May 17, 2007

Mr. James H. Lash
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SUBJECT: BEAVER VALLEY POWER STATION, UNIT NOS. 1 AND 2 - REQUEST FOR ADDITIONAL INFORMATION REGARDING THE SPENT FUEL POOL CRITICALITY ANALYSIS LICENSE AMENDMENT REQUEST (TAC NOS. MD2377 AND MD2378)

Dear Mr. Lash:

By letter dated June 14, 2006, FirstEnergy Nuclear Operating Company (FENOC, licensee) requested an amendment to the Beaver Valley Power Station, Unit Nos. 1 and 2 (BVPS-1 & 2) Technical Specifications (TSs). The proposed changes to the TSs would incorporate the results of topical report, Westinghouse Commercial Atomic Power (WCAP)-16518, "Beaver Valley Unit 2 Spent Fuel Pool Criticality Analysis," Revision 1, May 2006. The new criticality analysis will permit utilization of vacant storage locations dictated by the existing TS storage configurations in the BVPS-2 spent fuel storage pool.

The Nuclear Regulatory Commission staff is reviewing the submittal and has determined that additional information is needed to complete its review. The specific questions are found in the enclosed request for additional information (RAI). The licensee staff indicated that a response to the RAI would be provided within 60 days.

Please contact me at (301) 415-1016, if you have any questions on this issue.

Sincerely,

/RA/

Nadiyah S. Morgan, Project Manager
Plant Licensing Branch I-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-334 and 50-412

Enclosure:
RAI

cc w/encl: See next page

May 17, 2007

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REQUEST FOR ADDITIONAL INFORMATION

REGARDING THE SPENT FUEL POOL CRITICALITY

ANALYSIS LICENSE AMENDMENT REQUEST

FIRSTENERGY NUCLEAR OPERATING COMPANY

BEAVER VALLEY POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-334 AND 50-412

By letter dated June 14, 2006, FirstEnergy Nuclear Operating Company (FENOC, licensee) submitted letter L-06-094 (Reference 1) requesting a change to the Beaver Valley Power Station, Unit 2 (BVPS-2) spent fuel pool (SFP) Technical Specification (TS). The requested change would alter the approved BVPS-2 SFP storage configurations. To support this request, FENOC has submitted a new BVPS-2 SFP criticality analysis.

Appendix A General Design Criterion 62 of Part 50 to Title 10 of the *Code of Federal Regulations* (10 CFR) requires, "Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations."

10 CFR 50.68(b)(4) states, "If no credit for soluble boron is taken, the k-effective [k_{eff}] of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water. If credit is taken for soluble boron, the k_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k_{eff} must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water."

The new BVPS-2 SFP criticality analysis takes credit for soluble boron. Therefore, the acceptance criteria are that the SFP k_{eff} must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water, and k_{eff} of the SFP storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water.

The Nuclear Regulatory Commission (NRC) staff has provided guidance on meeting the regulatory requirements in Reference 2.

The NRC staff request responses to the following questions in order to continue the review of the license amendment request (LAR):

1. The LAR lists four SFP criticality analyses as precedents for its SFP criticality, specifically: R. E. Ginna (Reference 3), Diablo Canyon Power Plant (Reference 4), Millstone Power Station Unit 2 (Reference 5), and Vogtle Electric Generating Plant

(Reference 6). However, the technical justification provided for the LAR in WCAP-16518 only references the R. E. Ginna licensing activity as precedent. Please explain how the other precedents are applicable to the LAR.

2. The LAR and technical justification state 'unity' is the acceptance criterion of maintaining sub-criticality when flooded with unborated water. This appears to be in conflict with the 10 CFR 50.46(b)(4) requirement to maintain $k_{eff} < 1.0$ when flooded with unborated water. Please explain the use of 'unity' as the acceptance criterion, provide appropriate references.

3. The licensee has concluded that the proposed change does not involve a significant increase in the probability of occurrence or consequences of an accident previously evaluated. Please provide the following information:

   a. Generally, will the new fuel storage configurations require more or fewer fuel moves than the current configuration, i.e., will the new configuration require more fuel shuffling or less?

   b. Does the new configuration require a more complex methodology to characterize fuel assemblies or to identify the correct storage rack locations?

   c. Who identifies the correct location for a specific assembly?

   d. What barriers are in place to prevent a mislocation? For example, is there a written procedure or plan that delineates what is to be moved and in what sequence? Is there independent verification of the procedure or plan? Is there independent verification of each move?

   e. Should a fuel assembly be misloaded, how would the error be detected?

   f. What barriers are in place to prevent a common mode human error in misloading several assemblies, i.e., an initial error followed by dependent errors, such as inadvertently sequencing the fuel moves incorrectly, or mis-identifying the assemblies or locations?

