June 20, 2007

Mr. Dale E. Young, Vice President
Crystal River Nuclear Plant (NA1B)
ATTN: Supervisor, Licensing & Regulatory Programs
15760 W. Power Line Street
Crystal River, Florida 34428-6708

SUBJECT: CRYSTAL RIVER, UNIT NO. 3, REQUEST FOR ADDITIONAL INFORMATION REGARDING ADDITIONAL STORAGE PATTERNS FOR SPENT FUEL POOLS (TAC NO. MD3308)

Dear Mr. Young:

By letter dated October 5, 2006, as supplemented by letter dated April 4, 2007, the Florida Power Corporation (FPC) submitted an application to change the Crystal River, Unit No. 3, Technical Specifications to allow additional storage patterns for fuel in the spent fuel storage pools. The NRC staff has determined that it needs additional information in order to complete its review. The enclosed questions were sent by e-mail to FPC on May 15, 2007, and discussed during a conference call on May 29, 2007.

Please respond to the enclosed questions within 30 days of the date of this letter. This schedule was discussed and agreed to by Mr. Paul Infanger of FPC.

Please contact me at 301-415-1321 if you have any questions on this issue.

Sincerely,

/RA/

Stewart N. Bailey, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-302

Enclosure: As stated

cc: See next page

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REQUEST FOR ADDITIONAL INFORMATION

CRYSTAL RIVER UNIT NO. 3

REVISION TO SPENT FUEL STORAGE CONFIGURATIONS

DOCKET NO. 50-302

By letter dated October 5, 2006, as supplemented by letter dated April 4, 2007, the Florida Power Corporation (FPC, the licensee) submitted License Amendment Request (LAR) No. 292 for Crystal River Unit No. 3 (CR-3). The proposed amendment would change the CR-3 Technical Specifications (TSs) to permit additional storage patterns for CR-3 spent fuel pools (SFPs). To support this request, FPC submitted Holtec Report No. HI-2063579, which provides a new criticality analysis for the CR-3 SFP.

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

Section 50.68(b)(4) of 10 CFR states, "If no credit for soluble boron is taken, the k-effective 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-effective 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-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water."

The new CR-3 SFP criticality analysis takes credit for soluble boron. Therefore, the acceptance criteria are (1) the k-effective (k_{eff}) must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water, and (2) the k_{eff} must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water.

The staff has provided guidance on meeting the regulatory requirements in Reference 2.

The staff requests responses to the following questions in order to continue the review:

1. Not used.

2. 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. However, the information provided did not address a misloading or boron dilution event. Please provide the following information:

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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)?

3. Proposed TS Figure 3.7.15-2 lists the enrichment/burnup curves for determining storage configuration requirements in CR-3 Pool B. With respect to Figure 3.7.15-2, please provide the following information:

a. The LAR has named all areas on Figures 3.7.15-1 and 3.7.15-2, except the area under the lowest curve on Figure 3.7.15-2. Why was this area not named.

b. Note 1 to Figure 3.7.15-2 states Category B fuel may be stored in any location without restriction. Note 3 to Figure 3.7.15-2 states fuel meeting the lower curve criteria can only be stored in Pool B if surrounded by eight empty water cells. Please provide clarification on this apparent contradiction, as Category B fuel assemblies cannot be stored in those empty storage cells.

c. Note 2 to Figure 3.7.15-2 states, Category BP fuel may be stored in peripheral cells. The definition of peripheral cells has been changed from the cells against the SFP wall to the last cell containing fuel. The last cell containing fuel could be in the middle of the SFP. Are there any restrictions on how far from the SFP wall a cell can be and still be considered a peripheral cell?

4. When discussing the methodology used and specifically the MCNP4a computer code, Section 2 of HI-2063579 states, “Based on these studies, a minimum of 10,000 histories were simulated per cycle, a minimum of 100 cycles were skipped before averaging, a minimum of 150 cycles were accumulated, and the initial source was specified as uniform over the fueled regions (assemblies).” However, HI-2063579 Section 4 indicates axial blankets were explicitly modeled. Please reconcile this apparent contradiction.

5. Not used.

6. HI-2063579 Section 5.1 refers to Table 5.1 for the fuel assembly design specifications. Table 5.1 does not contain any tolerance information for Mark B-10/B-9 for Mark B/HTP fuel assemblies. What tolerances were used for the Mark B-10/B-9 for Mark B/HTP fuel assemblies?

