September 29, 2008

Chris L. Burton, Vice President
Shearon HNP 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 – REQUEST FOR ADDITIONAL INFORMATION REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS" (TAC NO. MC4688)

Dear Mr. Burton:

By letters dated February 28, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080670099), and March 28, 2008 (ADAMS Accession No. ML080940495), Carolina Power & Light Company (the licensee), submitted a supplemental response to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for the Shearon Harris Nuclear Power Plant, Unit 1 (HNP).

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the licensee's submittals. The process involved detailed review by a team of 10 subject matter experts, with focus on the review areas described in the NRC's "Content Guide for Generic Letter 2004-02 Supplemental Responses," (ADAMS Accession No. ML073110389). Based on these reviews, the staff has determined that additional information is needed in order to conclude there is reasonable assurance that GL 2004-02 has been satisfactorily addressed for HNP. The enclosed document describes these requests for additional information (RAIs).

The NRC requests that the licensee respond to these RAIs within 120 days of the date of this letter. However, the NRC would like to receive only one response letter for all RAIs with the exception noted below. If the licensee concludes that more than 120 days are required to respond to the RAIs, the licensee should request additional time, including a basis for why the extension is needed.

If the licensee concludes, based on its review of the RAIs, that additional corrective actions are needed for GL 2004-02, the licensee should request additional time to complete such corrective actions as needed. Criteria for such extension requests are contained in SECY-06-0078 (ADAMS Accession No. ML053620174), and examples of previous requests and approvals can be found on the NRC's sump performance website, located at: http://www.nrc.gov/reactors/operating/ops-experience/pwr-sump-performance.html.

Any extension request should also include results of contingency planning that will result in near term identification and implementation of any and all modifications needed to fully address

GL 2004-02. The NRC strongly suggests that the licensee discuss such plans with the staff before formally transmitting an extension request.

The exceptions to the above response timeline are RAIs 29 through 31. The NRC staff considers in-vessel downstream effects to not be fully addressed at HNP, as well as at other pressurized water reactors. HNP's submittal refers to the draft topical report, WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." At this time, the NRC staff has not issued a final safety evaluation (SE) for WCAP-16793-NP.

The licensee may demonstrate that in-vessel downstream effects issues are resolved for HNP by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve RAIs 29 through 31 by demonstrating, without reference to WCAP-16793-NP or the NRC staff SE, that in-vessel downstream effects have been addressed at HNP. The specific issues raised in RAIs 29 and 30 should be addressed regardless of the approach the licensee chooses to take.

The licensee should report how it has addressed the in-vessel downstream effects issue and the associated RAIs referenced above within 90 days of issuance of the final NRC staff SE on WCAP-16793-NP. The NRC staff is currently developing a Regulatory Issue Summary to inform the industry of the staff's expectations and plans regarding resolution of this remaining aspect of Generic Safety Issue 191, "Assessment of Debris Accumulation on PWR Sump Performance."

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,

/RA/

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

Docket No. 50-400

Enclosure: As stated

cc w/enclosure: See next page

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Sincerely,
/RA/
Marlayna Vaaler, Project Manager
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Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

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cc w/enclosure: See next page

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REQUEST FOR ADDITIONAL INFORMATION

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT 1

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02:

"POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION

DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS"

DOCKET NO. 50-400

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

1. The submittal dated February 28, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080670099), stated that the break selection process was simplified due to the large zones of influence (ZOIs) associated with the target materials. This simplification may be valid for the relatively large ZOIs, but may not be valid for the 4 pipe diameter (4D) ZOI that the licensee used for Min-K [microporous insulation], and the 5D ZOI used for qualified coatings, if care is not taken to maximize the amount of debris created for these smaller ZOIs.

   Please verify that the hypothetical breaks were moved systematically to ensure that the amount of debris created was maximized for ZOIs smaller than the entire compartment. This is especially important for the Min-K debris that has been shown to have the potential for a large effect on head loss and has a very small ZOI for the Shearon Harris Nuclear Power Plant, Unit 1 (HNP) evaluation.

2. The licensee stated that the licensing basis break size inside the reactor cavity is 150 square inches. This corresponds to a piping inside diameter (ID) of about 14 inches. The submittal was not clear as to what piping ID provided the basis for the ZOIs. Please provide the piping diameter or break size that is the basis for the ZOIs for each break.