4. Provide additional detail in TS 3.7.14 and TS Bases 3.7.14 to preclude a misloading event. The proposed revision to TS 3.7.14 and TS Bases 3.7.14 lack sufficient detail to avoid confusion and possible misapplication of the storage configuration requirements. In some cases an implicit relationship may be inferred. However, given the increased complexity of the proposed storage configurations, the NRC staff considers implicit assumptions, relationships, or requirements to be insufficient to ensure adequate control. See the following examples of the lack of specificity:

   a. The proposed TS Bases 3.7.14 describes the "All-Cell" storage configuration as, "Westinghouse 17 x 17 Standard fuel assemblies with nominal enrichments less than or equal to 1.856 w/o U-235 can be stored in any cell location. This configuration is designated as "All-Cell." Fuel assemblies with initial nominal enrichments greater than these limits must satisfy a minimum burnup requirement as shown in Table 3.7.14-2."

i. Where are the RFA [Robust Fuel Assembly], RFA-2, and other fuel designs to be placed? Does BVPS have other fuel designs which are stored in the SFP?

ii. Westinghouse 17 x 17 Standard fuel assemblies with nominal enrichments less than or equal to 1.856 w/o U-235 can not be stored in any cell location as the reactivity inherent in the "All-Cell" nominal case will exceed that of the reactivity in the nominal case of all subsequently described storage configurations.

iii. WCAP-16518-P Section 3.5.1 describes the "All-Cell" storage configuration as a repeating 2x2 array of storage cells that contain depleted fuel assemblies. That the "All-Cell" storage configuration is a 2x2 array is not captured in either the TS or the TS Bases.

iv. There is no discussion of boundary conditions.

b. TS Table 3.7.14-2, Fuel Assembly Minimum Burnup versus Initial Enrichment for the "All-Cell" Storage Configuration, states "Any fuel assembly may be loaded at the interface with another configuration." As noted above, what constitutes the "All-Cell" Storage Configuration has not been defined. The statement does not limit itself to fuel assemblies in an "All-Cell" Storage Configuration.

c. TS Tables 3.7.14-3, 3.7.14-4, and 3.7.14-5 state, "Only depleted fuel assemblies may be loaded at the interface with another configuration." Again, the statements do not limit themselves to the particular storage configuration in the table and the concept of what constitutes a 'depleted' fuel assembly changes with each storage configuration.

d. TS Table 3.7.14-6 does not have a discussion of an interface requirement.

e. The Note provided with each table is identical with no specific correlation to a particular table.

f. In the proposed TS Bases, the first paragraph on page B 3.7.14-3 provides a list of 'credits' taken into account for the SFP criticality analysis to ensure k_{eff} less than or equal to 0.95, but the list does not include initial enrichment or specific storage configuration. Explain why they were not included in the list.

5. Section 1.3, of the technical justification provided in WCAP-16518, states, "The most reactive SFP temperature (with full moderator density of 1 g/cc) is used for each fuel assembly storage configuration such that the analysis results are valid over the nominal spent fuel temperature range (50°F to 185°F) (Reference 6)." Please provide Reference 6.

6. Section 1.4.3, of the technical justification provided in WCAP-16518, states, "For fresh fuel conditions, the fuel nuclide number densities were derived within the CSAS25 module using input consistent with the data in Table 1-3." Explain the term "...using input consistent with..."

7. Section 1.5, of the technical justification provided in WCAP-16518, states, "The Westinghouse 17x17 Standard fuel was modeled as the design basis fuel assembly to conservatively represent all fuel assemblies residing in all the storage configurations. The model bounds Westinghouse fuel products with a 0.3740-inch fuel pin, such as the Westinghouse Standard design, the V5H product, as well as the Robust Fuel Assembly (RFA) and RFA-2 products." Provide the justification for using this design as the bounding assembly design. Include a consideration of manufacturing parameters and design tolerances for the applicable parameters.

    a. Section 3.2, of the technical justification provided in WCAP-16518, states, "No credit is taken for any spacer grids or sleeves." The analysis in WCAP-16518 indicates the BVPS-2 SFP is over moderated. Not modeling the spacer grids or sleeves increases the moderator to fuel ratio with a potentially beneficial negative reactivity effect. That effect must be balanced against the negative reactivity associated with the absorption cross section of the spacer grids or sleeves. Was the decision to not credit spacer grids or sleeves based on analysis or engineering judgment? How does crediting soluble boron affect the assumption?

8. Section 1.5, of the technical justification provided in WCAP-16518, states, "Fresh fuel assemblies were conservatively modeled with a U02 density of 10.686 g/cm3 (97.5% of theoretical density). This translates into a pellet density equal 98.6% of theoretical density with a 1.1% dishing (void) fraction." Provide the justification for this assumption. Is the 1.1% dishing (void) fraction a minimum, nominal, or maximum value?

    a. Section 3.2, of the technical justification provided in WCAP-16518, states, "The design basis fuel assemblies are modeled with the fresh fuel pellets as a solid right cylinder with a UO2 density of 10.686 g/cm3 (97.5% of theoretical density). No credit is taken for the nominal 1.1 void fraction percentage that is associated with dishing or chamfering. In addition, no credit is taken for any natural or reduced enrichment pellets, even for the blanketed assemblies. This assumption results in conservative calculations of reactivity for all fuel assemblies stored in the racks. No credit is taken for any spacer grids or sleeves."

