From: Thadani, Mohan

Sent: Wednesday, June 11, 2014 10:02 AM

Cc: Wood, Kent; Jackson, Christopher

Subject: RE: MILLSTONE POWER Station, Unit 2-Draft Request for Additional Information.

Hi Wanda:

By letter dated December 30, 2012, Dominion Nuclear Connecticut Inc. (the licensee) submitted license amendment request (LAR) for Millstone Power Station (Millstone), Unit 2. The Proposed amendment would revise the facility's Technical Specifications for the Spent Fuel storage at Millstone, Unit 2. The NRC staff has reviewed the licensee's request and has identified a need for additional information. The NRC staff's draft request for additional information (RAI)is provided below.

We request that you review this draft RAI and discuss the listed questions with the NRC staff if any clarifications are needed to provide response to this RAI. A formal RAI letter will follow documenting the agreed schedule for responding to the RAI.

Best regards,

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DOMINION NUCLEAR CONNECTICUT INC.

MILLSTONE POWER STATION, UNIT 2

DRAFT REQUEST FOR ADDITIONALINFORMATION IN SUPPORT OF

PROPOSED TECHNICAL SPECIFICATION CHANGES FOR SPENT FUEL STORAGE.

DOCKET NO. 50-336 (TAC NO. MF0435)

1. The updated criticality analysis, which was provided as Attachment 4 to the LAR, does not contain criticality analysis supporting storage of consolidated fuel storage boxes (CFSBs). Instead, it claims that, due to changes associated with crediting soluble boron, the original criticality safety analysis was conservative enough that no further analysis is required.

   According to the current operating license, fuel stored in the CFSBs must meet burnup credit limits that provide minimum burnup requirements as a function of initial (fresh fuel) enrichment.
   While it is quite unlikely that analysis of the non-CFSB fuel will be adversely affected by the presence of fuel in completely full CFSBs, it is less obvious to the NRC staff that the old CFSB burnup credit limits would be unaffected.

   Further, the proposed TS would permit storage of CFSB fuel in locations adjacent to new Regions 1, 2 and 4. Some of these rack modules previously credited Boraflex. Consequently, it is unlikely that the old analysis included consideration of fuel stored in CFSBs in positions on the periphery of Region 3 and adjacent to fuel stored in racks that no longer credit Boraflex.
   Provide supplementary criticality analysis or justify that the old analysis demonstrates that storage of fuel in CFSBs meets the requirements of 10 CFR 50.68. This analysis must include consideration of mixed fuel storage configurations (i.e. CEAs, poison pins and CFSBs) in Region 3 and interaction between fuel in adjacent regions. Note that including analysis of close-packed fuel pins in CFSBs will likely require updating the criticality analysis validation study to extend the area of applicability to cover fuel in the CFSBs.

2. Proposed TS Section 5.6.1(g) includes the following text:

   > *Finally, fuel assemblies utilizing Figure 3.9-1 D require that a control element assembly be installed in the fuel assembly (except for the full-length, reduced-strength control element assemblies and the part-length control element assemblies).*

   The intent of the text in the parenthetical expression is not clear. Please revise the proposed TS to improve clarity.

3. In several places the amendment talks about non-standard fuel configurations and components being analyzed at some time in the future. 'Non-standard fuel configurations and components' are never defined nor are any limitations placed on what might constitute a 'non-standard fuel configurations and components'. Given that vagueness in the request, it is essentially trying to establish a prior approval.

ENCLOSURE

4. Regarding any potential change without fully establishing a methodology for analyzing future fuel assemblies, please remove the discussion of the new "non-standard fuel configuration and components." Alternatively, the NRC staff requests the licensee to a provide full and complete description of the methodology including all analyses performed to support the methodology, assumptions both implicit and explicit, detailed implementation guidance, and all limitations and conditions.

5. Attachment 2 includes a new Figure 3.9-2 showing the SFP layout. A note on the figure states "A Restricted Location may contain non-standard fuel configurations or components, or is empty." It is not clear from the criticality analysis that it is safe to store an unspecified non-standard fuel configuration in the "Restricted Locations." Please justify using the "restricted locations" for storing non-standard fuel configurations.

6. The analysis for Regions 1, included the presence of the "Boraflex boxes," which are said in Section 6.1.1.1 to be removable. The proposed TS do not address whether or not the removable boxes are required. Revise the TS or provide justification for not doing so.