7. NUREG/CR-6665, “Review and Prioritization of Technical Issues Related to Burnup Credit for LWR Fuel” (Ref. 5), recommends using the maximum fuel and core outlet temperature. Table 5.2 indicates the average fuel and core outlet temperature was used in the analysis. Justify using less than the maximum fuel and core outlet temperature.

8. HI-2063579 Sections 5.3 and 7.1.4 discuss the axial burnup distribution. The axial burnup profile for blanketed assemblies is provided in Table 5.3a. The axial burnup profile for non-blanketed assemblies is provided in Table 5.3b. NUREG/CR-6801, “Recommendations for Addressing Axial Burnup in PWR [pressurized-water reactor] Burnup Credit Analysis” (Ref. 3), reports the results of an analysis of the axial-burnup-profile database of Reference (Ref. 4). That database contains 3169 PWR axial profiles from 1700 different assemblies, which represent 3 fuel vendors, 20 different reactors, and 106 cycles of operation through the mid-1990s. NUREG/CR-6801 set expectations for the number of axial zones to be used in determining the axial burnup distribution and identified current bounding axial burnup distributions. The bounding axial burnup distributions were set by Babcock and Wilcox 15x15 profiles. With respect to the axial burnup distribution, provide the following information.

   a. The axial burnup profiles in Table 5.3a do not match those in NUREG/CR-6801. What is the source for the Table 5.3a axial burnup distribution profiles? What is the justification for using those profiles?

   b. Table 5.3a has twenty axial zones, the last of which ends at a core height of 357.46 cm. However, Footnote number 9 to Table 5.1 indicates that all fuel assemblies were modeled as 144 inches (365.46 cm). Please reconcile this apparent contradiction. How does this affect the analysis discussed in Section 7.1.4 and represented in Table 7.7?

   c. Table 5.3b has 10 axial zones. NUREG/CR-6801 concluded that 10 axial zones are insufficient to adequately model the burnup distribution profile. No burnup dependency is indicated for the burnup profile in Table 5.3b. The axial burnup profile is typically burnup dependent. Provide the justification for the use of the axial burnup profile in Table 5.3b.

      i. Note, NUREG/CR-6801 included S. E. Turner’s, “An Uncertainty Analysis - Axial Burnup Distribution Effects” (Ref 6), which is essentially the same Reference 9 in HI-2063579.

   d. HI-2063579 Section 7.1.4 states, “For Pool B, previous analysis [11] investigated the reactivity effect of non-blanketed fuel. The study showed that non-blanketed fuel, which has a maximum enrichment of 4.24 wt% 235U at the appropriate burnup for Category B, was found to be acceptable below the regulatory criteria of 0.95. These results are still applicable for the analysis presented in this report. Therefore, both blanketed and non-blanketed fuel is bounded by the flat distribution."

i. There is no reference 11 in Section 8 of HI-2063579. What is reference 11? If reference 11 is not on the NRC docket, provide a copy of reference 11 for NRC staff review. Upon review of this document the staff may have further questions as the concept that non-blanketed fuel assemblies are bounded by a flat distribution is contrary to current analysis.

ii. What is the flat distribution being used?

e. HI-2063579 Section 7.1.4 indicates an analysis was performed for Pool A that concluded, ". . . The conclusion is that the maximum k_{eff} with blanketed fuel and a flat axial burnup distribution bounds the maximum k_{eff} with non-blanketed fuel and the distribution shown in Table 5.3b. Therefore, use of the flat profile with axial blankets is conservative." Provide the results of that analysis.

f. From the discussion in HI-2063579 Section 7.1.4 it is unclear which axial burnup profile is being used with the non-blanketed fuel assemblies. Clarify the use of the axial burnup profiles.

9. HI-2063579 Sections 5.4 and 7.1.3 discuss the effects of core inserts axial profile shaping rods (APSR) and burnable poison rod absorbers (BPRA). Tables 5.4, 5.5, and 5.6 provide some design specification information for the APSRs and BPRAs. No manufacturing tolerances for the APSRs and BPRAs are discussed. How would the manufacturing tolerances on the APSRs and BPRAs affect the analysis?

