UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 20, 2010

Christopher L. Burton, Vice President
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Zone 1
New Hill, North Carolina 27562-0165

SUBJECT: SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1 – SECOND REQUEST FOR ADDITIONAL INFORMATION REGARDING AMENDMENT TO REMOVE CREDIT FOR BORAFLEX IN BOILING-WATER REACTOR SPENT FUEL POOL STORAGE RACKS (TAC NO. ME0012)

Dear Mr. Burton:

By letter dated September 29, 2008, as supplemented by letters dated January 16, 2009, August 12, 2009, and January 18, 2010, Carolina Power & Light Company (the licensee), now doing business as Progress Energy Carolinas, Inc., submitted a proposed amendment for the Shearon Harris Nuclear Power Plant, Unit 1.

The proposed amendment would modify Technical Specification (TS) Sections 5.6.1.3.a and 5.6.1.3.b to incorporate the results of a new criticality analysis. Specifically the TSs would be revised to add new requirements for the Boiling-Water Reactor (BWR) spent fuel storage racks containing Boraflex in Spent Fuel Pools A and B. The requirements for the BWR spent fuel racks currently contained in TS 5.6.1.3 would be revised to specify applicability to the spent fuel storage racks containing Boral in Spent Fuel Pool B.

The U.S. Nuclear Regulatory Commission staff has determined that it needs additional information in order to complete its review. Please respond to the enclosed requests by August 16, 2010, in order to facilitate a timely completion of the staff review. If this date is not achievable, the review schedule for this action, which calls for a completion date of September 2010, will no longer be feasible and other options will need to be considered.

Please contact me at 301-415-3178 if you have any questions on this issue, would like to participate in a conference call, or if you require additional time to submit your responses.

Sincerely,

Marlayna Vaaler, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-400

Enclosure: Request for Additional Information

cc w/enclosure: Distribution via Listserv

SECOND REQUEST FOR ADDITIONAL INFORMATION

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

REQUEST FOR LICENSE AMENDMENT TO REVISE

TECHNICAL SPECIFICATION SECTIONS 5.6.1.3.a AND 5.6.1.3.b FOR

INCORPORATION OF UPDATED CRITICALITY ANALYSES TO REFLECT

REMOVAL OF CREDIT FOR BORAFLEX IN BOILING-WATER REACTOR

SPENT FUEL STORAGE RACKS

DOCKET NO. 50-400

The Nuclear Regulatory Commission (NRC) staff has determined that it needs responses to the following questions in order to continue its review of the subject request:

1. The technical report (Holtec Report No. HI-2043321, *Criticality Safety Analyses of BWR [Boiling-Water Reactor] Fuel Without Credit for Boraflex in the Racks at the Harris Nuclear Power Station*) states that the temperature coefficient of reactivity is positive and the void coefficient is negative.

    a. Were the temperature and void coefficients checked for multiple points covering the range of the proposed burnup credit loading curves and the range of boron concentrations credited in the analysis? If not, describe/justify what was done.

    b. The temperature coefficient should include both fuel and water temperatures. It would seem that the only way the temperature coefficient could be positive would be if the nuclear reactivity (k_{eff}) increased with decreasing water density. This indeed happens with over-moderated arrays. Unless the void coefficient is defined in some unusual way, a negative void coefficient means that as void increases (effectively decreasing water density), k_{eff} goes down. It is not clear how a system can have a positive temperature coefficient and a negative void coefficient. Explain how the system has a positive temperature coefficient and a negative void coefficient.

2. From the description provided in Section 5.2 of the technical report it appears that the bounding axial burnup profile was determined by averaging 4 profiles selected from 16 that were provided by Progress Energy. The initial 16 profiles were from assemblies that had initial enrichments around 4 weight-percent uranium-235 (^{235}U) and had accumulated burnup values between 30- and 46-gigawatt days per metric ton of uranium (GWd/MTU). It is not clear that this approach yielded a conservative axial burnup profile. Address the following issues:

    a. Provide justification for using the limited set of 16 profiles provided by Progress Energy. This justification should address coverage of the ranges in fuel designs (i.e., GE3 through GE13), variations of assembly features with the designs (i.e., Gadolinium (Gd) rod usage, enrichments, blankets, axial dimensions), variations in relevant fuel depletion history (i.e., power, temperature, void distribution, control rod usage), and the range of the final assembly burnup values to be credit by the burnup credit analysis (i.e., 1.4 to 54.2 GWd/MTU).

b. Provide justification for the further down-selection to 4 profiles. The justification should address why the 4 selected profiles are bounding compared to the 16 provided by Progress Energy.

c. It appears to be inappropriate to average the 4 selected profiles. Describe how an average profile can be bounding compared to the 4 profiles used to generate the average profile.