3. Please provide details on the assumptions made regarding the size and shape of each ZOI for each break. If the ZOIs are not spherical and based on the piping diameter, provide the basis for the assumptions. Describe how debris generation from a spherical ZOI based on a given piping diameter would compare to the debris generation from a corresponding alternate-shaped ZOI.

4. The licensee used a ZOI reduction for encapsulated Min-K from 28.6D to 4D based on Continuum Dynamics, Inc. (CDI) testing of Diamond Power reflective metal insulation (RMI). The test is documented in CDI Report Number 96-06. Considering that the debris generation analysis for encapsulated Min-K diverged from the approved guidance in NEI [Nuclear Energy Institute] 04-07, please provide the details of the testing conducted that justified the ZOI reductions.

Enclosure

The information should include the jacket materials and construction used in the testing, geometries and sizes of the targets and jet nozzle, and materials and construction of the jackets installed in the plant. (e.g. Diamond Power RMI was found to have a ZOI of 28.6D while Transco RMI was found to have a ZOI of 2D. The major difference in construction between the two is that Diamond Power RMI is spot welded and Transco RMI is seam welded.)

Provide information that compares the mechanical configuration and sizes of the test targets and jets, and the potential targets and steam jets in the plant. Evaluate how any differences in jet/target sizing and jet impingement angle affect the ability of the insulation system to resist damage from steam impingement. State whether the CDI testing cited in the submittal bounds the plant Min-K insulation jacketing system design. If not, provide information that compares the plant encapsulation and jacketing system structure with the system that was used in the CDI testing, showing that the CDI testing conservatively or prototypically bounds potential damage to the Min-K insulation system.

5. The supplemental response dated March 28, 2008 (ADAMS Accession No. ML080940495), provides four-category debris size distributions for low-density fiberglass debris in 3 sub-regions of the 17D ZOI. However, a single integrated size distribution for the entire 17D ZOI (i.e., one four-category size distribution created by summing the individual contributions from all three sub-regions) was not provided for the analyzed breaks. Without knowing the integrated debris size distribution over the entire 17D ZOI, the staff is unable to verify whether the transport results and head loss testing source term are reasonably representative of the expected plant values. Therefore, please provide the integrated debris size distribution for the 17D ZOI for the low-density fiberglass insulation for the analyzed breaks.

6. Since the time of the two pilot audits for Generic Safety Issue (GSI)-191 (Crystal River 3 and Fort Calhoun), the staff has had unresolved concerns associated with the use of turbulent kinetic energy (TKE) metrics for justifying the settling of fine debris, including the following: (1) the lack of experimental benchmarking of analytically derived TKE metrics; (2) uncertainties in the predictive capabilities of TKE models in computational fluid dynamics (CFD) codes, particularly at the low TKE levels necessary to suspend individual fibers and 10-micron particulate; (3) the analytical prediction of settling velocities in quiescent water due to the specification of shape factors and drag coefficients for irregularly shaped debris; and (4) the theoretical correlation of the terminal settling velocity to turbulent kinetic energy that underlies the Alion Science and Technology Corporation (Alion) methodology for fine debris settling.

   A justification for the settling of fine debris is provided on page A1-18 of the supplemental response, but this discussion does not fully address the staff's concerns above. Please describe the extent to which settling of fines was credited in the transport analysis, the metrics used, and, to justify any settling credit taken, please also address the four numbered points above, many of which were documented in previous audit reports for other licensees who used a similar methodology.

7. The staff questions the conservatism of assuming that 100 percent of latent debris is on the containment pool floor during pool fill up, such that 15 percent of this debris is transported directly to inactive pool volumes. In actuality, latent debris will be distributed throughout containment, and much of it would seemingly be washed down following the initial filling of the containment pool. For this reason, taking credit for 15 percent of latent debris being washed into inactive pool volumes appears non-conservative. Please provide justification for this position.