7. Identify which SCALE 6.0 nuclear data libraries were used for k_{eff} calculations and for fuel depletion calculations.

8. Describe how convergence was checked for KENO k_{eff} calculations.

9. T5-DEPL does not include a maximum flux difference check similar to that performed by the deterministic depletion codes. K_{eff} convergence in a Monte Carlo style code does not ensure local flux convergence. Describe how the convergence was checked for the burned fuel composition calculations.

10. Section 3.1.1 covers bounding fuel assembly selection. A study is reported that identifies a bounding fuel assembly design. Was this bounding design also used for the new fuel storage analysis?

    If so, provide a demonstration that the adopted bounding fuel assembly design also yields conservative k_{eff} values at peak moderation and full density moderation in the new fuel storage analysis. If not, explain what was analyzed for the new fuel storage.

11. This RAI is related to the uncertainty associated with burned fuel composition calculations.

    a. Table 3.1-1 of Ref. 2 contains the following errors:

        i. Case 13, "NUREG Table 6.3, Nuclide dK" is listed as 0.00081. It should be 0.0081.

        ii. Cases 57 through 64, incorrect values were used for "NUREG Table 6.3, Depleted Fuel k-eff" values.

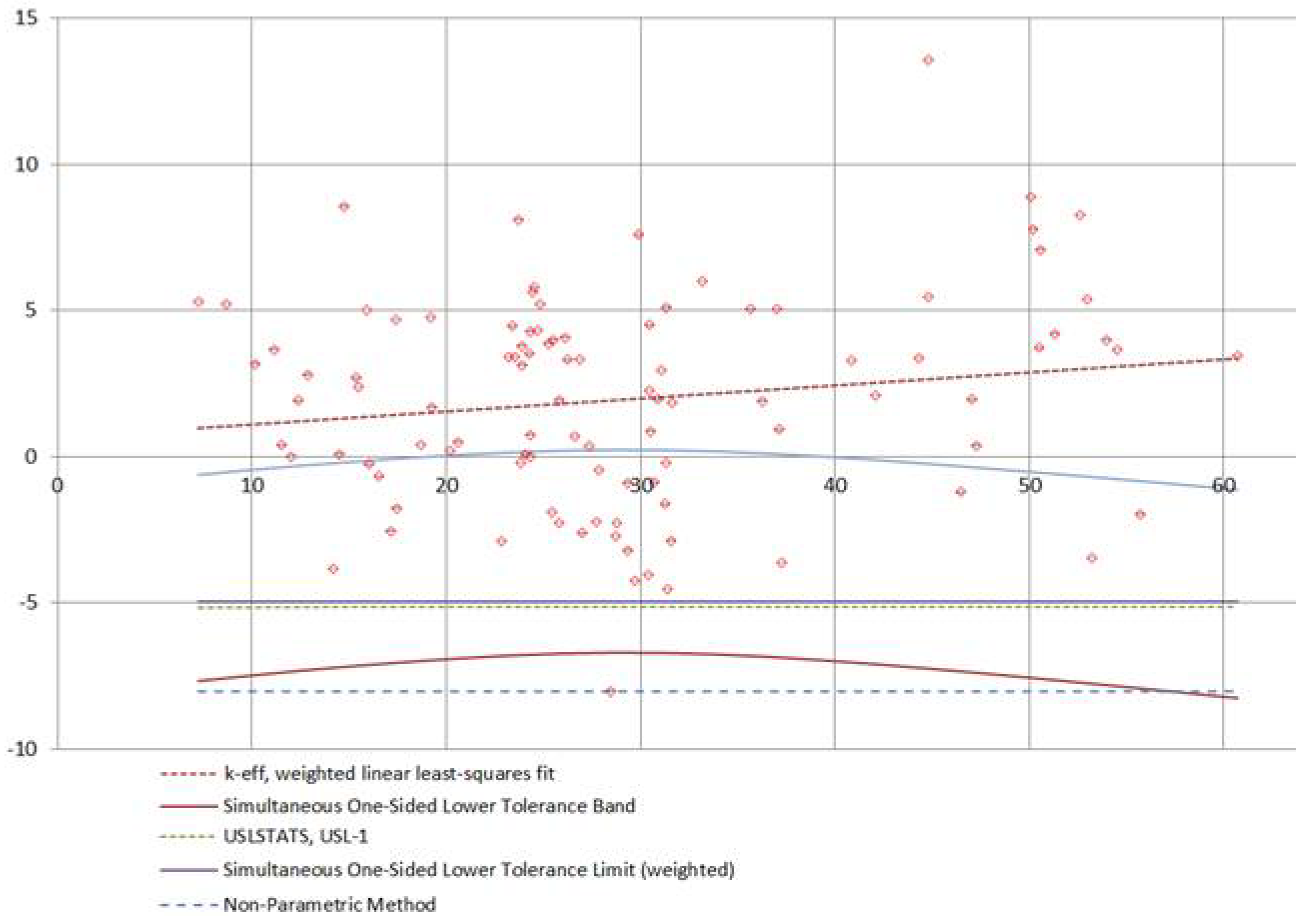
        iii. Case 81, "NUREG Table 6.3, Nuclide dK" is listed as 0.0008. It should be 0.0080.

