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

January 16, 2009

Mr. Mano Nazar
Senior Vice President, Nuclear and
Chief Nuclear Officer
Florida Power & Light Company
P.O. Box 14000
Juno Beach, Florida 33408-0420

SUBJECT: ST. LUCIE UNIT 2 - GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS," REQUEST FOR ADDITIONAL INFORMATION (TAC NO. MC4711)

Dear Mr. Nazar:

By letters dated February 27, 2008 and June 30, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080650560 and ML081840513), Florida Power & Light Company (the licensee) submitted the supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for the St. Lucie Unit 2.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the licensee's submittals. The process involved detailed review by a team of approximately 10 subject matter experts, with a focus on the review areas described in the NRC's "Revised 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 St. Lucie, Unit 2. The enclosed document describes these requests for additional information (RAIs).

The NRC requests that the licensee respond to these RAIs within 90 days of the date of this letter. However, the NRC would like to receive only one response letter for all RAIs, with the exception of RAI 34. The NRC staff considers in-vessel downstream effects to not be fully addressed at St. Lucie, Unit 2, as well as at other pressurized-water reactors (PWRs). The licensee's submittal refers to draft 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.

The licensee may demonstrate that in-vessel downstream effects issues are resolved for St. Lucie, Unit 2, by showing that the licensee's plant conditions are bounded by the final WCAP-16793 and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve RAI 34 by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects have been addressed at St. Lucie, Unit 2. The specific issues raised in RAI 34 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 RAI referenced above within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is currently developing a Regulatory Issue Summary to inform licensees 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."

Sincerely,

Siva P. Lingam

Siva P. Lingam, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-389

Enclosure: As stated

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ST. LUCIE PLANT, UNIT 2

REQUEST FOR ADDITIONAL INFORMATION

SUPPLEMENTAL RESPONSES TO GENERIC LETTER 2004-02

DATED FEBRUARY 27 AND JUNE 30, 2008

1. Provide a basis or justification for assuming a 17.0D spherical zone of influence for the FOAMGLAS® insulation.

2. For Nukon, calcium silicate, and foam glass debris, describe how the small fines category was divided into individual fines and small pieces for the head loss flume testing that was conducted for the replacement strainer and provide a technical basis that the quantity of individual fines was prototypical for plant conditions. Provide the characteristic size of the fines for each type of debris (Nukon, calcium silicate, and foam glass).

3. Describe the statistical methodology used to compute the sample mass used in the estimates of total latent debris mass.

4. Provide the accuracy of the individual sample mass measurements and the influence of the uncertainty on the total computed mass of latent debris.

5. Describe in more detail the methodology used to estimate the total area of tapes, stickers, and miscellaneous debris. Include any assumptions that would reduce the quantity of material transported to the sump screen.

6. Provide a contour plot of the velocity for the containment pool inside the bioshield wall. Provide a contour plot of the velocity in the emergency core cooling system (ECCS) trench. Provide a close-up plot of the velocity and turbulence contours in the region of the strainer and its immediate vicinity. Provide a table of the head loss test flume average velocity as a function of distance from the test strainer and identify the turbulence level simulated in the test flume.

7. Describe how the ECCS trench was modeled in the computational fluid dynamics (CFD) calculation, including the modeling of the various flows into the trench and the presence of obstacles in the trench, such as piping, tanks, Trisodium Phosphate Dodecahydrate (TSP) baskets, and other equipment.

8. Provide the general methodology used to determine the average flow to the strainer modules. In doing so, provide added detail concerning how the flow velocity in the ECCS trench approaching the modules from each side of the modules was "averaged" with the flow approaching from the shield wall openings in front of the modules. Identify the "four flow streams" discussed on page 20 of the supplemental response.

9. Provide the following additional information needed to support the assumption of 10% erosion of fibrous debris in the containment pool:

a. Demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fiberglass material present in the erosion tests to the analogous conditions applicable to St. Lucie Unit 2.

b. Identify the length of the erosion tests and how the results were extrapolated to the sump mission time.

10. Describe how the kinetic energy of the containment sprays entering the containment pool was modeled. This flow splashing down into the containment pool can have a significant impact on the velocity and turbulence distributions in the containment pool. Furthermore, the drainage from the containment sprays frequently is not uniform at the containment pool elevation (as is assumed for St. Lucie Unit 2) due to non-uniformities in the structures at higher elevations (e.g., refueling canal drains, hatch openings, gaps in curbs, etc.). Provide the justification for using a uniform spray drainage model.