8. The staff considers the assumption that small pieces of fibrous debris are held up on gratings in upper containment during washdown to be inadequately supported by the NRC Drywell Debris Transport Study (NUREG/CR-6369) data cited by the licensee. The 40 to 50 percent retention cited by the licensee from NUREG/CR-6369 was for a 30-minute test. The staff's conclusion from this testing, which is stated in NUREG/CR-6369, was that no credit should be allowed for retention based on this test data. Therefore, please provide an adequate technical basis to support the assumption of 40 to 50 percent retention of small fibrous debris pieces on containment gratings.

9. The licensee credited NUREG/CR-6369 results for the trapping of fibrous debris on gratings during blowdown. The staff noted that a number of tests were performed for NUREG/CR-6369, and that numerous tests showed much less capture than the value assumed by the licensee. The staff also noted that many of the NUREG/CR-6369 tests with larger capture fractions appeared to include debris fragments in the "6+" size category, which is larger than a standard floor grating opening. Therefore, the staff requests that the licensee identify the specific tests from NUREG/CR-6369 used to credit trapping of fibrous debris during blowdown and justify their prototypicality to HNP post-loss of coolant accident (LOCA) conditions.

10. Erosion testing performed at a relatively low velocity of 0.12 feet per second (ft/sec) was used to justify an erosion fraction of 10 percent for small and unjacketed large pieces of low-density fiberglass. The licensee provided a basis for applying this test data to the HNP post-LOCA conditions, but the staff considered the basis lacking in three respects.

    First, the licensee stated that the HNP "bulk pool velocity" was of the order of magnitude of 0.12 ft/sec, but it is questionable to the staff whether this apparently averaged velocity value adequately represents erosion conditions throughout the containment pool. In particular, based on the debris transport results presented by the licensee, it appears that a significant part of the containment pool at HNP could experience flows greater than the 0.12 ft/sec velocity tested.

    Second, since 0.12 ft/sec is an incipient tumbling velocity for shreds of fiberglass, most large and small pieces of fiberglass would actually require a larger velocity to transport. Thus, erosion of settled pieces of fiberglass would actually occur at velocities significantly larger than 0.12 ft/sec, particularly for large pieces.

    Third, there is uncertainty because the testing was likely performed in tap water, whereas higher-pH containment pool solutions could dissolve binder material and aid in the erosion process. Please provide additional justification that supports the application of the fibrous debris erosion testing results to the HNP post-LOCA conditions. In doing so, please address the three issues stated above.

11. In Table 3b.4 of the supplemental response, the licensee calculated that a total of roughly 375 square feet (ft^2) of foreign material debris would become post-LOCA debris available to collect on the strainer. Yet only 100 ft^2 of sacrificial area was allotted to accommodate this debris. The staff guidance allows the use of 75 percent of the total area to account for possible overlap of debris. Therefore, it would appear that approximately 280 ft^2 should have been subtracted from the total strainer area prior to scaling. Please provide the basis for crediting a reduction in debris transport of this magnitude.

12. Please clarify which CFD cases were used for each of the three scenarios analyzed in the debris transport discussion. In particular, the case of the reactor vessel nozzle break did not appear to be analyzed explicitly. Please justify the applicability of the analyzed CFD cases to the reactor nozzle break.

13. The Min-K-specific head loss test that incorporated the bypass eliminator mesh resulted in an unacceptable head loss (9.37 ft) and was considered non-representative of the plant because the bypass eliminator mesh was not installed in the final HNP strainer design. The licensee's supplemental response essentially concludes that the removal of the bypass eliminator mesh is solely responsible for the reduction in head loss (to 3.57 ft) observed in the subsequent head loss test that, according to the information provided by the licensee, ultimately demonstrated a very small passing margin of 0.12 ft.

    However, the staff has seen degrees of variation in head loss results on the order of feet when identical head loss tests have been repeated. The staff therefore believes that the difference between the two test results cited above, potentially due to or due in part to the presence of the bypass eliminator mesh, could also be due in part to random variation in head loss testing results.

    Please provide the basis for (1) attributing the lower head loss associated with the test without bypass eliminators solely to the removal of this mesh and (2) the position that the expected variation associated with a repeat test performed for the HNP strainer design without bypass eliminators could not exceed the small demonstrated margin available for the residual heat removal (RHR) pumps of 0.12 ft.

