS σ" column is the root-sum-square of the Monte Carlo standard deviations from the neutronic simulations – this is the uncertainty on each reported Δk value in the table.

Table 10 shows the results for the four assemblies (at 2.105 w/o ^{235}U) discharged from Cycle 1 that are lower than the Reference 1 burnup profile in zone 2. These results demonstrate that these actual fuel assemblies are less reactive than the limit from Reference 1 in all spent fuel pool storage configurations. Note that the assembly with burnup Profile 4 and 18,427 MWd/MTU of burnup is bounded by a small reactivity difference in the 3x3 storage configuration that may be statistically insignificant. This assembly was discharged from the core at the end of BVPS-2 Cycle 1 operation. When the ^{241}Pu decay (and associated ^{241}Am buildup) is credited over a 15 year period (this assembly has more than 15 years of decay time), the reactivity of the assembly is demonstrated to be 0.00924 Δk conservative relative to the Reference 1 limit. No credit is taken for the decay of any other actinides or fission products. This supports the conclusion that while four Cycle 1 burnup shapes have been identified that have less burnup in zone 2 than the Reference 1 burnup profile, the reactivity determined in the Reference 1 analysis is conservative in all cases.

Blanketed Assemblies

The blanketed assembly burnup profiles selected for investigation in this analysis are shown in Table 8. These are the burnup profiles that have the lowest relative burnup in the top two zones of the assembly, and therefore result in the highest reactivity. The reactivity behavior is investigated at 15000 MWd/MTU, 20000 MWd/MTU and 25000 MWd/MTU in each instance.

Natural Blanket Assemblies

Fresh fuel containing natural blankets was only inserted into BVPS-2 Cycles 2 through Cycle 8. Table 11 shows the spent fuel pool k_{eff} values for assembly burnup profiles with natural blankets. The bounding end-of-cycle burnup profile for all natural blanket assemblies ever used at BVPS-2 was selected. The reactivity of the bounding assembly is compared to that of a depleted assembly with the profile utilized in Reference 1 (without blankets) at the same absolute burnup in the All-Cell storage configuration. This configuration produces the largest coupling of blanketed fuel burnup profiles and will conservatively represent the effect relative to the other storage configurations. The isotopics for the natural blanket assembly were calculated using the limiting operating temperature profile shown in Table 6.

These comparisons are performed for a center-zone ^{235}U enrichment range of 3.2 w/o to 5.0 w/o. Note that the natural blankets were simulated with 1.0 w/o fuel to conservatively represent their reactivity-dampening effect.

The results in Table 11 demonstrate that this natural blanket burnup profile is less reactive than the Reference 1 profile in all spent fuel pool storage configurations. This supports the conclusion that while natural blanket burnup shapes have less burnup in the top zones than the Reference 1 burnup profile, the reactivity determined in the Reference 1 analysis is conservative in all cases.

Mid-Enriched Blanket Assemblies

Since Cycle 9, all fresh fuel inserted into BVPS-2 has contained mid-enriched (2.6 w/o) blankets. Table 12 and Table 13 show the spent fuel pool k_{eff} values for assembly burnup profiles with mid-enriched blankets. The bounding profiles which were used are provided in Table 8. The reactivity of an assembly with each of the bounding profiles is compared to that of a depleted assembly with the profile utilized in Reference 1 (without blankets) at the same absolute burnup in the All-Cell storage configuration. This configuration produces the largest coupling of blanketed fuel burnup profiles and will conservatively represent the effect relative to the other storage configurations. The isotopics for the mid-enriched assemblies were calculated using the limiting operating temperature profile shown in Table 6.

These comparisons are performed over two ^{235}U enrichment ranges. The burnup profiles occurring in assemblies with lower center-zone enrichment are grouped and analyzed across a range from 3.6 w/o to 4.6 w/o. Burnup profiles occurring in assemblies with higher center-zone enrichment are grouped and analyzed across a range from 4.6 w/o to 5.0 w/o. The enrichment ranges are selected because higher center-zone enrichment assemblies produce more limiting burnup profiles for a given blanket enrichment, and it would be overly conservative to apply these profiles to fuel assemblies with lower center-zone enrichments but containing the same blanket enrichment.