11. The supplemental response states on page 14 that streamline plots were used to identify isolated eddies that had velocities higher than the incipient tumbling velocity but did not contribute to debris transport from given zones in the containment pool. Provide the basis for considering debris assumed to be present in this area at the switchover to recirculation to not transport to the strainers, considering the following points:

    a. Even in steady-state turbulent flow problems, chaotic perturbations result in variance in the solution that will alter the flow pattern in isolated eddies and allow fluid and debris elements in these eddies to escape as time or the number of computational iterations increases. Sophisticated turbulence models are expected to be necessary to accurately predict the behavior of eddies if they are credited with retention of debris. Discuss the fidelity of the turbulence model used in the computational fluid dynamics code and discuss whether the converged solution was run further and checked at various intervals after convergence was reached to demonstrate evidence of the stability of any eddies credited with debris hold up.

    b. Suspended debris and floor-transporting debris do not precisely follow streamlines of fluid flow. This phenomenon (phase slip) can be particularly significant when the streamlines exhibit significant curvature, such as in an eddy.

    c. There are significant uncertainties associated with modeling blowdown, washdown, and pool fill transport mechanisms. As a result, the initial debris distribution at switchover can vary significantly.

12. Describe the methodology and technical basis for the conclusion that 23% of the calcium silicate debris settles in the containment pool. State the size distribution of the calcium silicate that is assumed to settle in the containment pool.

13. Summarize the transport analysis methodology and results for the blowdown, washdown and pool fill up transport processes. At the onset of recirculation, where are the various types of debris assumed to be distributed, and how is this distribution modeled for the head loss tests that credit debris settling? What fractions of the debris are assumed to be trapped in inactive containment pool volumes?

14. Although the increased flow due to a low pressure safety injection (LPSI) pump appeared to have been partially accounted for in the head loss calculation, the additional flow from a containment spray system (CSS) or LPSI pump did not appear to have been incorporated into the transport analysis. Identify the containment pool height and sump flow rate assumed for the containment pool CFD calculation. If operator action during the high-stress period immediately following a loss-of-coolant accident (LOCA) is credited with terminating one CSS pump or terminating a LPSI pump that has failed to trip at switchover to sump recirculation, provide a technical basis for allowing this credit immediately after switchover to recirculation.

15. In the upstream analysis, the supplemental response states that chokepoints in the ECCS trench are not an issue because large pieces of debris will not enter this trench due to the presence of trash racks around the bioshield wall. However, the supplemental response did not address the potential for large debris to be blown into upper containment and then washed down by containment sprays outside of the bioshield wall downstream of the trash racks. Provide a basis to justify that blockage in the ECCS trench will not occur in light of the phenomenon discussed above.

16. Your submittal indicates that the TSP is stored in sixteen open baskets in the vicinity of the containment sump. Discuss the distance from the various TSP baskets to the sump strainer relative to the distance in the Alden flume from the chemical precipitate addition point to the test strainer. Given the more rapid settling characteristics for calcium phosphate precipitate, justify why the transport of calcium phosphate in the test flume is conservative relative to the plant. The staff notes that there is uncertainty concerning where calcium phosphate would form as both calcium silicate insulation fines and TSP will dissolve in the post-LOCA pool.

17. Table 3.f-1 on page 18 of the supplemental response provided CSHL values for both the strainer modules and core tubes, as well as components between the strainers and the ECCS suctions. Describe the methodology used to calculate the CSHL values for the non-strainer module and core tube components.

18. The supplemental response stated that the total strainer head loss can be calculated by adding the CSHL and debris head loss, then temperature correcting the sum of the two. Separate methodologies should be used for the temperature correction for each of these two distinct head loss components because debris bed head loss is generally laminar while CSHL is always turbulent. Describe the methodology used to arrive at the total head loss for the system at elevated temperatures. If the clean strainer and debris head loss corrections were calculated separately, describe the method for each. Provide the assumptions and bases used for this evaluation.

19. The supplemental response stated that the B train CSHL is higher than the A train CSHL and is, therefore, bounding. However, the limiting calculations are presented using the A train CSHL. It is, therefore, unclear when the A and B train CSHL results should be applied. Provide information that justifies the use of the lower A train CSHL in some calculations.

20. The supplemental response stated that the debris bed portion of head loss for the single worst case failure of a LPSI pump to trip is 0.416 ft. This is lower than debris bed head

losses at similar temperatures and lower flow rates. It is unclear how this debris bed head loss was determined. Provide the raw test results for debris bed head loss and describe the methodology used to extrapolate these results to conditions other than the test condition. Provide the relevant test conditions. Provide the assumptions and bases for the methodology used. For each extrapolated condition, provide the debris bed head loss and clean strainer head loss separately.

21. Verify that the vortex testing was conducted at prototypical or conservative flow rates and physical conditions (e.g., test flume arrangement versus plant sump geometry).

22. Provide documentation of the head loss testing methodology, including:

    a. debris introduction sequences (debris type and size distribution) including time between additions

    b. description of test facility

    c. general procedure for conducting the tests

    d. debris introduction zones

    e. fibrous debris size distribution and comparison to transport evaluation predictions showing that non-prototypical fiber sizes were not added to the test. [Note that for head loss testing and transport evaluations the categories of small fines and large pieces may not provide sufficient information to adequately predict head loss and transport effects. In general, small fines should be divided further into small pieces and fines.]

    f. particulate debris size distributions

    g. amounts of each debris type added to each test

    h. test strainer area

    i. test flow rates

    j. description of debris introduction including debris mixes and concentrations showing that non-prototypical agglomeration did not occur
    k. flow velocity profile in the flume as compared to plant flow velocities in the areas adjacent to the strainer

23. Provide the details of both the methodology and results for the thin bed search tests that were conducted. Include the incremental amounts of fibrous debris added along with the number of flume turnovers between additions.