14. The staff has questions regarding the repeatability of the Alion testing based on the results of HNP test cases using Min-K and Microtherm [microporous insulation]. Specifically, given that Min-K and Microtherm are composed essentially of the same base materials (silicon dioxide and titanium dioxide), and given that the amounts of Min-K and Microtherm in the material-specific testing were close to the same (11.6 cubic feet (ft^3) and 12.1 ft^3, respectively), please provide a basis for why these two similar materials had significantly different head loss results in the tests with the bypass eliminator mesh installed. Although the final HNP strainer configuration does not contain a bypass eliminator mesh, this observation demonstrates the potential for a lack of repeatability in head loss test results.

15. Please provide the fibrous debris size distribution used in testing and compare it to the size distribution predicted by the transport evaluation.

16. Please provide details of the debris addition procedures used. Please include a description of fibrous concentration during debris addition and the method of adding fibrous debris to the test tank. Please provide verification that the debris introduction process did not result in non-prototypical settling or agglomeration of debris.

17. Please explain whether the stirring used to prevent debris settlement did or did not non-prototypically affect bed formation, and provide a basis for this conclusion.

18. Please provide the percentage by type of debris that settled in the test tank for each test.

19. Please provide information that shows a valid thin bed test was conducted. In doing so for the thin-bed test: (1) please verify that fibrous debris preparation and introduction would result in prototypical transport and bed formation (note that the staff considers that the most transportable debris will reach the strainer first); (2) please verify that flow conditions including any stirring used during testing would allow prototypical bed formation; (3) please verify that the installation of the debris bypass eliminator (DBE) would not change the prototypicality of bed formation on the strainer, or verify that testing was conducted with the same top hat arrangement (no DBE) installed in the plant; and (4) please verify that various incremental amounts of fiber were used in conjunction with limiting particulate debris loads during thin bed testing.

20. Please provide a basis for the use of the broad range of 2.5 to 20 micron diameter particles for Min-K and Microtherm debris during head loss testing.

21. The submittal stated that the vortexing evaluation was completed using RHR pump runout flow (4500 gallons per minute). It is not clear that containment spray (CS) flow was included in the evaluation. It is also not clear that testing or the clean strainer head loss (CSHL) calculation included the CS flow. Please provide the pump flows that were used to furnish inputs for head loss scaling and the bases for these flows. Please provide the same information for the flows used in the CSHL calculation. Please verify that these are maximum system flows and include both RHR and CS pump flows.

22. Please provide justification for neither running the high fiber and Microtherm tests (Tests 1 and 2) until a steady state was reached nor extrapolating the data to the emergency core cooling system mission time. Alternatively, please extrapolate the test data to the mission time and provide a new strainer head loss value.

23. Please identify whether any extrapolation of test data to different flow rates or temperatures lower than the test temperature was performed. If these extrapolations were conducted, please provide information that shows that the methods provided prototypical or conservative results. Please include a description of any data manipulation that was used to determine the final head loss.

24. It is not clear to the staff that the 0.12 ft of head loss discussed at the bottom of Page A1-27 of Attachment 1 to the supplemental response is equal to the clean strainer

head loss measured during testing. Please provide the clean strainer head loss measured during testing at the design flow rate.

25. Please provide a summary description and results of an evaluation of whether flashing across the strainer and debris bed could occur, including assumptions and bases for the evaluation.

26. Please describe the methodology used to compute the maximum pump flows for the RHR and CS pumps (e.g., the maximum runout flow from vendor pump curves, and a hydraulics program which calculates the flows for various system lineups).

27. Net positive suction head results were not reported for the hot leg recirculation configuration. Please describe why the hot leg recirculation configuration is bounded by the results presented in the supplemental response, or provide separate results for that configuration.

28. On page A1-46 of the supplemental response it is stated that: "Because the recirculation sump structures are not subject to the effects of pipe whip and jet impingement, the recirculation sump screens inside the sump structures are also not subject to the effects of pipe whip and jet impingement." The conclusion for the sump screens is based upon the statement regarding the sump structures.

    However, no justification or basis (e.g. separation distance, physical shielding, absence of high energy sources, etc.) is cited for the validity of the sump structure statement. Please provide a summary of the evaluations performed for dynamic effects which lead to the conclusion that neither the sump structures nor the sump screens are subject to the effects of pipe whip and jet impingement associated with high-energy line breaks.