        I. Is this the same 1.1% dishing (void) fraction cited in Section 1.5? If so, reconcile the use of the 1.1% dishing (void) fraction to reduce the maximum theoretical density used in the analysis and the claim that "No credit is taken for the nominal 1.1 void fraction percentage that is associated with dishing or chamfering."

        ii. If it is the same, justify using a nominal value rather than a bounding value or establishing an uncertainty for the dishing & chamfer on the fuel pellets.

9. Section 1.5, of the technical justification provided in WCAP-16518, states, "All fuel assemblies, fresh and depleted, were conservatively modeled as containing solid right cylindrical pellets and uniformly enriched over the entire length of the fuel stack height.

This conservative assumption bounds fuel assembly designs that incorporate lower enrichment blanket or annular pellets." What is the tolerance on enrichment? How is this tolerance used in the criticality analysis?

10. The LAR and Section 1.5, of the technical justification provided in WCAP-16518, states, "All of the Boraflex poison material residing in the storage racks was conservatively omitted for this analysis." Please provide the following information concerning this assumption:

    a. What does the analysis use in place of the Boraflex? What is the justification for that replacement?

    b. How does the analysis treat the material which holds the Boraflex in place? What is the justification for that treatment?

    c. WCAP-16518 Section 2.3, Table 2-2, and Figure 2-2 provide various dimensions for the individual storage cells.

        i. In Section 2.3, how is the thickness of the Boraflex sheathing known to four decimal places when the manufacturing tolerance is only given to three?

        ii. All other dimensions have a tolerance specified, what is the tolerance on Boraflex thickness?

        iii. What material is in the 'Gap+Boraflex' in Figure 2-2? How is this material modeled?

        iv. How are the tolerances associated with these dimensions factored into the SFP criticality analysis?

11. Section 1.5, of the technical justification provided in WCAP-16518, states, "In addition, the IFBA [Integral Fuel Burnable Absorber] pins were modeled as annular cylinders 120 inches in length and centered about the midplane of the active fuel. Therefore, the IFBA coating is modeled with a 12-inch "cut-back" on the total length of the fuel (blanket and non-IFBA section). Also, [proprietary] on the 1.5X IFBA loading [proprietary] is assumed to cover manufacturing uncertainty and tolerances." Provide the justification for this assumption.

    a. Confirm that the 1.5X IFBA loading bounds all IFBA loadings previously used or currently in use at BVPS-2.

    b. What effect would a 2.0X IFBA loading have on the analysis?

    c. How does the manufacturing phenomenon of Axial Offset Deviation affect the assumption?

12. Section 1.5, of the technical justification provided in WCAP-16518, states, "The design-basis limit for k_{eff} at the zero soluble boron condition was conservatively reduced from

1.0 to 0.995 for this analysis." Given that the regulatory requirement is that k_{eff} < 1.0 at the zero soluble boron condition and that for the same number of significant digits 0.995 is equal to 1.0, please explain how this assumption is conservative?

13. Section 2.3, Figure 2-2, and Table 2-2 of the technical justification provided in WCAP-16518 provide various dimensions for the individual storage cells. Provide the following information:

    a. Figure 2-2 shows what appears to be 'sheathing' extending the entire outside width of a cell. What is the material and how is it modeled? How does that affect the results?

    b. How are the tolerances associated with these dimensions factored into the SFP criticality analysis?

14. Section 3.3 discusses the modeling of axial burnup distributions. The methodology employed in WCAP-16518-P uses fewer axial zones than either the R. E. Ginna analysis (Reference 3), as cited precedent, or NUREG/CR-6665, "Review and Prioritization of Technical Issues Related to Burnup Credit for LWR Fuel," (Reference 7) recommends.

    a. Provide the justification for using fewer axial zones than either of the cited precedents.

    b. Provide the justification for the size of the zones used in the analysis.

    c. It is not clear from WCAP-16518-P as to how the axial burnup distribution is used to derive an uncertainty, what the uncertainty is, and how it is used.

        i. Provide the description of how the axial burnup distribution is used to derive the uncertainty.

        ii. Provide the derived uncertainty. Is it bounding for all scenarios?

        iii. Explain how the uncertainty is used.

    d. Has BVPS-2 experienced any occurrence of Axial Offset Anomaly/Crud Induced Power Shift or Axial Offset Deviation? If so were these factored into the axial burnup distribution?

15. Section 3.3.1 discusses the impact of the extended power uprate on SFP criticality. Specifically, the maximum core outlet temperature is stated as increasing from 615.1 °F to 621.4 °F, with a range between 608.6 °F and 621.4 °F. The actual core outlet temperature used, as given in Table 3-2, is in the lower portion of the range. NUREG/CR-6665 recommends using the maximum core outlet temperature. Justify using less than the maximum core outlet temperature.

16. According to the technical justification provided in WCAP-16518-P, the "All-Cell" Storage Configuration consists of a repeating 2 x 2 array of depleted assemblies.