b. The “Fresh Fuel k-eff” values reported in Table 3.1-1 were calculated using a different code than was used to calculate the values extracted from NUREG/CR-7108 Table 6.3. Since the “Burnup Worth Diff” values presented in Table 3.1-1 were calculated using the delta-k and “Depleted Fuel k-eff” values from NUREG/CR-7108 and the “Fresh Fuel k-eff” values calculated by the licensee, use of a different code system to calculate the “Fresh Fuel k-eff” values adds a potentially “systematic error” or bias.

c. The “dk” values used in Table 3.1-1 were calculated for NUREG/CR-7108 using a different fuel depletion sequence. It is not appropriate to assume that the dk values calculated for NUREG/CR-7108 using SCALE 6.1 and the NEWT-based depletion calculations would be the same if they were calculated using SCALE 6.0 and the KENO-based depletion calculation. KENO and NEWT have two significantly different flux solution techniques. NEWT iterates on the flux in each spatial mesh and in each energy group until the largest flux change in any mesh/energy group is less than the convergence criteria. KENO calculates fluxes that are passed to ORIGEN, but does not use the flux in the transport calculation or check the fluxes for convergence.

d. The 4.55% adopted for burnup worth uncertainty does not appear to have 95/95 statistical basis. Figure 3.1-2 plots the values calculated by the licensee for the burnup worth uncertainty.

   First, it is not appropriate to extrapolate outside the data points (i.e. below 7.4 GWd/MTU and above 60.7 GWd/MTU). Further, statistical analysis of the data should be used to set the 95/95 uncertainty. For data with a trend, the 95/95 uncertainty should increase near the edges of the data and within the range when the data is sparser. The figure below demonstrates a more statistically defensible uncertainty analysis.



Use of the simultaneous one-sided lower tolerance limit is not appropriate because it assume that there is no burnup dependent trend. Use of the more appropriate simultaneous one-sided lower tolerance band yields uncertainty values significantly larger than both the commonly used Kopp letter 5% of the decrement value and the 4.55% value proposed by DOMINION. The non-parametric method does not rely on the normality of distribution. The linear least squares fit, tolerance limit, tolerance band and non-parametric analyses were performed using techniques adapted from NUREG/CR-6698. Note that the student's t score for the slope of the fit indicates that there is a 92 % probability that the slope is non-zero and the F test based on the correlation coefficient indicates that there is an 84% probability that the fit is better than random.

e. Consistent with guidelines, bias and bias uncertainty values are calculated based on measured data. Extrapolation outside the data should be avoided and care should be exercised when doing so. Extrapolation to low burnups should be particularly avoided because the non-uranium actinides and fission products are changing rapidly over the first several GWd/MTU. Consequently, there is no technical justification to support linear extrapolation of uncertainties to low burnup values.

Considering items a. through e., the licensee should review and revise the fuel depletion analysis bias and uncertainty and the burned fuel criticality analysis presented in Ref. 2.

12. Section 3.1.2.4 provides limited justification for a 3.5% uncertainty for the assigned assembly average burnup. Please provide a more detailed justification for the burnup uncertainty that is integrated with the criticality analysis. The justification should address the calorimetric uncertainty, the uncertainty in flux measurements, the uncertainty associated with inferring assembly power from flux measurements, the uncertainty in assembly average power inferred for non-instrumented assemblies, and uncertainties associated with integration of power over the assembly's life.

    A review of the RW-859 (2002) data for Millstone Unit 2 shows that many of the older fuel assemblies have identical burnup values. This likely means that the RW-859 burnup values were either region average or design values. Confirm that the burnup values for these older assemblies have been recalculated from measurements. If the burnup values cannot be recalculated, include additional uncertainty to cover use of design and/or average assembly burnup values. The justification for the 3.5% uncertainty requested above should address this issue.