29. The supplemental response stated that 0.6 ft^3 of fiber is required for a $1/8^{th}$ inch thin bed formation (reduced from a calculated 0.8 ft^3 for conservatism), yet only 0.33 ft^3 of fiber "long enough to be caught on the underside of the fuel assemblies" can be bypassed. Thus, the supplemental response concluded that no thin bed can form on the fuel assembly inlets. There are three main reasons for considering that this argument may be oversimplified.

    First, not all of the bypassed fiber needs to be long enough to collect on the underside of the fuel assemblies to form the debris bed. Once some fiber that is long enough to collect there arrives (in total there is enough to get roughly halfway to $1/8^{th}$ inch), additional fiber will only need to be collected on the accumulated fiber layer, through which the openings will be much smaller than the clean fuel assembly openings. Shorter fibers could then easily accumulate and make up the remainder of the thin-bed layer needed to cause head loss.

    Second, shorter fibers will also accumulate around the edges of the fuel assembly structures, even before substantial accumulation of long fibers, and facilitate the formation of the filtering fiber layer. Third, debris beds thinner than $1/8^{th}$ inch can filter particulate and cause head loss, which is particularly true in the presence of microporous insulations such as Microtherm and Min-K, as well as precipitates.

Please describe the methodology used to determine that the amount of fiber that bypasses the recirculation sump screens is 0.33 ft^3. Also, in light of the three reasons stated above, please provide additional information to address the potential for thin-bed formation at the HNP fuel assembly inlets. Specifically, please describe the criteria used to determine the minimum length fiber which would be captured at fuel assembly inlets.

30. The in vessel downstream effects section of the February 28, 2008, supplemental response states: “The potential to locally block flow at the fuel spacer grids was also considered in the AREVA evaluation; a one-inch long solid plug around the limiting fuel pin at the peak power location was postulated. It was conservatively shown that the cladding temperature at the center of the plug is 1,029 °F [degrees Fahrenheit], which is well below the 10 CFR 50.46 [Title 10 *Code of Federal Regulations*, Section 50.46] acceptance criterion of 2,200 °F.”

    The staff believes and plans to document in its final SE on the topical report, WCAP-16793-NP, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid,” that, should a licensee calculate a temperature that exceeds 800 °F, the licensee should justify through analysis of cladding strength data for oxidized or pre-hydrided cladding material, the acceptability of the higer temperature reached. Therefore, please justify the acceptability of exceeding 800 °F cladding temperature. The staff also notes that the March 28, 2008, supplemental response shows a peak fuel temperature of 395 °F. Please reconcile the difference between the peak temperatures described in the two submittals.

31. The NRC staff considers in-vessel downstream effects to be not fully addressed at HNP as well as at other PWRs. The HNP GL 2004-02 submittal refers to the draft WCAP-16793-NP. The NRC staff has not issued a final SE for WCAP-16793-NP; nor is the staff aware that satisfactory testing for a problem bed of debris at the core inlet has been performed for HNP plant conditions and fuel type. The licensee may demonstrate that in-vessel downstream effects issues are resolved for HNP by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating, without reference to WCAP-16793-NP or the staff SE, that in-vessel downstream effects have been addressed at HNP.

32. Follow up calculations on spray and sump potential hydrogen (pH) values were noted (but not provided) on page A1-59 of the supplemental response since the amount of sodium hydroxide (NaOH) that can be added is greater than what was used in the calculations of maximum sump and spray pH. The additional NaOH beyond that assumed in the pH calculations could render those calculations non-conservative. Please explain how much additional chemical precipitate is predicted by the topical report, WCAP-16530-NP, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191,” spread sheet using the higher NaOH amounts with all other input parameters constant. Also, please explain whether the amount of chemical precipitate used in the head loss testing at Alion bounded the amount that was predicted

by the WCAP-16530-NP base model with the higher NaOH amounts. If not, please discuss why the head loss test results remain conservative.

33. The licensee performed integrated head loss testing prior to the revision to WCAP-16530-NP that changed chemical precipitate settling rates. The supplemental response indicates that some of the chemical precipitate settling did not meet the minimum revised criteria in WCAP-16530-NP. Please estimate the percentage of debris and chemical precipitate that settled during testing and discuss what steps were taken to ensure the chemical precipitate added to the test was transported to the test strainer.