10. HI-2063579 Sections 5.5.1 and 5.5.2 describe the CR3- Pool A and Pool B SFP racks. Pool A is described as ". . . stainless steel walls sandwiching a Carborundum neutron absorber panel, centered on each side of the storage cell." Pool B is described as " . . .a single Boral neutron absorber panel affixed to the stainless steel walls of adjacent storage cells." With respect to the SFP storage racks, provide the following information.

a. What is the stainless steel used in the walls of the storage cells and Boral sheathing?

b. HI-2063579 Section 5.5 states, "Only the B_4C is credited in the composition of the Carborundum in the Pool A racks. This is conservative as it neglects the other components of the Carborundum which may absorb additional neutrons." How are the other components modeled?

c. HI-2063579 Section 5.5.1 states, "The Carborundum is additionally assumed to be partially degraded (15% loss of B_4C)." What is the basis for this assumption? Why is there no similar assumption for the Boral in the Pool B storage cells?

d. HI-2063579 Section 5.5.2 discusses the potential in Pool B for misalignment between the Boral plates and the fuel assembly not sitting properly in the storage cell. Why isn't there a similar discussion for Pool A?

e. Boral's stainless steel sheathing cannot be discerned on Figure 5.3. Describe how the sheathing is modeled.

11. Not used.

12. HI-2063579 Section 7.2.1 indicates for Pool A, eccentric positioning of the fuel assemblies in the closest proximity resulted in an equivalent k_{eff} as centering the assemblies within the storage cell.

   a. How were the storage cell tolerances applied in this analysis?

   b. Explain why moving the fuel closer together had no effect on reactivity. What was the result of moving the fuel farther apart?

13. HI-2063579 Section 7.2.2 describes the development of uncertainties due to manufacturing tolerances for the fuel assemblies and storage racks in Pool A. The fuel assembly tolerances are provided in Table 5.1 and the storage rack tolerances are provided in Tables 5.7 for Pool A. The resultant uncertainties are listed in Table 7.8. With respect to the development of uncertainties due to manufacturing tolerances, provide the following information.

   a. What were the configurations used to determine the uncertainties listed in Table 7.8? Were these infinite lattices of the individual assemblies or specific checkerboard configurations? How are the results dependent on the configuration used in the analysis?

   b. HI-2063579 Section 7.2.2 indicates calculations are performed for different enrichments and burnups. What combinations of enrichments and burnups were used for each fuel type? Are the uncertainties listed in Table 7.8 the bounding uncertainties?

   c. HI-2063579 Section 7.2.2 indicates the full tolerance was used to determine the maximum reactivity effect. Were sensitivity studies performed to confirm whether the maximum or minimum dimension, after application of the tolerance, provided the maximum positive reactivity effect?

   d. Deleted.

14. HI-2063579 Section 7.2.3 describes the development of SFP temperature bias for Pool A. The results are listed in Table 7.9 and indicate Pool A has a negative moderator temperature coefficient. What were the configurations used to determine the biases listed in Table 7.9? Were these infinite lattices of the individual assemblies or specific checkerboard configurations? How are the results dependent on the configuration used in the analysis?

15. Not used.

16. HI-2063579 Section 7.2.5.4.1 describes the analysis to determine the soluble boron required to offset the possible misloading of a fuel assembly in Pool A.

    a. Provide a description of the controls that ensure the misloading of only a single fuel assembly need be considered.

    b. Provide the results of the various enrichment and burnup combinations that were used in the analysis.

    c. Were any analyses performed for the misloading of a fuel assembly in the boundary between the Category B and fresh fuel checkerboard and the Category A storage? If there were, provide the results of those analyses or explain why no analyses were performed.

    d. Provide the results of the analysis used to determine the soluble boron requirement.

17. HI-2063579 Section 7.3.1 indicates for Pool B, eccentric positioning of the fuel assemblies in the closest proximity resulted in an equivalent k_{eff} as centering the assemblies within the storage cell.

    a. How were the storage cell tolerances applied in this analysis?

    b. Explain why moving the fuel closer together had no effect on reactivity. What was the result of moving the fuel farther apart?

18. HI-2063579 Section 7.3.2 describes the development of uncertainties due to manufacturing tolerances for the fuel assemblies and storage racks in Pool B. The fuel assembly tolerances are provided in Table 5.1 and the storage rack tolerances are provided in Tables 5.8 for Pool B. The resultant uncertainties are listed in Table 7.10. With respect to the development of uncertainties due to manufacturing tolerances, provide the following information.

    a. What were the configurations used to determine the uncertainties listed in Table 7.10? Were these infinite lattices of the individual assemblies or a specific configuration? How are the results dependent on the configuration used in the analysis?

    b. HI-2063579 Section 7.3.2 indicates calculations are performed for different enrichments and burnups. What combinations of enrichments and burnups were used for each fuel type? Are the uncertainties listed in Table 7.10 the bounding uncertainties?

    c. HI-2063579 Section 7.3.2 indicates the full tolerance was used to determine the maximum reactivity effect. Were sensitivity studies performed to confirm whether the maximum or minimum dimension, after application of the tolerance, provided the maximum positive reactivity effect?