Note that the mid-enriched blankets were all modeled with 2.60 w/o solid fuel pellets. This is the only mid-enriched blanket enrichment that has been utilized at BVPS-2. Also, use of solid fuel pellets conservatively represents the reactivity behavior of annular fuel pellets that are sometimes utilized in blanket fuel at BVPS-2.

The results in Table 12 and Table 13 demonstrate that these mid-enriched blanket burnup profiles are less reactive than the Reference 1 profile in all spent fuel pool storage configurations. In most cases, a trend of increasing margin to the Reference 1 results with increasing burnup was noted. In two cases, however, this trend was not seen. The reactivity differences which establish these trends are noted to be relatively small, and the absence of such a trend is statistically insignificant, given that the one-sigma uncertainties on these reactivity differences are of similar magnitude to the trends themselves. This supports the conclusion that while mid-enriched blanket burnup shapes have less burnup in the top zones than the Reference 1 burnup profile, the reactivity determined in the Reference 1 analysis is conservative in all cases.

Table 8. Bounding Blanketed Assembly Burnup Profiles

Axial Zone	Natural Blankets (Cycles 2 – 8)	Mid-Enriched Blankets (Cycles 9 - 13)			
	3.20 – 5.00 w/o	3.60 - 4.60 w/o		4.60 - 5.00 w/o	
	Limiting Zone 1 & 2 Profile(1)	Limiting Zone 1 Profile(2)	Limiting Zone 2 Profile(2)	Limiting Zone 1 Profile(3)	Limiting Zone 2 Profile(3)
	Cycle 7	Cycle 9	Cycle 9	Cycle 9	Cycle 13
1	0.151	0.334	0.344	0.331	0.341
2	0.638	0.741	0.698	0.703	0.696
3	0.864	0.836	0.908	0.911	0.871
4	1.064	1.052	1.050	1.050	1.052

(1) Profile used for Table 11 analysis.
(2) Profile used for Table 12 analysis.
(3) Profile used for Table 13 analysis.

Table 9. k_{eff} Comparison of Non-Blanketed Cycle 3 Discharge Shape and Reference 1 Burnup Limit

Description	Enrichment	Burnup	k_{eff}	+/-	σ	Δk	+/-	RSS σ
Ref. 1 profile, Ref. 1 temps, non-blanketed, All-Cell	3.099	14131	0.97635	+/-	0.00032	*Rel. to Ref. 1*		
Ref. 1 profile, Ref. 1 temps, non-blanketed, 1-out-of-4 with 15k	3.099	21377	0.97274	+/-	0.00032			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 20 years decay	3.099	27003	0.97550	+/-	0.00051			
Cycle 3, Profile 1 [1]								
All-Cell	3.099	27491	0.89555	+/-	0.00032	-0.08080	+/-	0.00045
1-out-of-4 with 15k	3.099	27491	0.95431	+/-	0.00036	-0.01843	+/-	0.00048
3x3, 20 years decay	3.099	27491	0.97424	+/-	0.00047	-0.00126	+/-	0.00069
1-out-of-4 with 3.85 w/o	3.099	27491	*Assembly with this enrichment & burnup not permitted to be stored in this configuration*					

[1] Burnup profile described in Table 7. Used limiting temperature profile described in Table 6.

Table 10. k_{eff} Comparison of Non-Blanketed Cycle 1 Discharge Shapes and Reference 1 Burnup Limit

