FANP-Lynchburg k_{eff} Amendment
Request for Additional Information

1. Explain whether all k_{eff} calculations for analyzed benchmark experiments were performed using the same computer code system as that validated in the report. Some calculated k_{eff} values listed in the validation report were drawn from other internal documents, but it is not clear whether these were performed using the same system configuration as that in the submitted validation report.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. This requires performing benchmark calculations on the same computer code system as that being validated, because results can vary from one system to another. If changes were made to the computer code system between performance of the original calculations and compilation of the validation report, use of these values in the validation analysis would be meaningless.

2. In Section 2, identify the computer operating system and hardware platform, as well as any assumptions, techniques, or limitations (e.g., code options) associated with the calculational method, including the criteria used for determining the convergence of calculational results. In particular, provide a clear statement indicating which options were validated and which options cannot be used, preferably as part of the executive summary or conclusion.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. NUREG-1520, Section 5.4.3.4.1(8)(c), states that the applicant should commit to use pertinent computer codes, assumptions, and techniques in the methodology. This information is needed to ensure that the calculational method is defined in sufficient detail so that it can be appropriately maintained and controlled. In addition, the use of other options than those used in modeling the benchmarks may not give the same results. The validation report defines some options (such as use of the LATTICECELL cross section treatment) that must be used, but these are often buried deep in the validation report.

3. Provide the following information: (a) a detailed description of the finished fuel assemblies to be loaded into the air cleaning and drag gauge stations, including a quantitative description of the exacting tolerances used in assembly fabrication; (b) a discussion of the sensitivity of the calculated k_{eff} to each of the manufacturing tolerances, and (c) the cumulative effect of manufacturing tolerances on the calculated k_{eff}.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of

subcriticality for safety. Part of the justification for the chosen margin of subcriticality of 0.02 is that fuel assemblies are well-defined and manufactured to exacting tolerances that limit potential increases in reactivity, but no analysis is provided to support this. A description of the geometric and material form of the assemblies, the associated tolerances, and the potential effect on the bias is needed to show that the systems are sufficiently well-defined to be credited for approving a reduced margin.

4. In Section 3.7, provide the derivation of the factor of 27.01 for converting the v^m/v^f ratio for heterogeneous benchmarks to an equivalent $H/^{235}U$ atom ratio.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. NUREG-1520, Section 5.4.3.4.1(8)(h) states that the applicant should determine, among other things, bias and uncertainty in the bias. The applicant has chosen the $H/^{235}U$ ratio as one of the parameters against which to trend the bias. However, $H/^{235}U$ is only directly applicable to homogeneous fuel-moderator mixtures, and not to heterogeneous assemblies. Therefore, it is necessary to convert the moderator-to-fuel volumetric ratio of the analyzed heterogeneous benchmarks to an atom density ratio, in order to compare them to the homogeneous benchmarks. How this conversion is done may have an impact on the results of the validation effort.

5. Describe the anticipated normal and credible abnormal conditions for finished fuel assemblies in the air cleaning and drag gauge stations, including detailed descriptions sufficient to allow reconstruction of the analyzed models. In particular, address whether the assembly may credibly be damaged subsequent to its placement in either of the stations in a way that may cause its k_{eff} to exceed the requested limits.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. Adequate assurance of subcriticality requires that analyzed benchmarks be similar to plant systems to be evaluated. A description of both the benchmarks and plant systems is needed to draw this comparison. In addition, if conditions more reactive than a fully-flooded undamaged assembly may occur (e.g., the assembly comes loose and is damaged during a flooding upset), then license limits may be exceeded or abnormal conditions may not be adequately covered by the validation.

6. Justify the acceptability of the benchmark experiments analyzed in Tables A-2, A-6, A-12, and A-14 of the validation report, given that only four experiments were taken from the International Criticality Safety Benchmark Evaluation Program (ICSBEP) handbook. In particular, address the following with regard to the experimental k_{eff} and its uncertainty:

   (a) Footnote (c) stating that it is assumed that the cited k_{eff} values and their uncertainties can be applied to all cases; and

   (b) Footnote (b) stating that the source of experimental uncertainties could not be found

in the experimental reference. Similar statements are footnoted in Tables A-6, A-12, and A-14.

For those experiments not taken from the ICSBEP handbook, demonstrate that they meet established criteria referenced in the handbook for evaluation as a critical benchmark experiment.

