From: Mozafari, Brenda
Sent: Thursday, March 04, 2010 2:04 PM
To: Frehafer, Ken; Eric.Katzman@fpl.com; john.laffrey@fpl.com
Cc: Scott, Michael
Subject: DRAFT - REQUEST FOR ADDITIONAL INFORMATION ON GL-2004-02

Eric and Ken,

By two letters to the U.S. Nuclear Regulatory Commission (NRC) both dated July 30, 2009, you (Florida Power and Light Company) submitted responses to the NRC staff's January 22, 2009, request for additional information regarding Generic Letter 2004-02 for St. Lucie Unit 1.

The NRC staff has reviewed the information provided and determined that in order to complete its evaluation, additional information is required. We would like to discuss the questions, in draft form below, with you in a conference call by the end of this month. The NRC staff would like to have a public phone conference to discuss your planned responses to each RAI by the end of April 2010.

This e-mail aims solely to prepare you and others for the proposed conference calls. It does not convey a formal NRC staff position, and it does not formally request for additional information.

To support resolution of the remaining sump performance issues identified below, we propose the following interactions:

Not later than 3/31/2010: We intend to hold a phone call to provide you an opportunity to ask clarifying questions about the attached RAIs or to show us where the information requested has already been provided, if applicable. After this call is held, we will issue the RAIs in a final docketed letter.

A public phone conference (or meeting, if you prefer) will be held by 4/30/2010, to discuss the your planned responses to each RAI. Due to the number, scope, and complexity of these RAIs, this will likely be an all-day phone conference with a lunch break.

Contact me so we can work out the schedule for the next steps.

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St Lucie Unit 1
Request for Additional Information Regarding Licensee Responses to Generic Letter 2004-02

Debris generation/Zone of Influence (ZOI)

The licensee has stated it intends to rely on testing sponsored by the Pressurized Water Reactor Owners Group (PWROG) to support reduced ZOIs for certain insulation materials. Request for additional information (RAI) 1 in the NRC staff's letter dated January 22, 2009, sought information on the PWROG-sponsored testing. In its July 30, 2009, submittal, the licensee did not provide additional information in the Debris Generation/ZOI area and did not provide a technical response to RAI 1. Since that RAI was issued, the NRC staff has provided more detailed questions to the PWROG and affected licensees regarding this testing. These questions follow, as applicable to St Lucie Unit 1, and they replace the previous RAI 1.

1. Although the ANSI/ANS standard referenced in WCAP-16851-P predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not intuitive that this would necessarily correspond to a generally conservative debris generation result. Justify the initial debris generation test temperature and pressure with respect to the plant-specific reactor coolant system (RCS) conditions, specifically the plant hot and cold leg operating conditions. If ZOI reductions are also being applied to lines connecting to the pressurizer, then also discuss the temperature and pressure conditions in these lines. Explain whether any tests were conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications. If so, provide that assessment.

2. Describe the jacketing/insulation systems used in St Lucie Unit 1 and compare those systems to the jacketing/insulation systems tested. Demonstrate that the tested jacketing/insulation system adequately represented the plant jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, etc. At a minimum, the following areas should be addressed:
   a. explain how the characteristic failure dimensions of the tested jacketing/insulation compare with the effective diameter of the jet at the axial placement of the target. The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system, e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches must be effectively impacted by the pressure for which the ZOI is calculated. Applying test results to a ZOI based on a centerline pressure for relatively low L/D nozzle to target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.
   b. Explain whether the insulation and jacketing system used in the testing was of the same general manufacture and manufacturing process as the insulation used in the plant. If not, explain what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation. For example, it is known that there were generally two very different processes used to manufacture calcium silicate whereby one type readily dissolved in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing, as well.
   c. The information provided should also include an evaluation of scaling the strength of the jacketing or encapsulation systems to the tests. For example, a latching system on a 30 inch pipe within a ZOI could be stressed much more than a latching system on a 10 inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically sized target were impacted by an undersized jet it would similarly be under-stressed. Evaluations of banding, jacketing, rivets,

screws, etc., should be made. For example, scaling the strength of the jacketing was discussed in the OPG report on calcium silicate debris generation testing.

3. There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used in the WCAP reports. Explain what steps were taken to ensure that the calculations resulted in conservative estimates of these values. Provide the inputs for these calculations and the sources of the inputs.

4. Describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle. In your description, address the following points.
   a. For WCAP-16851-P, evaluate any difference in the analysis initial temperature condition and the initial test temperature.
   b. Explain whether the water subcooling used in the analysis was that of the initial tank temperature or was it the temperature of the water in the pipe next to the rupture disk. Test data indicated that the water in the piping had cooled below that of the test tank.
   c. The break mass flow rate is a key input to the ANSI/ANS-58-2-1988 standard. Explain how the associated debris generation test mass flow rate was determined. If the experimental volumetric flow was used, explain how the mass flow was calculated from the volumetric flow given the considerations of potential two-phase flow and temperature dependent water and vapor densities. If the mass flow was analytically determined, describe the analytical method used to calculate the mass flow rate.
   d. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first tenths of a second, explain how the transient behavior was considered in the application of the ANSI/ANS-58-2-1988 standard? Specifically, explain whether the inputs to the standard represent the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second.
   e. Given the extreme initial transient behavior of the jet, justify the use of the steady state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

5. Describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard.
   a. Describe the assumed plant-specific RCS temperatures and pressures and break sizes used in the calculation. Note that the isobar volumes would be different for a hot leg break than for a cold leg break since the degrees of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard and which affects the diameter of the jet. Note that an under calculated isobar volume would result in an under calculated ZOI radius.
   b. Discuss the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant LOCA, which was used as input to the standard for calculating isobar volumes.
   c. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-2-1988 standard and that this parameter affects the pressure isobar volumes, explain what steps were taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections? Explain whether multiple break conditions were calculated to ensure a conservative specification of the ZOI radii.

6. Provide a detailed description of the test apparatus, specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system.
   a. Based on the temperature traces in the test reports it is apparent that the fluid near the nozzle was colder than the bulk test temperature. Explain how the fact that the fluid near the nozzle was colder than the bulk fluid was accounted for in the evaluations.
   b. Explain how the hydraulic resistance of the test piping which affected the test flow characteristics was evaluated with respect to a postulated plant-specific loss-of-coolant accident (LOCA) break flow where such piping flow resistance would not be present.
   c. Provide the specified rupture differential pressure of the rupture disks.

7. Discuss the potential for a shock wave resulting from the instantaneous rupture of piping, considering in particular the following points.
   a. Explain whether any analysis or parametric testing was conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions. Explain whether temperatures and pressures prototypical of PWR hot legs were considered in this analysis or testing.
   b. Explain whether the initial lower temperature of the fluid near the test nozzle was taken into consideration in the evaluation. Specifically, explain whether the damage potential was assessed as a function of the degree of subcooling in the test initial conditions.
   c. Explain the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping.
   d. Explain how the effect of a shock wave was scaled with distance for both the test nozzle and plant condition.

8. Provide the basis for concluding that a jet impact on piping insulation with a 45° seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment for which the testing is credited. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. Provide a technical basis to demonstrate that the test results for piping insulation are prototypical or conservative of the degree of damage that would occur to insulation on steam generators and other non-piping components in the containment if the testing is credited for these components.

9. Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation will have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially oriented pipe significantly beyond the distances calculated by Westinghouse. Provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative of the degree of damage that would occur to insulation on piping lines oriented axially with respect to the break location.

Debris Characteristics

10. In its January 22, 2009, letter, the NRC staff requested that the licensee state the quantity of fibrous fines generated during a loss-of-coolant accident (LOCA) and provide a technical basis for any assumptions made in this regard that are not consistent with approved regulatory guidance. The licensee responded to this request in letters dated April 22, 2009, and July 30, 2009, by indicating that fibrous fines were not explicitly considered in either the analysis or head loss testing, and that this treatment was considered to be consistent with the guidance in the NEI 04-07 guidance report and corresponding NRC staff safety evaluation (SE). However, the NRC staff does not consider the licensee's assumptions to be consistent with NEI 04-07 and the corresponding NRC staff SE in the following respects:
    - Page 3-19 of NEI 04-07 indicates that under the baseline methodology, small fines should be assumed to be individual fibers, whereas the licensee treated them as small pieces.
    - Page 59 of the SE indicates that 100% transport of small fines is expected for a baseline evaluation using a two-size-category debris size distribution. As stated above, the licensee's response indicated that fines were not explicitly considered.
    - Page 101 of the SE indicates that, when applying debris transport refinements such as computational fluid dynamics, a two-size category is inappropriate, since a portion of this group must be treated as suspended fines with complete transport
    - Although strainer testing that credits debris settlement was not proposed in NEI 04-07 nor discussed in the SE, the subsequent NRC Staff March 2008 Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing, emphasizes the importance of accurately modeling fine debris during head loss testing, particularly for tests that credit debris settlement.
    - Page 75 of the SE indicates that the acceptance of the baseline methodology was based on the methodology "taken as a whole" and "as a package." The SE further indicates that incorporating analytical refinements without, for example, appropriate changes to baseline assumptions to ensure technical consistency, could lead to an evaluation that is on balance non-conservative.