19. HI-2063579 Section 7.3.3 describes the development of SFP temperature bias for Pool B. The results are listed in Table 7.11 and indicate Pool B has a negative moderator temperature coefficient. What were the configurations used to determine the biases listed in Table 7.11? Were these infinite lattices of the individual assemblies or specific checkerboard configurations? How are the results dependent on the configuration used in the analysis?

20. HI-2063579 Section 7.3.4 describes the development of maximum k_{eff} for Pool B. The model used for the analysis is shown in Figures 5.3 and 5.4. Figure 5.4 is a representative sketch of the storage cell. Figure 5.3 is a drawing representative of a fresh fuel assembly bordered by eight empty storage cells, which in turn are bordered by Category B fuel assemblies.

    a. Figure 1.2 shows two arrangements of a fresh fuel assembly bordered by eight empty storage cells bordering each other and not separated by four rows of Category B fuel assemblies as would be the case in the model represented by Figure 5.3. What is the maximum k_{eff} in this arrangement?

    b. According to the definition and restrictions of Category B and Category BP fuel assemblies in the proposed revised TS Figure 3.7.15-2 the empty cells could be bordered on two sides by Category BP fuel assemblies instead of Category B fuel assemblies. What is the maximum k_{eff} if the Category B are replaced with Category BP fuel assemblies?

21. HI-2063579 Section 7.3.5.4.1 describes the analysis to determine the soluble boron required to offset the possible misloading of a fuel assembly in Pool B.

    a. Provide a description of the controls that ensure the misloading of only a single fuel assembly need be considered.

    b. Provide the results of the various enrichment and burnup combinations that were used in the analysis.

    c. It is presumed that the 7x7 array used for this analysis is the same 7x7 array used to determine the maximum k_{eff} for Pool B as depicted in Figure 5.3.

        i. Which empty cell produced the maximum k_{eff} for the misloading analysis?

        ii. How would changing the configuration as described in question 20 above change the results?

    d. Provide the results of the analysis used to determine the soluble boron requirement.

22. HI-2063579 Section 7.5 describes the change in definition of a ‘peripheral cell’ for Pool B. The definition of a ‘peripheral cell’ is changed from ". . . those that are adjacent to the walls of the spent fuel pool" to ". . . the outermost row of cells in the pool containing fuel assemblies." With the new definition a ‘peripheral cell’ could be in the

center of the SFP, and perhaps back-to-back with a 'peripheral cell' from the each side of the SFP. The discussion in HI-2063579 Section 7.5 refers to Figure 1.2, which shows the outer most row, BT, completely empty and the next row in, BS, completely filled with Category BP fuel assemblies. The discussion indicates this is bounded by the previous analysis, which used a 30-centimeter water reflector for the periphery. While both scenarios would yield similar results, they do not represent other potential arrangements that would be allowed by the revised definition of a 'peripheral cell.' Under the current definition and the arrangements depicted in Figure 1.2 a Category BP fuel assembly is bordered on one side by at least three empty storage cells, one face-to-face and two diagonally. Under the new definition a Category BP fuel assembly may be placed in an arrangement such that is would only be bordered by one empty storage cell, face-to-face, while the previously empty diagonal storage cells may be filled with either Category B or BP fuel assemblies. It is not clear that these potential arrangements were considered in the analysis. Provide the analyses to show these potential arrangements are acceptable.

REFERENCES

1. Progress Energy letter 3F1006-01 from Daniel L. Roderick, Director Site Operations Crystal River Nuclear Plant, to USNRC document control desk, re: "Crystal River Unit 3 - License Amendment Request # 292, Revision 0, Additional Storage Patterns for Crystal River Unit 3 Storage Pools A and B," October 5, 2006. (ADAMS ML062830073)

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

4. R. J. Cacciapouti and S. Van Volkinburg, "Axial Burnup Profile Database for Pressurized Water Reactors," YAEC-1937, Yankee Atomic Electric Company (May 1997). Available from the Radiation Safety Information Computational Center at Oak Ridge National Laboratory as DLC-201.

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

6. S. E. Turner, "An Uncertainty Analysis - Axial Burnup Distribution Effects," *Proc. Workshop Use of Burnup Credit in Spent Fuel Transport Casks, Washington D. C., February 21-22, 1988,* SAND89-0018, TTC-0884, UC-820, T. L. Sanders, Ed., Sandia National Laboratories, October 1989.