Description	Enrichment	Burnup	k_{eff}	+/-	σ	Δk	+/-	RSS σ
Ref. 1 profile, Ref. 1 temps, non-blanketed, All-Cell	2.105	*2940*	*0.97140*	+/-	*0.00032*	*Relative to the actual, Ref. 1 conditions*		
Ref. 1 profile, Ref. 1 temps, non-blanketed, 1-out-of-4 with 15k		8235	0.97357	+/-	0.00032			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 1-out-of-4 with 3.85 w/o		15154	0.98219	+/-	0.00039			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 0 years decay		17967	0.97820	+/-	0.00050			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 5 years decay		16780	0.97747	+/-	0.00050			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 10 years decay		15044	0.97850	+/-	0.00043			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 15 years decay		14695	0.97866	+/-	0.00051			
Ref. 1 profile, Ref. 1 temps, non-blanketed, 3x3, 20 years decay		14332	0.97778	+/-	0.00051			
Cycle 1, Profile 2 [(1)]								
All-Cell	2.105	15874	0.86628	+/-	0.00031	-0.10512	+/-	0.00045
1-out-of-4 with 15k			0.94181	+/-	0.00035	-0.03176	+/-	0.00047
1-out-of-4 with 3.85 w/o			0.97992	+/-	0.00037	-0.00227	+/-	0.00054
3x3, 10 years decay			0.97670	+/-	0.00054	-0.00180	+/-	0.00069
Cycle 1, Profile 3 [(1)]								
All-Cell	2.105	17853	0.85341	+/-	0.00028	-0.11799	+/-	0.00043
1-out-of-4 with 15k			0.93475	+/-	0.00036	-0.03882	+/-	0.00048
1-out-of-4 with 3.85 w/o			0.97323	+/-	0.00040	-0.00896	+/-	0.00056
3x3, 5 years decay			0.97544	+/-	0.00050	-0.00203	+/-	0.00071
Cycle 1, Profile 4 [(1)]								
All-Cell	2.105	18427	0.84840	+/-	0.00028	-0.12300	+/-	0.00043
1-out-of-4 with 15k			0.93225	+/-	0.00034	-0.04132	+/-	0.00047
1-out-of-4 with 3.85 w/o			0.97252	+/-	0.00037	-0.00967	+/-	0.00054
3x3, 0 years decay			0.97805	+/-	0.00049	-0.00015	+/-	0.00070
3x3, 15 years decay			0.96896	+/-	0.00053	-0.00924	+/-	0.00074
Cycle 1, Profile 5 [(1)]								
All-Cell	2.105	14686	0.87381	+/-	0.00029	-0.09759	+/-	0.00043
1-out-of-4 with 15k			0.94548	+/-	0.00037	-0.02809	+/-	0.00049
3x3			*Assembly with this enrichment & burnup not permitted to be stored in these configurations*					
1-out-of-4 with 3.85 w/o								

[(1)] Burnup profile described in Table 7. Used limiting temperature profile described in Table 6.

Table 11. k_{eff} Comparison of Bounding Natural Blanket Burnup Profile and Reference 1 Burnup Profile

Description	Enrichment	Burnup	k_{eff}	+/-	σ	Δk		
Ref. 1 profile, Ref. 1 temps, non-blanketed	3.2	15000	0.97812	+/-	0.00034	*Relative to the base, Ref. 1 conditions*		
		20000	0.94221	+/-	0.00032			
		25000	0.91075	+/-	0.00034			
	4.6	15000	1.07106	+/-	0.00030			
		20000	1.03841	+/-	0.00033			
		25000	1.00682	+/-	0.00032			
	5.0	15000	1.09134	+/-	0.00031			
		20000	1.05857	+/-	0.00034			
		25000	1.02857	+/-	0.00029			**RSS σ**
Natural Blankets								
Table 8 Natural Blanket Limiting Profile [1]	3.2	15000	0.97480	+/-	0.00032	-0.00332	+/-	0.00047
		20000	0.93679	+/-	0.00030	-0.00542	+/-	0.00044
		25000	0.90285	+/-	0.00031	-0.00790	+/-	0.00046
	4.6	15000	1.06796	+/-	0.00031	-0.00310	+/-	0.00043
		20000	1.03345	+/-	0.00032	-0.00496	+/-	0.00046
		25000	1.00068	+/-	0.00031	-0.00614	+/-	0.00045
	5.0	15000	1.08847	+/-	0.00032	-0.00287	+/-	0.00045
		20000	1.05478	+/-	0.00031	-0.00379	+/-	0.00046
		25000	1.02343	+/-	0.00031	-0.00514	+/-	0.00042

[1] Isotopics determined using limiting temperature profile described in Table 6. Natural blanket conservatively represented using 1 w/o ^{235}U fuel.