10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. NUREG-1520, Section 5.4.3.4.1(8)(g), states that validation should include determination of the bias and uncertainty in the bias. Determination of bias and uncertainty in the bias necessarily includes knowledge of both the experimental and calculated k_{eff} values as well as their uncertainties. In addition, critical configurations should meet established criteria for being considered benchmarks to provide confidence in the validation results. Established criteria from the Physics Criteria for Benchmarks Working Group of the DOE-sponsored Nuclear Criticality Technology and Safety Project are summarized in NEA/NSC/DOC(95)03/IV (Volume 4 of the ICSBEP handbook).

7. Demonstrate that trends in the bias have been adequately evaluated for all discrete subsets of benchmark experiments analyzed in the validation report. Evaluate whether the bias and uncertainty for the complete set of analyzed benchmarks is sufficient to bound the bias and uncertainty appropriate for each individual cluster of experiments.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. NUREG-1520, Section 5.4.3.4.1(8)(g) , states that validation should include determination of the bias and uncertainty in the bias. In general, the bias may be a function of the various physical parameters of the system. Because the data in Figures 6-2, 6-3, and 6-4 are observed to be clustered, the bias may be significantly different for plant calculations having similar characteristics to the experiments in the individual clusters. As a result, the bias determined using the entire set of benchmark experiments may be non-conservative for plant calculations similar to experiments in a cluster having a low calculated k_{eff}.

8. Demonstrate that the benchmark experiments containing poison plates are applicable to models containing undamaged fuel assemblies without poison materials. In particular, determine the reactivity worth of the poison plates and whether the poison can have a significant effect on the calculational bias. If they do have a significant effect on the bias, justify why they are acceptable to validate models of fuel assemblies in the air cleaning and drag gauge stations. If they do not have a significant effect on the bias, justify why the different cases can be treated as independent benchmarks.

   10 CFR 70.61(d) requires that nuclear processes be ensured to be subcritical under normal and credible abnormal conditions, including use of an approved margin of subcriticality for safety. NUREG-1520, Section 5.4.3.4.1(8)(b), states that validation should include a description of the area of applicability that identifies the range of values

over which the code has been demonstrated to be valid. It is not clear from the validation report whether cases without poison plates as described in Table A-2 are within the area of applicability. If the poison plates have a large effect on the system reactivity, then the bias for these experiments may differ from the bias for unpoisoned plant calculations. On the other hand, if the poison plates have a small effect on the system reactivity, then a set of several experiments essentially may comprise a single experimental configuration and the individual members of the set should not be treated as independent statistical data points.

9. Explain the choice of experiments used in the validation report and why other experiments closer to 5% enrichment were not used. For example, only 83 experiments were used, but 19 were at 4.74%, 14 were at 4.31, and the rest were at 2.46%, when there are many experiments at 5% in the International Handbook of Evaluated Criticality Safety Benchmark Experiments.

   10 CFR 70.61(d) requires that all nuclear processes must be assured to be subcritical under normal and credible abnormal conditions. NUREG-1520, Section 5.4.3.4.1(6), states that the applicant should demonstrate that the calculation of k-eff is based on a set of variables whose values lie in a range for which the methodology used to determine k-eff has been validated. This is necessary to ensure that processes are subcritical under normal and credible abnormal conditions. In addition, the methodology described in NUREG/CR-6698, Section 2.5, states: "The analyst needs to consider the overall parametric span and try to ensure that experiments provide a spectrum of critical experiments throughout the range.... It may be desirable to include additional critical experiments in the validation. Often experiments within these ranges do not exist or are not readily available. In such cases, a larger margin of subcriticality will be needed."

10. Explain the basis for using fewer experiments (only 83) in the validation report than are available for these types of systems, and how using fewer experiments demonstrates that the margin of safety for subcriticality has been adequately established. Experience with NRC's review of other NRC licensee's validations and from DOE validations shows that using more experiments would significantly decrease the USL in many cases.

    10 CFR 70.61(d) requires that all nuclear processes must be assured to be subcritical under normal and credible abnormal conditions. NUREG-1520, Section 5.4.3.4.1(6), states that the applicant should demonstrate the adequacy of the margin of safety for subcriticality by assuring that the margin is large compared to the uncertainty in the calculated value of k-eff. This is necessary to ensure that processes are subcritical under normal and credible abnormal conditions.