The information provided in the technical report is not adequate to support a conclusion that the axial burnup profile in Table 6 conservatively bounds the axial burnup profiles for the fuel to be stored in the spent fuel storage racks. Provide a stronger justification supporting use of the specified axial burnup profile, or perform and document a more thorough analysis to determine one or more bounding axial burnup profiles.

3. The analysis report should describe assumptions, approximations, and simplifications used in the analysis and should address their impact on the calculated k_{eff} value and on the total uncertainties used to calculate the maximum k_{eff} values. Address the following:

   a. Use of CASMO-4 typically includes a "lumped fission product" model. This modeling simplification/approximation is not described in the technical report.

   b. For this analysis, CASMO-4 was used to generate the burned fuel compositions used in the Monte Carlo N-Particle Transport Code (MCNP) models. Were the lumped fission product compositions used in the MCNP models or were they discarded? The modeling of lumped fission products in CASMO and subsequent handling of lumped fission products was not described in the technical report.

   c. Typically, the fuel composition calculations include either some post-irradiation decay period or some post-processing of the CASMO burned fuel compositions to remove xenon and, in some cases, to convert neptunium-239 (^{239}Np) to plutonium-239 (^{239}Pu). Post-irradiation modeling and adjustment of the burned fuel compositions is not discussed in the technical report.

4. One of the primary products of the analysis is the burnup credit loading curves, which are presented (1) in equation form in Section 1.0 of the technical report, (2) in Table 5, and (3) in Figures 2 and 2a. The following issues should be addressed concerning the burnup credit loading curves:

   a. The loading curves utilize the "initial maximum planar average enrichment" (IMPAE). This quantity is not defined in the analysis. Provide a clear and complete definition of IMPAE.

   b. Other than for natural uranium blankets, will any single fuel rod have more than one fuel enrichment? In other words, do enrichment and the IMPAE vary with axial zone? If so, describe how axial zone enrichment variation is taken into account in the analysis.

   c. The analysis uses an average enrichment for each plane rather than the detailed pin-by-pin enrichment distribution. Provide a justification for this modeling simplification. If appropriate, include bias and uncertainty associated with the modeling simplification.

d. No range is provided for acceptable use of the burnup credit loading curves. It appears that their use should be limited to initial enrichments no lower than 1.5 weight-percent ^{235}U and no greater than 4.6 weight-percent ^{235}U. Confirm the acceptable range for use of the burnup credit loading curves.

5. The second bullet in Section 2.0 of the technical report is:

Minor structural materials were neglected; i.e. spacer grids were conservatively assumed to be replaced by water.

Confirm that this modeling simplification was checked over the full range of the burnup credit loading curves and over the full range of soluble boron concentrations credited. If appropriate, include bias and uncertainty associated with the modeling simplification.

6. Section 4.1 of the technical report provides a description of the limiting fuel assembly design. No information is provided on the use of fuel rods that contain gadolinium. Provide information concerning the ranges of the numbers of Gd rods used, the Gd loading, and the axial location of the Gd in the Gd rods.

7. There appears to be an unstated assumption that it is conservative not to model the gadolinium present in some of the fuel rods. NUREG/CR-6760, "Study of the Effect of Integral Burnable Absorbers for Pressurized Water Reactor (PWR) Burnup Credit," does present some information for full-length Gd rods in PWR assemblies that one might extrapolate to BWR fuel to support such a hypothesis. However, the validity of applying this assumption to BWR fuel has not yet been fully demonstrated. BWR fuel features that may affect this issue include axial zoning of gadolinium and radially varying ^{235}U enrichments that are somewhat correlated with the Gd rod locations.

This issue was raised in earlier requests for additional information (RAIs); the response provided in Enclosure 1 to the licensee's supplemental letter dated January 18, 2010, and its Attachment 1 has been reviewed. The information provided does not fully address the issue. The calculations documented in the RAI response were performed with CASMO-4, a two dimensional (2D) lattice code. This calculational approach does not address the impact of axially dependent design features such as blankets, part-length rods, axial zoning of Gd, and, if utilized, axial zoning of fuel ^{235}U enrichments.