Table 12. k_{eff} Comparison of Bounding Mid-Enriched Blanket Burnup Profiles and Reference 1 Burnup Profile at Low Enrichments (3.6 – 4.6 w/o)

Description	Enrichment	Burnup	k_{eff}	+/-	σ	Δk	+/-	RSS σ
Ref. 1 profile, Ref. 1 temps, non-blanketed	3.6	15000	1.00853	+/-	0.00032	*Relative to the base, Ref. 1 conditions*		
		20000	0.97339	+/-	0.00030			
		25000	0.94150	+/-	0.00032			
	4.6	15000	1.07106	+/-	0.00030			
		20000	1.03841	+/-	0.00033			
		25000	1.00682	+/-	0.00032			
Mid-Enriched Blankets (2.6 w/o)								
Table 8 Mid-Enriched Blanket, 3.6-4.6 w/o, Limiting Zone 1 Profile [1]	3.6	15000	1.00786	+/-	0.00031	-0.00067	+/-	0.00045
		20000	0.97175	+/-	0.00031	-0.00164[2]	+/-	0.00043
		25000	0.94064	+/-	0.00032	-0.00086	+/-	0.00045
	4.6	15000	1.06995	+/-	0.00033	-0.00111	+/-	0.00045
		20000	1.03582	+/-	0.00033	-0.00259	+/-	0.00047
		25000	1.00301	+/-	0.00031	-0.00381	+/-	0.00045
Mid-Enriched Blankets (2.6 w/o)								
Table 8 Mid-Enriched Blanket, 3.6-4.6 w/o, Limiting Zone 2 Profile [1]	3.6	15000	1.00794	+/-	0.00031	-0.00059	+/-	0.00045
		20000	0.97206	+/-	0.00030	-0.00133	+/-	0.00042
		25000	0.93915	+/-	0.00032	-0.00235	+/-	0.00045
	4.6	15000	1.06953	+/-	0.00030	-0.00153	+/-	0.00042
		20000	1.03545	+/-	0.00031	-0.00296	+/-	0.00045
		25000	1.00314	+/-	0.00030	-0.00368	+/-	0.00044

(1) Isotopics determined using limiting temperature profile described in Table 6.

(2) Note that the Δk result does not follow the general trend of increasing conservatism with increasing burnup due to the statistical variation of the calculations.

Table 13. k_{eff} Comparison of Bounding Mid-Enriched Blanket Burnup Profiles and Reference 1 Burnup Profile at High Enrichments (4.6 – 5.0 w/o)

Description	Enrichment	Burnup	k_{eff}	+/-	σ	Δk	+/-	RSS σ
Ref. 1 profile, Ref. 1 temps, non-blanketed	4.6	15000	1.07106	+/-	0.00030	*Relative to the base, Ref. 1 conditions*		
		20000	1.03841	+/-	0.00033			
		25000	1.00682	+/-	0.00032			
	5.0	15000	1.09134	+/-	0.00031			
		20000	1.05857	+/-	0.00034			
		25000	1.02857	+/-	0.00029			
Mid-Enriched Blankets (2.6 w/o)								
Table 8 Mid-Enriched Blanket, 4.6-5.0 w/o, Limiting Zone 1 Profile [1]	4.6	15000	1.06948	+/-	0.00032	-0.00158	+/-	0.00044
		20000	1.03560	+/-	0.00032	-0.00281	+/-	0.00046
		25000	1.00344	+/-	0.00031	-0.00338	+/-	0.00045
	5.0	15000	1.08954	+/-	0.00035	-0.00180	+/-	0.00047
		20000	1.05640	+/-	0.00031	-0.00217	+/-	0.00046
		25000	1.02566	+/-	0.00030	-0.00291	+/-	0.00042
Mid-Enriched Blankets (2.6 w/o)								
Table 8 Mid-Enriched Blanket, 4.6-5.0 w/o, Limiting Zone 2 Profile [1]	4.6	15000	1.06961	+/-	0.00033	-0.00145	+/-	0.00045
		20000	1.03611	+/-	0.00033	-0.00230	+/-	0.00047
		25000	1.00369	+/-	0.00031	-0.00313	+/-	0.00045
	5.0	15000	1.08945	+/-	0.00034	-0.00189	+/-	0.00046
		20000	1.05705	+/-	0.00034	-0.00152 [2]	+/-	0.00048
		25000	1.02540	+/-	0.00032	-0.00317	+/-	0.00043

(1) Isotopics determined using limiting temperature profile described in Table 6.

(2) Note that the Δk result does not follow the general trend of increasing conservatism with increasing burnup due to the statistical variation of the calculations.