Depleted assemblies must meet the enrichment/burnup limits in Table 3-9. Provide the following information with respect to the "All-Cell" Storage Configuration.

a. With respect to Table 3-4, provide the following information:

   i. Provide the dimensions and tolerances used in each case that was run to obtain the data. Tabular form is acceptable. If this information is identical for each storage configuration, provide only one table.

   ii. Explain how the Off-Center Assembly Positioning uncertainty was maximized.

   iii. How are the manufacturing tolerances of the fuel assemblies incorporated into the uncertainties?

   iv. Why is 1.911 w/o U235 used as the enrichment for the nominal case?

   v. With respect to the U235 enrichment uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the U235 enrichment uncertainty was determined.

   vi. With respect to the burnup uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the burnup uncertainty was determined.

   vii. With respect to the methodology uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the methodology uncertainty was determined.

   viii. With respect to the pool temperature bias, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the pool temperature bias was determined. Include the justification for the use of 4.0 w/o initial enrichment at 25,000 MWD/MTU of burnup for determining the temperature bias.

b. With respect to Table 3-9, provide the following information:

   i. The initial enrichment values are calculated to the third decimal place. Provide the justification for this precision. Are the enrichments in Table 3-9 nominal values?

   ii. Accompanying Table 3-9 is a third degree polynomial equation describing the relationship between initial enrichment and burnup. All factors are given to three decimal places. The third factor has eight significant digits. Provide a justification for the precision of the factors in that equation.

iii. The third degree polynomial is a fit to four points. Three of those points are the result of second degree polynomial fits to three points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

iv. Have any confirmatory calculations been performed to verify these enrichment and burnup combinations actually provide a k_{eff} that meets the specific configuration target k_{eff}?

c. In Section 3.5.1, the last sentence of the second paragraph states, "Therefore, the target k_{eff} value for the "All-Cell" storage configuration is 0.96457 (0.995-0.03034)." However, when the calculational uncertainty is added to the nominal k_{eff} for the initial enrichment of 1.856 w/o U235 with no burnup entry in Table 3-8, the target k_{eff} is exceeded. Please explain why this is acceptable.

17. According to the technical justification provided in WCAP-16518-P, the "3x3" Storage Configuration consists of a repeating 3x3 array with a fresh fuel assembly with an initial enrichment up to 5.0 w/o, surrounded by depleted assemblies. Depleted assemblies must meet the enrichment/burnup/decay limits in Table 3-10. Provide the following information with respect to the "3 x 3" Storage Configuration.

a. With respect to Table 3-5, provide the following information:

i. Provide the dimensions and tolerances used in each case that was run to obtain the data. Tabular form is acceptable. If this information is identical for each storage configuration, provide only one table.

ii. Explain how the Off-Center Assembly Positioning uncertainty was maximized.

iii. How are the manufacturing tolerances of the fuel assemblies incorporated into the uncertainties?

iv. Why is 1.263 w/o U235 the enrichment used for the peripheral assemblies for the nominal case?

v. With respect to the U235 enrichment uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the U235 enrichment uncertainty was determined.

vi. With respect to the burnup uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the burnup uncertainty was determined.

vii. With respect to the methodology uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the methodology uncertainty was determined.

viii. With respect to the pool temperature bias, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the pool temperature bias was determined. Include the justification for the use of 4.0 w/o initial enrichment at 45,000 MWD/MTU of burnup for determining the temperature bias.

b. Section 3.5.6 states, "For the 3x3 storage configuration that credits 241Pu decay, burnup requirements for intermediate decay time points should be determined using at least a second order polynomial." The results of the 241Pu decay effects are presented in Table 3-10. They are used to develop the enrichment/burnup/decay requirements in Table 3-11.

  i. Why is this polynomial left to the reader, but all other polynomials are specified?

  ii. How would this polynomial be applied? With five decay times specified in Table 3-10, a higher degree polynomial should be warranted.

  iii. How would it affect Table 3-11?

  iv. Provide the controls necessary for the use of any polynomial for interpolating between specified decay times.

c. With respect to Table 3-11, provide the following information:

  i. Enrichment is shown to three decimal places. Provide the justification for this precision. Are the enrichments in Table 3-11 nominal values?

  ii. Accompanying Table 3-11 are five third degree polynomial equation describing the relationship between initial enrichment and burnup. All factors are given to three decimal places. The third factor has eight significant digits. Provide a justification for the precision of the factors in these equations.

  iii. Each third degree polynomial is a fit to four points. Three of those points are the result of second degree polynomial fits to three points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

  iv. Have any confirmatory calculations been performed to verify these enrichment and burnup combinations actually provide a k_{eff} that meets the specific configuration target k_{eff}?

d. In Section 3.5.2, the last sentence of the second paragraph states, "Therefore, the target k_{eff} value for the "3x3" storage configuration is 0.97077 (0.995-0.02423)." However, when the calculational uncertainty is added to the nominal k_{eff} for the initial enrichment of 1.194 w/o U235 with no burnup entry in Table 3-10, the target k_{eff} is exceeded. Please explain why this is acceptable.