24. Provide a graph of the head loss testing for the duration of the chemical effects test including the nonchemical portions. Include information regarding events that would be expected to affect strainer debris bed head loss such as debris addition, large flow changes, etc.

25. The supplemental response stated that credit was taken for near-field settling. Provide the estimated amount (lbm) of debris settled in the test flume.

26. The strainer submergence and vortexing evaluation included the volume of the Safety Injection Tanks (SIT) for the small-break LOCA. It is possible for some breaks that this volume would not be available for sump pool inventory. Provide a justification for the crediting of SIT volumes for sump pool level for all required breaks.

27. The supplemental response stated that the test cases were observed and photographed to ensure the absence of bore holes. However, bore holes normally cannot be detected visually. Additionally, the supplemental response stated that a thin bed did not form during testing. It is unclear from the supplemental response whether there was clean strainer area after all debris was added. In order to assure that viscosity correction is applicable to the test results, flow sweeps should have been conducted at the conditions from which extrapolations are conducted. Provide additional justification that bore holes did not occur during testing (e.g., flow sweeps were conducted with acceptable linear results). Also, if boreholes or significant clean strainer areas occurred, provide an evaluation of how these debris bed characteristics would affect the results of the extrapolation to higher fluid temperatures.

28. Provide the test data used to determine the stated exponential extrapolation to the final mission time. State what portion of the head loss data was used to perform the extrapolation. Provide any assumptions used in the evaluation and their bases. Provide sufficient data that a review of the evaluation, test termination criteria, assumptions, and bases can be conducted. Note that the most recent staff guidance (Enclosure 1 of ADAMS Accession No. ML080230112) recognizes linear extrapolation as a conservative extrapolation method.

29. Show that the head loss cases presented at 210 °F are the limiting cases for net positive suction head margin and that lower temperatures do not result in more limiting conditions.

30. Provide an evaluation of flashing across or within the strainer. If the head loss across the strainer can exceed the submergence, provide an evaluation of the physical phenomena that prevent flashing. Provide the margins available to prevent flashing.

31. On page 34, the supplemental response describes an accordion divider plate with 1/16-inch holes being installed in the suction plenum to prevent debris from transporting from one half of the strainer to the opposite suction line. This opening size is the same as the openings in the perforated plate. This strainer design is similar to independent strainers in that, for the case of a failure of a single train, much of the debris will be accumulated only on one half of the strainer surface if the limited surface area divider plate were to become blocked. Even during the design basis, non-single failure case, there will be a flow asymmetry due to one CSS train being shut down. That is, a steady-state flow across the divider plate will be present. If blockage occurs across this divider plate, the clean strainer and debris bed head losses will be greater than those calculated assuming no divider plate blockage. Based on these considerations, demonstrate either that blockage will not occur at the divider plate, or, if blockage at the

divider plate can occur, demonstrate that the current St. Lucie Unit 2 head loss testing results bound this condition. Separately, provide the surface area of the divider plate.

32. Provide technical justification in support of the assumption of "no blockage of the refueling pool canal drains." Identify the type, physical characteristics (size, shape, etc.), and amounts of debris which may be blown into the refueling cavity during a LOCA. If it is determined that drainage from the refueling cavity could be blocked, specify the volume of water held up in the cavity and state the effect on minimum containment sump pool level.

33. The NRC staff considers in-vessel downstream effects to not be fully addressed at St. Lucie Unit 2 as well as at other PWRs. Florida Power & Light Company's submittal refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." 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 St. Lucie Unit 2 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 alternatively resolve this item by demonstrating, without reference to WCAP-16793 or the staff SE, that in-vessel downstream effects have been addressed at St. Lucie Unit 2. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is 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.

34. Provide a description for the item in Table 3.g-3: "NaH_4" storage tank.

35. Provide more details concerning the plant-specific integrated head loss testing at Alden Labs including the following:

    a. A plot of the pressure drop as a function of time that also shows when debris and chemical precipitates were added to the test flume.

    b. A discussion of how the integrated head loss test results were extrapolated to 30 days.

    c. Photographs showing the strainer test section and flume after test completion.

    d. An estimate of the percentages of material that settled in the flume upstream of the test strainer.

36. State whether FOAMGLAS® insulation material, if floating in the containment pool, leaches any chemicals that need to be considered as part of the chemical effects analysis. If so, describe the chemicals leached and estimate the quantities of these chemicals as a function of time.

The licensee should report how it has addressed the in-vessel downstream effects issue and the associated RAI referenced above within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is currently developing a Regulatory Issue Summary to inform licensees 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."

Sincerely,

/ra/

Siva P. Lingam, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-389

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