In light of the discussion above, identify the quantity of fiberglass fines that would be generated during a LOCA. Further evaluate the consequent effects of explicitly modeling fine fibrous debris with respect to transport, head loss, and other parts of the evaluation that would be affected if fine debris transport were explicitly considered, or alternately demonstrate that the existing evaluation would be bounding had a more refined debris size distribution consistent with the approved guidance been considered.

11. The January 22, 2009, NRC staff RAI requested that the licensee state the assumed size distribution and characteristics for calcium silicate debris and provide justification for any assumptions made that are not consistent with the approved guidance in NEI 04-07 and the corresponding SE. The licensee responded to this request in letters dated April 22, 2009, and July 30, 2009, by indicating that calcium silicate was assumed to be 100% small fines, and that pulverized calcium silicate was used for the strainer head loss testing. However, the licensee further indicated in the debris transport discussion that only 41% transport was calculated as the transport fraction for calcium silicate. Based on a rationale similar to that described above in RAI #10, the NRC staff considers this calculated transport percentage to be inconsistent with the approved regulatory guidance for characterization and transport of debris. Furthermore, based on the high average pressures within the 3D ZOI assumed for calcium silicate, it is not clear that an adequate basis exists to assume that the destroyed calcium silicate is not essentially 100% fines. Therefore, either (1) provide

prototypical test data to demonstrate the size distribution of calcium silicate destroyed within a 3D ZOI is consistent with the calculated 41% transport percentage, or (2) revise the debris transport licensing basis analysis such that the calculated debris transport percentage for calcium silicate reflects the assumption of 100% fine particulate.

Debris Transport

12. The January 22, 2009, NRC staff RAI requested that the licensee provide a defensible basis for the assumed transport fraction for Nukon and Thermal Wrap fibrous debris and provided specific points for the licensee to address. In response, the licensee performed a revised debris transport analysis that was described in two letters, both dated July 30, 2009. After reviewing the new information presented by the licensee regarding the revised debris transport methodology, the NRC staff has the following remaining questions:
    a. Significant credit was taken for settlement of fiberglass and calcium silicate debris; however, as noted above in RAIs in the debris characteristics area, it is not clear that the debris size distributions assumed for these debris types is appropriate in light of the settling credit assumed in the transport analysis. Therefore, identify the specific phenomena credited with preventing fiberglass debris and calcium silicate debris from reaching the sump strainers (e.g., capture in upper containment, capture in a trench during pool fill or recirculation, settlement during recirculation, etc.) and the types and quantities of debris involved. For example, complete logic trees showing the debris transport logic from the blowdown phase through the recirculation phase would provide the information requested.
    b. Justify any credit taken for debris assumed to be captured in the trench beyond the drain portal openings and provide a basis for the capture credit considering the potential for fibrous debris to float temporarily in the post-LOCA containment pool, particularly during initial pool fill. Also, clarify that the volume of debris assumed to be captured in the trench (including reflective metal) is appropriate given the volumetric capacity of the trench. For debris types for which erosion is applicable, also, clarify whether this debris was considered to be subject to erosion when captured in the trench.
    c. Demonstrate that only a negligible amount of credit was taken for debris assumed to be captured for the entire sump mission time in isolated eddies that had velocities higher than the incipient tumbling velocity. Due to a number of factors, including uncertainties associated with computational fluid dynamics (CFD) codes' simplified turbulence models (e.g., standard k-ε model), phase slip, inherent instabilities in turbulent flows, and uncertainties in the modeling of blowdown, washdown, and pool fill transport, the NRC staff believes that crediting debris capture in isolated eddies where velocities exceed the incipient tumbling velocity I likely nonconservative.
    d. Provide the basis for assuming that debris washed down from upper containment would find its way into inactive containment pool volumes. Without additional justification, this assumption appears contrary to the discussion on page 58 of the NRC staff's SE on NEI 04-07, which indicates that inactive pools would typically be filled after several minutes, whereas debris washdown would be a longer term process that would largely occur after inactive pools have filled.
    e. Provide an adequate basis to demonstrate the prototypicality or conservatism of the assumption that 92% of small fines debris in remaining in lower containment in active pools would remain inside the bioshield wall during pool fill. The approach described in the letter dated July 30, 2009, of assuming the percentage of small fines remaining inside the bioshield after pool fill equals the percentage of the total sump fluid volume that is located inside the

bioshield appears to lack a physical basis for small pieces of debris. The NRC staff expects that, in reality, due to high pool velocities and directed flow toward the annulus, there would likely be an increased potential for debris to transport into the annulus than this volume ratio approach would predict. As such, there would likely be an increase in debris transport to the strainers, which are located in the annulus, compared to what the licensee has predicted.