18. According to the technical justification provided in WCAP-16518-P, the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" Storage Configuration consists of a repeating 2x2 array with one fresh fuel assembly, with an initial enrichment up to 5.0 w/o, and three depleted assemblies. Depleted assemblies must meet the enrichment/burnup limits in Table 3-13. Provide the following information with respect to the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" Storage Configuration.

a. With respect to Table 3-6, provide the following information:

i. Provide the dimensions and tolerances used in each case that was run to obtain the data, tabular form is acceptable. If this information is identical for each storage configuration, provide only one table.

ii. Explain how the Off-Center Assembly Positioning uncertainty was maximized.

iii. How are the manufacturing tolerances of the fuel assemblies incorporated into the uncertainties?

iv. Why is 1.627 w/o U235 the enrichment used for the 'depleted' assemblies for the nominal case?

v. With respect to the U235 enrichment uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the U235 enrichment uncertainty was determined.

vi. With respect to the burnup uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the burnup uncertainty was determined.

vii. With respect to the methodology uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the methodology uncertainty was determined.

viii. With respect to the pool temperature bias, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the pool temperature bias was determined. Include the justification for the use of 4.0 w/o initial enrichment at 25,000 MWD/MTU of burnup for determining the temperature bias.

b. With respect to Table 3-13, provide the following information:

i. The initial enrichment values are calculated to the third decimal place. Provide the justification for this precision. Are the enrichments in Table 3-13 nominal values?

ii. Accompanying Table 3-13 is a third degree polynomial equation, describing the relationship between initial enrichment and burnup. All factors are given to three decimal places. The third factor has eight significant digits. Provide a justification for the precision of the factors in these equations.

iii. The third degree polynomial is a fit to four points. Three of those points are the result of second degree polynomial fits to three points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

iv. Have any confirmatory calculations been performed to verify these enrichment and burnup combinations actually provide a k_{eff} that meets the specific configuration's target k_{eff}?

c. In Section 3.5.3, the last sentence of the second paragraph states, "Therefore, the target k_{eff} value for the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" storage configuration is 0.96742 (0.995-0.02758)." However, when the calculational uncertainty is added to the nominal k_{eff} for the initial enrichment of 1.569 w/o U235 with no burnup entry in Table 3-12, the target k_{eff} is exceeded. Please explain why this is acceptable.

19. According to the technical justification provided in WCAP-16518-P, the "1-out-of-4 3.85 w/o Fresh with IFBA" Storage Configuration consists of a repeating 2x2 array with one fresh fuel assembly, with an initial enrichment up to 3.85 w/o, and three depleted assemblies. Depleted assemblies must meet the enrichment/burnup limits in Table 3-15. Fresh assemblies must meet the IFBA limits in Table 3-19. Provide the following information with respect to the "1-out-of-4 3.85 w/o Fresh with IFBA" Storage Configuration.

a. With respect to Table 3-7, provide the following information:

i. Provide the dimensions and tolerances used in each case that was run to obtain the data. Tabular form is acceptable. If this information is identical for each storage configuration, provide only one table.

ii. Explain how the Off-Center Assembly Positioning uncertainty was maximized.

iii. How are the manufacturing tolerances of the fuel assemblies incorporated into the uncertainties?

iv. How are the IFBA manufacturing and calculation uncertainties applied?

v. Why is 1.296 w/o U235 the enrichment used for the 'depleted' assemblies for the nominal case?

vi. With respect to the U235 enrichment uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the U235 enrichment uncertainty was determined.

vii. With respect to the burnup uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the burnup uncertainty was determined.

viii. With respect to the methodology uncertainty, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the methodology uncertainty was determined.

ix. With respect to the pool temperature bias, the footnote does not provide sufficient information to make an assessment of adequacy of the value in the table. Provide a detailed explanation of how the pool temperature bias was determined. Include the justification for the use of 4.0 w/o initial enrichment at 25,000 MWD/MTU of burnup for determining the temperature bias.

b. With respect to Table 3-15, provide the following information:

i. Enrichment is shown to three decimal places. Provide the justification for this precision. Are the enrichments in Table 3-15 nominal values?

ii. Accompanying Table 3-15 is a third degree polynomial equation, describing the relationship between initial enrichment and burnup. All factors are given to three decimal places. The third factor has eight significant digits. Provide a justification for the precision of the factors in these equations.

iii. The third degree polynomial is a fit to four points. Three of those points are the result of second degree polynomial fits to three points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

iv. Have any confirmatory calculations been performed to verify these enrichment and burnup combinations actually provide a k_{eff} that meets the specific configuration's target k_{eff}?

c. With respect to Table 3-19, provide the following information:

i. Enrichment is shown to three decimal places. Provide the justification for this precision. Are the enrichments in Table 3-19 nominal values?

ii. Accompanying Table 3-19 is a third degree polynomial equation, describing the relationship between initial enrichment and IFBA pins. All factors are given to three decimal places. The third factor has six significant digits. Provide a justification for the precision of the factors in these equations.

iii. The third degree polynomial is a fit to four points. Three of those points are the results of second degree polynomial fits to four points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

iv. The analysis was performed using the IFBA loading patterns in Figure 3-5. What is the sensitivity of the analysis to those loading patterns? Provide the justification for that conclusion.

v. Identify any restrictions on the IFBA loading patterns using the results of Table 3-19. Provide the justification for those restrictions.

vi. Explain how the 3.85 w/o enrichment case was determined to not require any IFBAs.

vii. Table 3-19 includes odd numbers and the third degree polynomial presents the possibility of fractional IFBAs. How are these scenarios addressed?

viii. How are fresh assemblies addressed that has IFBAs, but do not meet the requirements of Table 3-19?