Further, the RAI response notes that "representative gadolinium loading and location of gadolinium rods were used." A three dimensional (3D) analysis should be performed using gadolinium rod loading and radial and axial locations that are expected to cover the range of acceptable configurations. Provide additional justification supporting the assertion that neglecting gadolinium is a conservative simplification.

8. The text in Section 4.1 of the technical report refers to Tables 7 and 7a showing comparisons of the reactivities of the fuel assembly designs that are or will be stored in the BWR spent fuel storage racks. These tables are used to justify that the GE13 assembly design is the limiting fuel assembly design.

a. No details are provided in the technical report concerning how these calculations were performed. Describe the calculations, including information on the codes used, geometry, the axial burnup distributions utilized, variations within each assembly design considered, fuel channels, gadolinium modeling, etc. Note that simple 2D comparisons of these assembly designs with varying 3D features may not be appropriate.

b. Provide comparisons with and without design-specific fuel channels.

A similar issue was raised in an earlier RAI; the response provided in Enclosure 1 to the licensee's supplemental letter dated January 18, 2010, and its Attachment 1 has been reviewed. The response appears to address only GE13 fuel. The analysis results presented in Tables 7 and 7a of the technical report should have included results for assemblies with and without channels to establish that GE13 fuel with channels is more reactive than the previous fuel designs with or without channels, provided assemblies of those designs had met their design-specific minimum cooling time requirements. Provide additional justification for the assertion that GE13 fuel with fuel channels is more reactive than previous designs with or without fuel channels.

c. Provide comparisons for assemblies with 1.5 wt weight-percent initial enrichment.

d. The cooling times presented in Table 7a of the technical report for GE3 through GE10 vary from 9 to 27 years. It appears that the analysis relies on design-dependent post-irradiation cooling times beyond the 4 or 7 year cooling times stated for the burnup credit loading curves. Explain why design-dependent post-irradiation cooling times are not required or describe how they will be implemented. Address why the cooling times in Table 7a vary from the cooling times in Table 7 and in the first paragraph of Section 4.1 of the technical report.

9. Section 4.2 of the technical report discusses reactor depletion modeling. The text in this section notes that the void fraction value is taken as the upper bound of the core operating parameters of Brunswick. The text at the top of page 6 includes the following:

> *The neutron spectrum is hardened by each of these parameters, leading to a greater production of plutonium during depletion, which results in conservative reactivity values.*

Other BWR plants have performed depletion calculations which showed that for their plants a zero void fraction was conservative. Confirm that calculations were performed for BWR fuel depleted in the Brunswick reactor showing that use of the high void fraction in fuel depletion calculations was conservative.

10. The simplified fuel storage rack model used in the analysis is described in Section 4.3 and in Figure 3 of the technical report. The simplified model differs from the actual rack geometry in a few significant ways. First, the simplified model creates a flux trap type geometry at the corners of each cell. The actual geometry does not have water between steel plates at the corners. Second, the simplified geometry assumes that the wrapper extends all the way to the corners. This is likely not correct for the actual geometry.

Confirm that a detailed rack model calculation was performed showing that the simplified model yields results equivalent or conservative when compared to the detailed model results. Note that this assumption should be checked over the range of the burnup credit loading curve and over the ranges of soluble boron concentrations credited. If appropriate, include bias and uncertainty associated with the modeling simplification.

11. Simplified fuel assembly models were used in the analysis. Address the following issues related to the fuel assembly models:

    a. Were fuel compositions in each axial layer modeled on a pin-by-pin basis or were average compositions used?

    b. Was buildup of Pu in the natural uranium blankets modeled?

    c. What is the impact on in-rack k_{eff} of extending the 8-inch top blanket to 12 inches?

    d. Table 2 indicates that only GE13 fuel assemblies have part-length rods. Did any of the fuel designs other than GE13 have part-length rods or blankets?

    e. It seems appropriate to use different axial burnup distributions for fuel assemblies with different axial features. Provide justification for the use of a single axial burnup distribution for modeling fuel assemblies with different axial features.

    Describe and justify fuel assembly modeling simplifications used. If appropriate, include bias and uncertainty associated with the modeling simplification.