RAI Item 3

WCAP-16518 calculates the burnup uncertainty in a method different than that specified in the NRC staff guidance, Reference 3. The NRC staff has reviewed the justification for the new method and determined it is inadequate to justify the method. Calculate the burnup uncertainty in accordance with the NRC staff guidance in Reference 3.

Response to Item 3

The 5% Reactivity Decrement method suggested in the NRC guidance document (Reference 4) has been used to determine a revised burnup uncertainty. In this method, fresh fuel assemblies (5 w/o, 0 GWd/MTU burnup) are substituted into each "Depleted Fuel" location in the storage configurations presented in Section 3.1 of Reference 1. The total reactivity credit associated with fuel burnup is determined by comparing the burnup-credited k_{eff} of the configuration (i.e., 0.995 minus the Sum of Biases and Uncertainties) to the k_{eff} of the same configuration with the Depleted Fuel locations replaced with the most reactive possible fuel assemblies (5 w/o, 0 GWd/MTU burnup). This reactivity difference is multiplied by 5% to determine the decremental burnup uncertainty.

As summarized in Table 14, using the revised burnup uncertainty, the overall Sum of Biases and Uncertainties is increased by 0.00222 to 0.00303 Δk_{eff}, depending on storage configuration, compared to the methodology presented in Reference 1.

Table 14. Sum of Biases and Uncertainties

	Configuration (units in Δk_{eff})			
Parameter	**All Cell**	**3x3**	**1-out-of-4 3.85 w/o Fresh with IFBA**	**1-out-of-4 5.0 w/o at 15 GWD/MTU**
Increased Enrichment	0.00284	0.00173	0.00338	0.00226
Decreased Cell Pitch	0.00674	0.00472	0.00538	0.00678
Decreased Rack Thickness	0.00609	0.00645	0.00411	0.00505
Increased Rack ID	0.00033	0.00090	0.00111	0.00037
Off-Center Positioning	0.00740	0.01602	0.00670	0.00760
Wrapper Thickness	0.00326	0.00362	0.00294	0.00278
Burnup Uncertainty	*0.01246*	*0.01217*	*0.01112*	*0.01097*
Methodology Uncertainty	0.00643	0.00645	0.00643	0.00643
Statistical Sum of Uncertainties	**0.01878**	**0.02296**	**0.01664**	**0.01743**
Methodology Bias	0.00310	0.00310	0.00310	0.00310
Temperature Bias	0.01077	0.00120	0.00534	0.00983
5% Reactivity Decrement Method - Sum of Biases and Uncertainties	**0.03265**	**0.02726**	**0.02508**	**0.03036**
Reference 1 Method – Sum of Biases and Uncertainties	**0.03043**	**0.02423**	**0.02217**	**0.02758**
Δk_{eff} Between 5% Reactivity Decrement Method and Reference 1 Method	0.00222	0.00303	0.00291	0.00278

RAI Item 4

WCAP-16518 calculates a typical temperature bias for each storage configuration. The staff has reviewed the justification for method calculating the temperature bias and determined it is inadequate for the staff to reach a reasonable assurance conclusion that the limiting temperature bias has been determined for each storage configuration. Provide a site-specific analysis that demonstrates that the limiting temperature bias has been determined for each storage configuration.

Response to Item 4

Additional temperature bias calculations have been performed for each of the four storage configurations presented in Reference 1. For each storage configuration, a temperature bias has been calculated as a function of fuel enrichment (3, 4, and 5 w/o), fuel burnup (at each enrichment level, two burnup levels are selected that bracket above and below the required fuel burnup versus enrichment curves presented in Reference 1), and temperature (50°F and 185°F). Therefore, the reactivity effects of spent fuel pool temperature have been calculated for a total of 48 unique combinations of storage configuration (4), fuel enrichment (3), fuel burnup (2), and temperature (2).

It is observed that, for each unique storage configuration and fuel enrichment, there is a consistent trend wherein the temperature bias decreases with increasing fuel burnup. Therefore, for each configuration, the temperature biases calculated at the two burnup levels (a span of only 10 GWD/MTU) are interpolated to obtain the temperature bias at the minimum required fuel burnup to satisfy the fuel storage requirement for that configuration as presented in Reference 1.