d. In Section 3.5.4.1, the last sentence of the first paragraph states, "Therefore, the target k_{eff} value for the "1-out-of-4 3.85 w/o Fresh with IFBA" storage configuration is 0.97283 (0.995-0.02217)." However, when the calculational uncertainty is added to the nominal k_{eff} for the initial enrichment of 1.279 w/o with no burnup entry in Table 3-14, the target k_{eff} is exceeded. Please explain why this is acceptable.

e. Section 3.5.4.3 states, "Analysis have shown that reactivity at any point in the burnup history of a 17x17 Standard fuel assembly with 5.0 w/o enrichment and [proprietary] IFBA pins is less than the BOC reactivity. Therefore, in the case of an early discharge part way through a cycle, the discharged fuel assembly with IFBA can be stored in the "1-out-of-4 3.85 w/o Fresh with IFBA" storage configuration provided that it meets the storage requirements of that configuration."

i. It is unclear what this paragraph means. Does it mean that slightly burned fuel assembly, that met the requirements of Table 3-19 as a fresh assembly, may be stored as if it were unburned? Or does it have to meet the depleted requirements of Table 3-15? Please provide clarification.

ii. As cores, which use IFBAs, can exhibit a flat or even increasing critical boron concentration for the early portion of the cycle, the first sentence cannot be considered applicable to all combinations of enrichment and IFBA loading. Provide clarification and the supporting analysis to address other scenarios.

20. According to the technical justification provided in WCAP-16518-P, the interface requirements were determined by taking a single array of a specific storage configuration and surrounding it with repeating arrays of a different storage configuration until the SFP was filled. The arrangement was considered acceptable, if the k_{eff} of the composite SFP was less than the k_{eff} of the most reactive storage configuration. The SFP pool dimensions are provided in Table 2-1. The composite SFP analysis was performed at a moderator temperature of 20°C and a density of 1.0 gm/cc. Per Table 3-21, the interface between storage configurations is limited to depleted fuel assemblies. With respect to the storage configuration interface requirements, please provide the following information:

a. Section 2.2 and Table 2-1, of the technical justification provided in WCAP-16518, provide various dimensions for the SFP.

i. How are these dimensions used?

ii. What is the tolerance/uncertainty associated with them?

iii. How is that factored into the SFP criticality analysis?

iv. Is Figure 2-1 supposed to be Reference 17?

b. Were sensitivity studies performed to determine the most reactive moderator temperature and density? In over moderated conditions, as is likely in the SFP, the maximum moderator density is not the most reactive condition.

c. Table 3-20 provides the results for a "3x3" Storage Configuration surrounded by the "All-Cell" Storage Configuration, but does not include the results for the "All-Cell" Storage Configuration surrounded by the "3x3" Storage Configuration. In keeping with that example, Table 3-20 only provides results for half of the possible combinations. Provide the justification for not performing analysis for the rest of the possible combinations.

d. "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" and "1-out-of-4 3.85 w/o Fresh with IFBA" storage configurations are 2x2 arrays with one non-depleted fuel assembly.

i. With respect to the analysis, explain how the limitation of only depleted assemblies being in contact with another storage configuration will be met for the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" and "1-out-of-4 3.85 w/o Fresh with IFBA" storage configurations.

ii. The proposed controls do not preclude the potential for multiple locations of a storage configuration and the inherent repetitive interfacing between storage locations. With respect to the actual use in the SFP, explain how the limitation of only depleted assemblies being in contact with another storage configuration will be met for the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" and "1-out-of-4 3.85 w/o Fresh with IFBA" storage configurations.

iii. What controls prevent the non-depleted fuel assemblies in these configurations from being side by side?

21. Tables 3-4, 3-5, 3-6, and 3-7 present uncertainties that have been determined for each specific configuration. While the physical dimensions and tolerance do not change for each storage configuration, the uncertainties do. This indicates a dependency on initial conditions and/or assumptions in the analysis. Have any confirmatory calculations been performed to determine the sensitivity of the uncertainties to the various conditions that the specific configuration will see?

22. Tables 3-16, 3-17, and 3-18 are presented as fresh fuel enrichment versus depleted fuel burnup versus IFBA tables. However, no information for the 'depleted' fuel is given except burnup. What are the other parameters for this 'depleted' fuel in each table? What is the sensitivity of the analysis to these parameters?

23. Section 3.5.7 states, "For all configurations at Beaver Valley Unit 2, an empty cell is permitted in any location of the SFP to replace an assembly since the water cell will not cause any increase in reactivity in the SFP. Non-fissile material and debris canisters may be stored in empty cells of All-Cell storage configuration provided that the canister does not contain fissile materials." Is this section based on analysis, evaluation, or engineering judgment?

24. Section 3.5.8 states, "Non fissile equipment, such as UT cleaning equipment is permitted on top of the fuel storage racks, as these equipments will not cause any increase in reactivity in the SFP." Have these non fissile equipments been evaluated for other potential adverse impact on the SFP, such as blocking cooling flow through the storage cells?