    From the description in the analysis, it looks like this uncertainty would be calculated as 0.035 times the burnup worth. From examining the various tables in the Region 2, 3 and 4 analyses, this does not appear to be how it was calculated. For one of many examples, see Table 6.1-11, uncertainty for 2B burnup (3.5% reduced bu), which is listed as 0.0009, when it seems it should be 0.035*0.106 =0.0037. It looks like it is being calculated incorrectly. Note in the same table, the Region 2B 3.5% uncertainty in the last two columns decreases from 0.0026 to 0.0009, while the burnup increases from 30 to 34.1 GWd/MTU. There are other instances of this uncertainty behavior. Describe and justify how the assembly burnup uncertainty ("3.5% reduced bu") is calculated. Where appropriate, review and revise the uncertainty analyses for Regions 2, 3 and 4.

13. Section 3.1.3.1 discusses axial burnup distributions. Typically, at low assembly burnup values (i.e. < 20GWd/MTU) and for systems with mixed fresh and spent fuel, such as at the region-to-region interfaces on the edges of Region 1, and for accident analysis models involving misleading of a fresh fuel assembly, the NUREG/CR-6801 axial burnup profiles may not be limiting. Typically, this is addressed by using both uniform and distributed axial burnup profiles and using the most reactive for that model. The physics involved is that a fresh fuel assembly will have a fission density peak near its axial mid-plane, while in a highly burned assembly in excess of 90% of the fission density is near the top. This sort of axial fission density axial location mismatch was not considered when the limiting axial burnup distributions described in NUREG/CR-6801 were determined. Confirm whether uniform axial burnup distributions were considered for the analysis and also that the uniform axial burnup distributions were also utilized when burnup credit curves were generated, when k_{eff} values for region-to-region interfaces were quantified, and when accident analysis calculations were performed.

14. Section 3.1.3.3 discusses fuel temperature. Please confirm that a conservative fuel temperature has utilized during fuel depletion calculations. Higher temperature increases resonance absorption in ^{238}U, resulting in higher Pu generation. The input file included in Ref. 2 as Appendix B reflects a fuel temperature of 907K. Doing a quick survey of resonance effective fuel temperatures used in other work, this value

seems to be a little low compared to values that range between 900 and 1200k. Typically, the resonance effective fuel temperature (REFT) is a weighted average of the pellet surface, center-line and mid-radius fuel temperatures. The weighting factors include the effects of temperature and neutron flux distributions. Confirm that conservative REFT values were used. Note that low burnup fuel generally has a higher than average power density and, consequently, higher fuel temperatures.

15. Provide a list of nuclides that were retained for criticality calculations. Confirm that noble or volatile gases and short-lived radioactive nuclides are not credited, because they would not be present in the SFP. For such nuclides that were retained in the analysis, provide an estimate for their worth.

16. Section 4.4 is on "Non-Standard Storage Configurations." The text in this section states:

    There are non-standard fuel configurations and components, and non-fuel containing components present in the MP2 SFP.

    The text goes on to say:

    These non-standard configurations and components may be stored in fuel assembly locations or in Restricted Locations (see Section 6.1) if they are demonstrated to be non-limiting with respect to the storage patterns that have been analyzed. The same methodology used for the analysis herein that established the Technical Specification requirements will be employed to evaluate non-standard configurations and components. These assessments would employ the requirements for documentation and implementation under the provisions of 10CFR50.59.

    The analysis provided does not include evaluation of the effects of non-standard "fuel" configurations and components (NSFCC) that may be stored in both the fuel assembly locations and in the restricted locations.

    Please provide the evaluation of the effects of the NSFCC. The supplementary criticality analyses described in Section 4.4 should include consideration of whether or not the validation study is applicable to the NSFCC, whether or not any new accident conditions are introduced, whether or not the additional NSFCC are modeled conservatively, and whether or not neutronic interaction between NSFCC and intact fuel assemblies is appropriately considered.

17. Section 5.1 notes that the new fuel storage racks are reflected by concrete on all six faces. Describe and justify the concrete composition model used. Note that sensitivity studies performed for a different new fuel storage vault have shown that k_{eff} may vary by up to 3% Δk with different concrete compositions. If the concrete composition is unknown, a conservative bounding model should be used, which should also include consideration of the potential for water loss associated with concrete aging. Revise the uncertainty analysis for the new fuel storage racks to address the uncertainties in the concrete composition.