As summarized in Table 15, the temperature bias has no impact on the reactivity of two of the storage configurations (All Cell and 1-out-of-4 3.85 w/o Fresh with IFBA), compared to the values presented in Reference 1. For the other two configurations (3x3 and 1-out-of-4 5.0 w/o at 15 GWD/MTU), the temperature bias increases the reactivity of these storage configurations by 0.00025 Δk_{eff} and 0.00090 Δk_{eff}, respectively, compared to the values presented in Reference 1.

Table 15. Sum of Temperature Biases

	Configuration (units in Δk_{eff})			
Parameter	**All Cell**	**3x3**	**1-out-of-4 3.85 w/o Fresh with IFBA**	**1-out-of-4 5.0 w/o at 15 GWD/MTU**
Increase in Temperature Bias	≤0.00000	0.00025	0.00090	≤0.00000

The conclusion for Items 3 and 4 is that the combination of the increased temperature bias and the increase in burnup uncertainty by applying the 5% reactivity decrement method is less than the 0.00500 Δk_{eff} administrative margin included in the Reference 1 analysis.

<u>RAI References</u>

1. **FirstEnergy Nuclear Operating Company letter L-07-084, Peter P. Sena III, Site Vice President, Beaver Valley Power Station, to USNRC document control desk re: "Beaver Valley Power Station, Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, Responses to a Request for Additional Information (RAI dated May 21, 2007) in Support of License Amendment Request Nos. 333 and 204 (TAC Nos. MD2377 and MD2378)," July 20, 2007. (ADAMS ML072050213)**

2. **FirstEnergy Nuclear Operating Company letter L-07-103, Edward H. Hubley, Acting Director, Maintenance, Beaver Valley Power Station, to USNRC document control desk, re: "Beaver Valley Power Station, Unit Nos. 1 and 2, BV-1 Docket No. 50-334, License No. DPR-66, BV-2 Docket No. 50-412, License No. NPF-73, Supplemental Information for License Amendments Request Nos. 333 and 204 (Revision 2 of WCAP-16518) (TAC Nos. MD2377 and MD2378)" July 26, 2007. (ADAMS ML073320036)**

3. **NRC Memorandum from L. Kopp to T. Collins, Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," August 19, 1998. (ADAMS ML003728001)**

4. **NUREG/CR-6665, "Review and Prioritization of Technical Issues Related to Burnup Credit for LWR Fuel." (ADAMS ML003688150)**

5. **NUREG/CR-6801, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analysis." (ADAMS ML03110292)**

<u>Response References</u>

1. WCAP-16518-P, Revision 2, "Beaver Valley Unit 2 Spent Fuel Pool Criticality Analysis," V.N. Kucukboyaci, July 2007.

2. Code of Federal Regulations, Title X, Part 50.68, "Criticality Accident Requirements," November 16, 2006.

3. ANSI/ANS-8.17-2004, "Criticality Safety Criteria for Handling, Storage, and Transportation of LWR Fuel Outside Reactors," November 3, 2004.

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

5. NUREG/CR-6801, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses," J.C. Wagner, et. al., March 2003.

6. YAEC-1937, Yankee Atomic Electric Company, "Axial Burnup Profile Database for Pressurized Water Reactors," R. J. Cacciapouti and S. Van Volkinburg, May 1997.

Regulatory Commitment List

The following list identifies those actions committed to by FirstEnergy Nuclear Operating Company (FENOC) for Beaver Valley Power Station (BVPS) Unit No. 2 in this document. Any other actions discussed in the submittal represent intended or planned actions by FENOC. They are described only as information and are not Regulatory Commitments. Please notify Mr. Thomas A. Lentz, Manager - Licensing, at (330) 761-6071 of any questions regarding this document or associated Regulatory Commitments.

Regulatory Commitments	Due Date
The following conditions are required to be met for any new BVPS-2 fresh fuel assemblies in order to remain bounded by the Reference 1 analysis conclusions. • Fresh fuel assemblies with nominal center-zone enrichments of 3.6 w/o to 4.95 w/o must contain a blanket with a minimum nominal length of 6 inches and with a nominal enrichment that does not exceed 2.6 w/o. • Fresh fuel assemblies with nominal center-zone enrichments less than 3.6 w/o must contain a blanket with a minimum nominal length of 6 inches and with a nominal enrichment that does not exceed 1.0 w/o.	Prior to, or concurrent with, amendment implementation.