25. Section 3.5.9 states, "Table 3-22 lists the k_{eff} values for the storage configurations with one of the depleted fuel assemblies replaced with an FRSC [Fuel Rod Storage Canister] containing fresh 5.0 w/o 235U fuel rods. The calculations were performed at 68°F, with maximum water density of 1.0 g/cm3 to maximize the array reactivity. As seen from Table 3-22, the resulting k_{eff} values were less than the nominal k_{eff} values of the storage configurations. Therefore, FRSCs filled with fresh fuel rods with a maximum enrichment of 5.0 w/o 235U and no burnable absorbers can be stored in any storage configuration."

a. Should the need arise, where would fresh fuel pins that contain a burnable absorber be stored?

b. According to Section 3.1.5, the FRSC is modeled as a stainless steel box. Please explain what this means.

c. Section 2.4, of the technical justification provided in WCAP-16518-P, provides various dimensions for the Fuel Rod Storage Canister. How are these dimensions used? What is the tolerance/uncertainty associated with them? How is that factored into the SFP criticality analysis?

d. How were the bias and uncertainties from Tables 3-4, 3-5, 3-6, and Tables 3-7 used in the analysis to determine the values in Table 3-22?

e. Were sensitivity studies performed to determine if one cell in the storage configuration was more limiting than another for the placement of a FRSC?

f. Were any analysis performed to determine the effects of placing an FRSC on an interface boundary between storage configurations?

26. According to Section 3.6 of WCAP-16518-P, the SFP soluble boron requirements are based on a third degree polynomial equation. The third degree polynomial equation is based on four cases of varying soluble boron content for a "3x3" Storage Configuration utilizing 5.0 w/o enriched fuel with 55,000 MWD/MTU of burnup as the depleted fuel assemblies. With respect to Table 3-23 and the third degree polynomial equation, please provide the following information:

a. Explain why the Table 3-23 k_{eff} for the 0 ppm case is different from the 0 Decay and 0 ppm case in Table 3-10 for the "3x3" Storage Configuration utilizing 5.0 w/o enriched fuel with 55,000 MWD/MTU of burnup as the depleted fuel assemblies.

b. In the third degree polynomial equation, describing the relationship between k_{eff} and soluble boron, all factors are given to three decimal places. The third factor has eight significant digits. Provide a justification for the precision of the factors in that equation.

c. The third degree polynomial is a fit to four points. Explain how this does not create a new uncertainty that must be accounted for in the analysis.

d. Section 3.6.1, states, "Table 3-23 contains the KENO-calculated k_{eff} values for the SFP from 0 to 600 ppm of soluble boron, in increments of 200 ppm. These KENO models assume that the pool is filled with the "3x3" storage configuration containing depleted fuel at 55,000 MWD/MTU with 5.0 w/o 235U initial enrichment. The initial enrichment and burnup chosen to represent the storage configuration was based on minimizing the soluble boron worth. The soluble boron worth decreases as burnup increases." Provide the results of the analysis that show "3x3" Storage Configuration containing depleted fuel at 55,000 MWD/MTU with 5.0 w/o 235U initial enrichment. Provide the limiting soluble boron requirements for the "3x3" Storage Configuration.

e. Table 3-23 and its associated equation is used to determine the soluble boron concentrations for all proposed storage configurations. Provide the analysis that shows how Table 3-23 and its associated equation is bounding for the other storage configurations.

27. According to Section 3.6.2, reactivity uncertainties for fuel assembly reactivity and burnup are determined. With respect to these uncertainties, provide the following information.

    a. The fuel assembly reactivity uncertainty, "...is calculated by employing a depletion reactivity uncertainty of 0.010 delta k_{eff} units per 30,000 MWD/MTU of burnup (obtained from Reference 2) and multiplying by the maximum amount of burnup credited in a storage configuration." Reference 2 to WCAP-16518-P is the Safety Evaluation Report for WCAP-14416-P-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, (Reference 8). However, the NRC subsequently withdrew its approval of WCAP-14416 in Reference 9. Therefore, provide the justification for the continued use of this means of determining the fuel assembly reactivity.

    b. Section 3.6.2 states, "The uncertainty in absolute fuel burnup values is conservatively calculated as 5% of the maximum fuel burnup credited in a storage configuration analysis. The maximum fuel burnup credited in the various storage configurations, the 5% uncertainty in these burnup values, and the corresponding reactivity values are given in Table 3-24."

        i. Provide the justification for the use of 5% of maximum fuel burnup as conservative.

        ii. Explain how the 5% of the maximum fuel burnup credited in a storage configuration analysis is converted into the delta k_{eff} numbers in Table 3-24.

    c. Explain why the uncertainties from Tables 3-4, 3-5, 3-6, and 3-7 are not included.

    d. Explain why the fuel assembly reactivity uncertainty and burnup uncertainties are not included in determination of the zero boron condition.