18. The following deficiencies were noted with respect to the uncertainty analysis:

a. Uncertainty analysis was not performed at the low-moderator density peak conditions.

b. Eccentric fuel location was handled as an uncertainty. This is not appropriate. The criticality calculations should be performed with the fuel at its most reactive approved location/arrangement.

c. Uncertainties associated with (1) spacing between assemblies and (2) spacing between rack modules and walls/floor/ceiling were not evaluated.

Revise the analysis to perform a more complete uncertainty analysis and to evaluate eccentric fuel assembly placement as a bias rather than an uncertainty, or provide a justification for treating eccentric positioning as an uncertainty.

19. From the results presented in Table 5.3-1, it looks like a higher optimum moderation peak k_{eff} value may occur between 4 and 2.5 % water density. Perform additional calculations to ensure the peak k_{eff} value has been identified.

20. Provide the EALF of the low water density optimum moderation point for the new fuel storage analysis. This will be compared with the validation study to ensure these calculations are adequately validated.

21. From the descriptions provided in Sections 4 and 6 of Ref. 2, it appears that what is referred to as a poison box or Boraflex box was included in all new Region 1 and 2 calculations. Section 6.1.1.1 explicitly notes that they are removable. Poison box dimensions and some tolerances are provided in Table 6.1-1. The poison box is visible in Figure 6.1-2.

    a. Provide a better description of the poison box model.

    b. Expand the Regions 1 and 2 uncertainty analyses to address poison box dimensional tolerances.

    c. The text in Section 4.2.1 states the poison boxes are “centered” in the open stainless steel boxes. What forces them to be centered? What is the uncertainty on the location of the box within the storage cell? What sensitivity studies were performed to address variation in k_{eff} with poison box location?

    d. If nothing centers the poison box, revise the analysis to use the most reactive arrangement of storage cell, poison boxes and fuel assemblies to calculate the maximum k_{eff} values.

    e. From the text in Section 4.2.1, there should be a [[ ]] thick steel plate on both the inside and outside of the poison gap in the poison box. From Figure 6.1-6, it looks like the cover sheet is missing off of the outside of the poison box. Review the Region 1 and 2 models to confirm the models are correct. If they are not correct, either revise the analysis or provide an evaluation of the impact of the modeling error.

22. The following issues are related to the fuel assembly model used.

    a. The text in Section 6.1.1 notes that the lower rack structure, lower tie plate, and upper tie plate are modeled as 30% stainless steel and 70% water. Are these volume percentages? Is the water and steel a homogenized mixture? Were the total steel and water masses conserved? Provide a justification for these modeling simplifications and for the steel to water ratio used.

    b. The effects of fuel rod growth and clad creep are not addressed. Evaluate and incorporate the impacts of fuel rod growth and clad creep. Note these phenomena are not uncertainties as they affect every assembly in a similar way.

    c. From the text in the numbered list on page 49 of Ref. 2, fuel rod end plugs and upper plenum are apparently modeled. Confirm that conservative end plug dimensions were used. This likely means the shortest end plug design. Also, describe and justify how the fuel rod upper plenum is modeled.

23. Eccentric fuel placement was evaluated as an uncertainty throughout the analysis. A relatively small number of assemblies grouped in the most reactive arrangement will result in the maximum keff value. Even if assembly placement is truly random, the large number of sets of assemblies that do occur in a SFP significantly increases the probability of occurrence of one of the small sets having the maximum keff value. It is not appropriate to simply assume that there are no mechanical or operational drivers that may result in systematic (i.e. non-random) assembly location in the storage cells. The maximum keff value should be calculated with the fuel in the most reactive approved configuration. This may be accomplished by using the most reactive assembly location in the analyses or by incorporating a conservative bias term. Revise the analysis to calculate the maximum keff values using the most reactive arrangements or incorporate a conservative bias term to cover the keff increase due to asymmetric placement.