12. The next to last paragraph in Section 5.2 of the technical report states that separate CASMO-4 depletion calculations were made for each of the 25 axial segments. The details as to how these calculations were performed are not adequate to support the review. Address how the depletion calculations were performed, including details of Gd rod depletion, and how the CASMO-4 calculated fuel compositions were incorporated into the MCNP models.

13. A rather limited set of uncertainties due to manufacturing tolerances is presented in Section 6.1 of the technical report. In addition to the items listed on page 10, the uncertainties associated with manufacturing tolerances on the following should have been evaluated: wrapper thickness, wrapper width, Boraflex gap thickness, Boraflex gap width, fuel pin pitch, pellet outer diameter (OD), clad OD and thickness, channel inner diameter and thickness, water tube OD and thickness, initial Gd content, Gd pellet density, and the length and location of each axial zone.

14. The text in Section 6.1 of the technical report describes a temperature correction calculated using CASMO, which is applied as a bias to MCNP results in Tables 1 and 1a. Calculation of Δk values related to temperatures changing from 20 °C to 150 °F using CASMO-4 has not been validated. Further, application of Δk values calculated using a 2D model to a 3D system is questionable. Additionally, an estimate of the uncertainty in the Δk correction due to temperature should be provided. Provide better

justification for the temperature correction and provide an estimate of the uncertainty in the correction.

15. The text in Section 6.1.1 of the technical report documents that a 5-percent reactivity decrement uncertainty is included in the uncertainties. The text does not clearly describe how this uncertainty was calculated. Confirm that the depletion uncertainty was calculated as 5 percent of the change in k_{eff} of the 3D spent fuel storage rack due to changing from fresh fuel with no Gd to a burned fuel assembly at its minimum burnup allowed by the loading curves.

16. Section 6.2.1 of the technical report discusses the analysis of eccentric location of fuel assemblies in each cell in the spent fuel storage racks. The analysis is inappropriately presented in the section on abnormal and accident conditions. The most reactive fuel assembly position is part of the normal conditions, not an abnormal condition. Second, confirm that the analysis was performed both with and without fuel channels. Lastly, confirm that the analysis included a configuration where all assemblies in a rack module were moved toward a single common interior corner near the center of a rack module.

17. Section 6.2.3 of the technical report discusses evaluation of accidents involving a misloaded fuel assembly. The level of detail provided is not sufficient to support review. Provide the following information:

    a. Fully describe the model of the misloaded assembly. Provide information on the IMPAE, final burnup, axial burnup distribution used, elevation-dependent lattice design, presence or lack of a fuel assembly channel, etc.

    b. Fully describe the rack model into which the misloaded assembly was placed. Provide information on the model extent (e.g., 15x15 spent fuel storage rack module, axial and radial boundary modeling) and burnup of fuel other than the misloaded assembly. Note that the misloaded assembly and normal loaded assemblies should have similar axial fission density profiles. If highly burned fuel assemblies are loaded with a low burnup misloaded assembly, neutronic interaction between the most reactive parts of the assemblies will be minimized.

    c. Describe the location inside and outside the rack module where the misloaded assembly was modeled. Address the potential for placement of an assembly between and beside the fuel storage racks.

18. Are controls implemented that preclude movement of PWR fuel assemblies near the BWR fuel storage racks? If not, the analysis should include a PWR fuel assembly next to the BWR fuel storage racks as a “normal” condition. It may also be necessary to consider a PWR assembly dropped onto the BWR spent fuel storage racks.

19. Are controls implemented that preclude movement of more than one assembly of any type at the same time? If not, the normal and, possibly, abnormal conditions analysis should include consideration of the maximum number of assemblies that may be near the BWR spent fuel storage racks at any one time.

20. The text in Section 1 of the technical report states that a soluble boron concentration of 300 parts per million (ppm) is required to maintain k_{eff} below 0.95 under normal conditions and that 325 ppm is required to assure k_{eff} is less than 0.95 for the misload accident. Do these soluble boron concentrations include margin to ensure that k_{eff} will be less than 0.95 with 95-percent probability and a 95-percent confidence level? If not, revise the required soluble boron concentrations to include such margin.

21. The analysis does not address interaction between rack modules within the BWR spent fuel storage region and between the BWR spent fuel storage racks and other fuel storage racks such as the PWR spent fuel storage racks. The analysis should address interaction between rack modules or provide justification for not doing so.