28. According to Section 3.6.3, soluble boron required to mitigate accidents is based on the evaluation/analysis of four potential accident scenarios. A fuel assembly dropped onto the SFP storage racks is considered creditable, but not analyzed as the distance between the dropped assembly, and the fuel in the storage racks is considered to be sufficient to neutronically decouple the configuration. The mishandling of a fuel assembly, a reduction in the intramodule water gap due to a seismic event, and an elevated SFP temperature is considered creditable and is analyzed. With respect to the soluble boron required to mitigate an accident, provide the following information:

    a. What is the distance between the top of a fuel assembly in the storage cell and the top of the storage racks?

    b. Is it possible for the non-fissile materials, which may be stored in the SFP cell, to displace a sufficient amount of water such that a dropped assembly may become neutronically coupled with the fuel in the storage cells?

c. The fuel mishandling analysis events all assumed a fresh Westinghouse standard 17x17 fuel assembly enriched to 5.0 w/o U235 was misloaded. Justify this fuel assembly design as appropriate for the analysis.

d. The fuel mishandling analyses all consist of an SFP filled with a single storage configuration. Why was the possibility of a misload of a fuel assembly on the interface boundary between storage configurations not considered?

e. There is no discussion of the cases that were used to derive the k_{eff} for the different accident scenarios in Table 3-25. Provide a description of those cases.

f. The delta k_{eff} in Table 3-25 is based on the k_{eff} of the SFP filled with only that particular storage configuration. The development of these values is never discussed. Provide a discussion of their development.

g. The text says the misloading of a Westinghouse standard 17x17 fuel assembly enriched to 5.0 w/o U235 in the "1-out-of-4 5.0 w/o at 15,000 MWD/MTU" Storage Configuration produced the largest delta k_{eff}. However, in Table 3-25, the misloading of a Westinghouse standard 17x17 fuel assembly enriched to 5.0 w/o U235 in the "1-out-of-4 3.85 w/o Fresh with IFBA" Storage Configuration has the largest delta k_{eff}. Please correct the text.

29. Total soluble boron requirement is developed in Section 3.6.4. The previous sections determined a delta k_{eff}. That delta k_{eff} was then used in the third degree polynomial equation associated with Table 3-23 to determine the soluble boron necessary to offset that delta k_{eff}. Each soluble boron determination was initiated from a zero boron condition. The results are then summed algebraically. However, the equation associated with Table 3-23 clearly shows a decreasing incremental boron worth as the total boron concentration increases. If each delta k_{eff} is treated as an incremental increase, the total soluble boron requirement increases. The amount of soluble boron necessary to maintain k_{eff} less than 0.95, with bias and uncertainties, increases from 441.8 ppm to 486 ppm. The amount of soluble boron necessary to maintain k_{eff} less than 0.95, with bias and uncertainties, under the worst identified accident increases from 824.1 ppm to 1018 ppm.

a. Explain this apparent non-conservative use of the third degree polynomial equation associated with Table 3-23.

b. Were results confirmed through computer cases?

30. In NRC Regulatory Issue Summary (RIS) 2001-12, "Nonconservatism in Pressurized Water Reactor Spent Fuel Storage Pool Reactivity Equivalencing Calculations," (Reference 10) the NRC informed the industry about the potential for a non-conservative result when using reactivity equivalencing. The reactivity equivalencing discussed in RIS 2001-12 equates the reactivity of a fuel assembly that has a particular initial enrichment and burnup combination to the reactivity of a fuel assembly that has a different initial enrichment and zero burnup. This is a fictitious fuel assembly that is used in subsequent analyses. The non-conservatism can occur when the equivalent fresh fuel enrichment is determined for a reference configuration (e.g., an infinite array

of storage rack cells in unborated water) and then used for various similar, but not identical, configurations. As WCAP-16518-P uses reactivity equivalencing in this manner, explain how the potential non-conservatism is taken into account.

REFERENCES

1. FirstEnergy Nuclear Operating Company letter L-06-094 from James H. Lash, Site Vice President, Beaver Valley Power Station, to USNRC document control desk, re: "Beaver Vallley 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-72, License Amendment Request Nos. 333 and 204," June 14, 2006 (ADAMS ML06170010).

2. 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)

3. R. E. Ginna Nuclear Power Plant - Amendment re: Revision to the Storage Configuration Requirements Within the Existing Storage Racks and Taking Credit for a Limited Amount of Soluble Boron (TAC NO. MA8443), dated December 7, 2000 (ADAMS ML003761578).

4. Diablo Canyon Nuclear Power Plant, Unit Nos. 1 and 2 - Issuance of Amendment re: Credit for Soluble Boron in the SFP Criticality Analysis (TAC Nos. MB2982 and MB2984), dated September 25, 2002 (ADAMS ML022610080).

5. Millstone Power Station, Unit No. 2 - Issuance of Amendment re: SFP Requirements (TAC No. MB3386), dated April 1, 2003 (ADAMS ML030910485).

6. Vogtle Electric Generating Plant, Units 1 and 2 re: Issuance of Amendments that Revise the SFP Rack Criticality Analyses (TAC Nos. MC4225 and MC4226), dated September 22, 2005 (ADAMS ML052420110).

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

8. WCAP-14416-P-A, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology," November 1996.

9. U.S. NRC letter "Non-Conservatisms in Axial Burnup Biases for Spent Fuel Rack Criticality Analysis Methodology," dated July 27, 2001 (ADAMS ML012080337).

10. NRC Regulatory Issue Summary 2001-12, "Nonconservatism in Pressurized Water Reactor Spent Fuel Storage Pool Reactivity Equivalencing Calculations," May 18, 2001 (ADAMS ML010990300).