24. The last paragraph in Section 6.1.1.2 states that "Sensitivity values treated as a bias are calculated as K2-K1. Significance is defined as k2-k1>k1sd." The goal of bias and uncertainty calculations is to generate an accurate or conservative estimate for the biases and uncertainties. When Monte Carlo calculations are used to calculate biases and uncertainties, these values are to be calculated to include the appropriate Monte Carlo uncertainties. It is not appropriate to discard Monte Carlo uncertainties. If necessary, the analyst may reduce these Monte Carlo uncertainties by running more neutron histories. It is also inappropriate to discard biases or uncertainties as not being significant based on comparison with the Monte Carlo calculation uncertainties. All biases and uncertainties should be calculated using an equation similar to that provided at the bottom of page 57 of Ref. 2. Revise the analysis to properly incorporate accurate or conservative biases and uncertainties.
25. Table 6.1-2 is a list of "Specific Bias and Uncertainty Values."

    a. The following items appear to be missing from the table:

        i. B-SS rodlet length

        ii. Material, dimension, and location information, and associated tolerances/uncertainties for CEAs used in Region 3

iii. Dimensional tolerances and location information on “poison boxes” used in Regions 1 and 2

iv. Bias and uncertainty associated with elevated fuel temperature calculations

v. Fuel stack height, height of the bottom of the active fuel above the bottom of the cell, and associated uncertainties.

Justify leaving out the above information, or provide the missing information and, where appropriate, incorporate the information into the analysis.

b. It does not look like the nominal dimensions for the Region 1 and 2 cells add up. With a nominal cell pitch of [[ ]] and a single wall thickness of [[ ]], the cell inner dimension is [[ ]], which is larger than the [[ ]] stated in Table 6.1-2. The text in Section 4.2.1 states the cell ID is [[ ]] or [[ ]]. What dimensions were used in the base model and were the tolerance uncertainty calculations adjusted to be consistent with the base model?

c. A spent fuel pool temperature bias term is included. Did this term include both temperature and the associated water density variation? If not, please explain

26. Confirm the 0.0056 value provided for the “2 x KENO std. dev.” uncertainty for 0 ppm. In general, Monte Carlo style calculations are run to standard deviations that are much smaller than 0.0028. If the 0.0056 value is correct, identify the cases where such large Monte Carlo uncertainties were used in the analysis.

27. In Section 6.1.3.2, the text on page 66 appears to be stating that burnup dependent fission product and minor actinide worth for Region 2 will be based on Region 3 calculations. Region 3 is poisoned with either CEAs or borated steel rods. These components will impact the calculated worth of the FP&MAs. Justify that Regions 2 and 4 are bounded by the Region 3 calculations.

28. In Section 6.1.3.2, the text on page 66 appears to be stating some of the uncertainties calculated for Region 1 will be applied to Region 2. Since Region 1 is 2-out-of-4 storage and Region 2 is 3-out-of-4 storage, the sensitivity of the k_{eff} value to some parameters will be different. Identify the specific uncertainties that were not recalculated for each region and provide the logic for why the uncertainties will not vary from region to region. That the racks are of identical design is of course part of the logic for Regions 1 and 2, but the variation in storage configuration and minimum burnup limits also affects the uncertainty calculations.

29. The proposed Region 3 would permit storage of assemblies in which either B-SS rodlets or CEAs have been installed, provided they meet the burnup credit acceptance limits for that component. Analyses are performed for CEAs and for B-SS rods. The proposed TS would permit mixing of assemblies loaded with CEAs with assemblies loaded with B-SS pins. Because geometric effects of the rodlets would impact the calculations analysis should have been performed demonstrating that mixing assemblies with these components will not result in higher Region 3 k_{eff}

values Provide analysis demonstrating that mixtures of assemblies with CEAs and assemblies with B-SS rodlets is bounded by the existing analysis.

30. The analysis results presented in Table 6.1-26 and the text provided in Section 6.1.4.2 do not address uncertainties associated with the CEAs. While the degree of boron depletion in the CEA is admittedly conservative, it is still appropriate to check the uncertainties for the CEA dimensions and materials. In particular, the uncertainties for the B_4C pellet density, ID, and OD, clad OD and thickness, B_4C axial location and extent should be calculated. Provide analysis of the uncertainties associated with CEA manufacturing tolerances.

31. Confirm that the Region 3 k_{eff} values are insensitive to the location of the CEAs and B-SS rods within the guide tubes. For example, is k_{eff} higher if the B-SS rod is moved such that it is in-contact with the GT inner surface rather than centered? If there is a significant uncertainty associated with the positions of the CEA or B-SS rods in the guide tubes, review the designs of these components to determine whether or not the locations are truly random. If they are random they can then be handled as uncorrelated uncertainties. However, if the positions are not random and the systems are sensitive to the rod locations, develop and incorporate a bias term to cover CEA and B-SS rod locations.