    The response to Request 6 in Enclosure 1 of the licensee's supplemental letter dated January 18, 2010, addressed a similar question. The RAI response indicates that the interface was already addressed in the PWR Boraflex Rack Criticality Analysis. In the referenced analysis, was the BWR Boraflex rack modeled with no Boraflex and at zero soluble boron? The normal condition, which now will include no Boraflex in the BWR racks, must be subcritical at zero soluble boron.

    Further, implementation of the new BWR burnup credit analysis would result in storage of BWR fuel assemblies that will have axial fission density profiles that vary significantly with fuel burnup. The original PWR analysis included only fresh BWR assemblies. If the PWR analysis credited fuel burnup, the PWR/BWR interface model should consider optimizing the interaction between the most reactive parts of the PWR and BWR assemblies. For example, one may find that the worst cases would include storage of highly burned BWR fuel next to highly burned PWR fuel or low burnup BWR fuel next to low burnup PWR fuel.

    Accordingly, the response to Request 6 is not sufficient to address the issue. Provide additional information to support that the PWR/BWR interface does not need to be revisited with the implementation of the new BWR fuel storage rack analysis.

22. Table 2a of the technical report provides the Brunswick core operating parameters used for depletion. The text in Section 4.2 identifies these parameters "as the upper bound (most conservative) of the core operating parameters of Brunswick." Are these parameters bounding on a local level or on a core average basis? The values used should be bounding locally, not just on average.

23. Provide the following information related to the specific power used for depletion:

    a. The supplemental information submitted by letter dated January 16, 2009, stated that maximum specific power for Brunswick was 26.7 MW/MTU. Table 2a of the technical report shows that 30 MW/MTU was used. Confirm that the assumed specific power is conservative considering the presence of fission products. Also, confirm that the assemblies depleted at the pre-extended power uprate level are bounded.

    b. Show how specific power was calculated.

24. Table 4 includes the following text for the temperature increase "condition":

> *150 °F used for normal storage condition. Higher temperatures are accident conditions with credit for soluble boron allowed.*

What is a credible higher temperature and how much soluble boron is required to address the higher temperature abnormal condition identified in Table 4 of the technical report?

25. Table 4 of the technical report describes the consequences of a dropped assembly and of a seismic event as "negligible." How much seismic movement (i.e., rack module sliding) is considered credible? Were calculations performed to show that the assumed consequences of these conditions are negligible? If not, provide justification for not performing these calculations.

26. The validation analysis presented in Appendix A of the technical report should have evaluated bias trends as a function of plutonium content [e.g., g Pu/(g Pu + g U)] and soluble boron concentration. Evaluate the bias trends for these parameters or provide justification for not evaluating the trends using these parameters. Where appropriate, incorporate parameter dependent biases and uncertainties.

27. Provide the following information related to the Technical Specifications (TS):

    a. It appears that TS 5.6.1.3.a.5 and TS 5.6.1.3.a.6 can be in conflict (i.e., an assembly might meet TS 5.6.1.3.a.6 but not TS 5.6.1.3.a.5) since TS 5.6.1.3.a.6 does not specify a burnup requirement. The enrichment requirement is in the loading curve.

    b. Provide the NRC staff Safety Evaluation that approved the basis for TS 5.6.1.3.b.3, which states that "BWR assemblies are acceptable for storage in BWR Boral storage racks provided the maximum planar average enrichments are less than 3.2 weight-percent U235."

    c. TS Figure 5.6-3 should specify "Initial Maximum Planar Average Enrichment (wt%U-235)" instead of just "Enrichment." Having just "Enrichment" might be confused with assembly average enrichment.

28. Confirm that HNP currently only stores fuel depleted at Harris, Robinson, or Brunswick. Also, discuss the licensing approach to be used if, in the future, HNP decides to restart the storage of fuel from other facilities, which may include fuel designs not covered by this license amendment request.

July 20, 2010

Christopher L. Burton, Vice President
Shearon Harris Nuclear Power Plant
Carolina Power & Light Company
Post Office Box 165, Mail Zone 1
New Hill, North Carolina 27562-0165

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Sincerely,
/RA/
Marlayna Vaaler, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-400

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DATE	7/14/10	7/13/10	6/17/2010	7/20/10

* by memo

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