32. The text in the final paragraph on page 88 notes that uncertainty analysis for Region 4 with soluble boron is not provided because Region 4 has analogous trends and is the same rack design. The 3-out-of-4 storage in Region 4 versus 4-out-of-4 storage in Region 3 and the presence of the CEAs or B-SS rodlets in the Region 3 analysis may cause some of the uncertainties calculated with soluble boron present to vary significantly from the Region 3 analysis. Provide uncertainty analysis for Region 4 calculations with soluble boron.

33. Describe the lateral “full spent fuel pool model” details, including distance to the wall, materials and dimensions, sensitivity of the model to these parameters, and comparison with the actual SFP.

34. The final sentence in Section 6.2.1, on page 97 is:

    Therefore, it can safely be concluded that there are no detrimental boundary effects with respect to pool reactivity because the overall pool Keff is less than the maximum regional Keff value.

    Insufficient basis is provided for this conclusion. It does not look like the impacts of burned fuel, asymmetric fuel placement optimized to maximize region-to-region interaction, optimal rotation of assemblies with B-SS rodlets were considered. Please evaluate the impacts of modeling burned fuel, Region 3 B-SS bundle rotations, and asymmetric bundle locations on the full pool k_{eff} value without soluble boron, particularly between the interfaces of the different rack regions.

35. Please provide clarification and justification for Section 6.2.1.1. For example, why are the region specific target k_{eff} values so low and why did they need to be adjusted lower? How was the Region 3 with B-SS rods target k_{eff} value determined? How was the Region 4 target k_{eff} value determined? Note that Region 3 with B-SS rods and Region 4 “target k_{eff}” values appear to be 0.8998, which does not include the

adjustments used to determine the target k_{eff} for Region 2 and Region 3 with CEAs. How was the full pool model target k_{eff} value determined?

The last paragraph of Section 6.2.1.1 describes full pool model calculations and appears to indicate that full pool calculations were performed with only fresh fuel. Perform similar full pool calculations with all non-restricted fuel locations filled with the most highly burned fuel combinations on the loading curves and for both Region 3 with B-SS rodlets and Region 3 with CEAs. Alternatively, perform these calculations for each region to demonstrate that for the infinite array k_{eff} with biases and uncertainties will be no greater than 0.95 when the required soluble boron is present.

36. The last paragraph on page 99 states:

> *Should the removed fuel rod be replaced by another fuel rod, the assembly average bumup must be recomputed and the fuel assembly must be prequalified according to the revised burnup, which will be bounded by the criticality safety analysis.*

It is not obvious that simply recalculating the assembly average burnup will adequately bound the replacement of a burned fuel pin with another fuel pin. Provide additional justification for this fuel assembly reconstitution procedure.

37. Section 6.2.1.3 includes a list of accident scenarios analyzed Several misleading scenarios appear to be missing from the list, For the following scenarios, please either provide an analysis showing acceptable results or provide a justification for no performing the analysis. If administrative controls are credited, please demonstrate how multiple independent actions would be necessary to put the SFP in an unanalyzed condition. Include a detailed description of the controls in place (for example independent qualified software to check move sheets, locking devices to prevent movement of assemblies, etc.):

   a. Misplacement of multiple fresh fuel assemblies
   b. Use of incorrect loading curves
   c. Placement of fuel assemblies into Region 3 without the required CEAs or B-SS rods (note that it is not clear from the description whether the Region 3 misloads are with or without the required CEAs or B-SS rods)
   d. Missing multiple poison boxes in Regions 1 or 2.

38. The fourth item in the bulleted list on page 102 is:
   - *Misplacement of a 5.0 wt% U-235 fresh fuel assembly between Region 3 and the new fuel elevator, with a fresh 5.0 wt% U-235 fuel assembly in the new fuel elevator.*

   Unless there are controls that are intended to prevent this configuration, fuel handling should be treated as a normal condition. Describe why this is treated as an abnormal condition rather than a normal condition. If the analysis is revised to treat it as a normal condition, include a bias term in the calculation of maximum k_{eff} values.

39. Table 6.2-3 provides the full pool model results for many single assembly misloads. Please justify the following:

a. The Region 1 misloads of assemblies placed into a required empty location along the Region 3 boundary is missing.

b. Was the Region 1 misload along the Region 2 boundary along the flat or in the corner?

c. The Region 2 misloads along the Regions 3 and 4 boundaries are missing.

d. Were the Region 3 misloads that were along the Region 1, 2 and 4 boundaries next to a Region 1/2/4 assembly or a required empty location? Describe the analysis performed to ensure the most reactive misload position was identified.

e. For the assembly placed between Region 3 and the new fuel elevator, was a range of locations considered? Note that a small spacing between two assemblies frequently yields a higher k_{eff} than two assemblies that have no separation. Describe the analysis performed to ensure that the most reactive location was identified.

f. Was the Region 4 misload along the Region 2 boundary in a position adjacent to a high reactivity assembly?

g. Region 4 misloads along the Region 3 boundary are missing.

h. For the misloading of a fresh 5 wt % assembly into the SFP, were various burned fuel enrichment/burnup combinations considered for the burned fuel already in the rack? The peak axial fission density distribution for fresh fuel is near the axial mid-plane of the assembly. Due to similar axial fission density profiles, use of the zero burnup maximum enrichment point will likely maximize reactivity of the misload.

40. The analysis of the soluble boron required for the bounding misload is described on Page 106. There a couple of questions concerning this analysis.

a. Justify that using the most highly burned fuel approved for use in Region 4 is conservative. The 1.74 wt % fuel with zero burnup will yield an axial fission density profile more similar to that of the misloaded 5 wt % new fuel assembly. Was the zero burnup fuel also considered in analysis? If not, why not?

b. The analysis showed that the Region 4 misload yielded the highest k_{eff} at zero soluble boron. However, the soluble boron worth for a Region 3 misload may be significantly lower due to the reliance on the CEAs and B-SS rods. Consequently, the amount of soluble boron required for a Region 3 misload may be higher than what appears to be required for the Region 4 misload. Either evaluate the soluble boron requirements for other misloads or provide justification for not doing so.

c. The analysis utilizes the Region 4 target k_{eff} value to determine the required soluble boron concentration. Depending on the responses to the RAIs provided above, it may be necessary to rework the analysis of soluble boron required for misload accidents.

41. The analysis of boundary misalignment is provided starting on page 107. The text and figures are not clear to support review of this analysis. Please clarify the boundary misalignment descriptions and provide clearer figures. Address the following questions/concerns:

   a. It does not look like a Region 2 misalignment was considered wherein the whole Region 2 pattern is shifted to the west one row, placing a full Region 2 row next to Region 1.

   b. It is does not appear that the misalignment between Regions 3 and 4 were considered. This scenario might involve moving the Region 4 pattern one column to the east, thereby placing a full Region 4 row next to Region 3.

   c. Figures 6.2-1 through 6.2-4 are of such low quality that it is not possible to see what was analyzed. For example;

      i. Region 3 shows up as solid gray blocks. Does this mean Region 3 was modeled as empty? Confirm that all fuel storage racks were modeled as fully loaded.

      ii. In Figure 6.2-1, it is not possible to see how the Region 1 misalignment was modeled. Also, it looks like the Region 2 pattern may have been shifted a row to the west. Check the base case full pool model to ensure it is consistent with Figure 6.1-1 (and the TS).

      iii. In Figure 6.2-2, it is not clear how the misalignment was modeled. It looks like only one Region 2 row may have been misaligned. If so, it seems more appropriate to shift the entire pattern because a break in the pattern would more likely be identified by operations as incorrect.

      iv. In Figure 6.2-3, it looks like the Region 4 pattern was shifted, but it appears that the Region 2 pattern was also shifted. Thereby avoiding a solid Region 2 row next to a solid Region 4 row.

      v. Using Figure 6.2-4, it is not possible to verify by the reviewer that the boundary misalignment has been properly modeled.

42. The following RAIs are provided concerning the validation study provided in Appendix A and the use of the validation study results.

   a. Some of the limiting calculated k_{eff} values were at 100C. Elevated temperature calculations have not been validated. Provide validation or adopt appropriate uncertainty to cover unvalidated elevated temperature calculations. An acceptable approach would be for the applicant to revise the validation study to include and use results from International Handbook of Evaluated Criticality Safety Benchmark Experiments evaluation LEU-COMP-THERM-046 (temperature variation from 14C to 85C) to estimate potential biases associated with nuclear data temperature adjustments.

   b. MOX experiments are required to validate burned fuel k_{eff} calculations. The MOX experiments documented in Appendix A are restricted to the HTC experiments.

The validation should be supplemented with additional non-HTC MOX experiments to ensure that an evaluation- or facility-specific bias is not built into the bias and 95/95 uncertainty generated by the validation study.