f. The licensee's July 30, 2009, letter states that the CFD model flow velocities are compared to the settling and incipient tumbling velocities for small debris to determine transport. Identify the transport metrics that were used and further describe how large-piece transport during recirculation was analyzed.

g. Sufficient information was not provided by the licensee to demonstrate that the flow conditions simulated in the strainer head loss test flume are prototypical or conservative with respect to the plant conditions. Therefore, provide plots of velocity and turbulence contours in the containment pool for the bounding computational fluid dynamics case(s) with respect to these two parameters that include the entire pool and which are based on the computational fluid dynamics model used in the debris transport analysis. Also, provide close-up plots of the velocity and turbulence contours in the region of the strainer and its immediate surroundings from the computational fluid dynamics model, showing the flow streams that were used to determine the flume velocities and turbulence levels for head loss testing. Identify the bounding break scenario that was used to derive the flow parameters (e.g., velocity and turbulence) that were simulated in the head loss test, identify which of the strainers is modeled in the test, and identify the flow streams that were averaged to determine the test flume velocity. Demonstrate that the velocity and turbulence values used for the strainer qualification testing are prototypical or conservative with respect to the plant condition.

h. Describe how the emergency core cooling system (ECCS) trench was modeled in the 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. Include plant-specific details and information on the minimum clearances in the plant and in the CFD calculation. Address the potential for debris pieces to block the trench flowpaths and result in increased flow velocities and debris transport along the containment pool floor.

13. The January 22, 2009, NRC staff RAI requested that the licensee provide a basis for the assumptions made concerning debris erosion in the post-LOCA containment pool. The licensee's April 22, 2009, response indicated that testing performed by Alion formed the basis for the assumed erosion value for small pieces of fiberglass of 10% over a 30-day period. The NRC staff does not consider the response adequate, but notes that Alion is currently in the process of conducting additional confirmatory testing to address NRC staff concerns with the 10% erosion value. Following the completion of the confirmatory testing, provide test results that demonstrate that 10% erosion over a 30-day period is justified for small pieces of fiberglass in the post-LOCA containment pool. In addition, the NRC staff noted that new strainer head loss testing was performed for St. Lucie 1 at Alden Laboratory using a test protocol that presumably permitted debris settlement. Identify the flow velocities applicable during the period where the debris settlement was credited, and provide justification for neglect of erosion of any debris that settled during the performance of the head loss test. Specific justification should be provided for the assumed eroded percentage if the velocities in the test flume during the transport portion of the test were in excess of the incipient tumbling velocity at which erosion testing was performed.

<u>Head Loss and Vortexing</u>

14. Justify that the debris added to the test apparatus was prepared to adequately or conservatively represent the debris predicted to arrive at the strainer by the plant transport evaluation. Specifically address the following points.
    a. Clearly define the fibrous debris size categories considered in the transport evaluation.
    b. Provide the amount of each fibrous debris size predicted to arrive at the strainer by the transport calculation.
    c. Provide the amounts of each debris type and size added to the test. Provide justification for how the surrogate categories realistically or conservatively represented the debris predicted to reach the strainer by the transport evaluation. Provide information that quantifies the sizes of the fibrous debris surrogates.
    d. Provide information that justifies that the fine fibrous debris added to the head loss testing was prepared such that it was easily suspendable.
    e. State whether fine debris was removed from the small fibrous debris prior to addition to the test flume. If the fines were removed, provide information that justifies that this action resulted in prototypical or conservative head loss testing parameters
    f. Justify that significant agglomeration of debris did not occur during its addition to the test flume.
    g. There was no surrogate for latent particulate debris included in the test debris materials list. Describe the surrogate for latent particulate debris that was added to the test or or justify not adding a surrogate for this debris source.
    h. Provide the order of debris addition to the flume including he amounts of debris added during each addition and the time of the debris additions.
    i. Provide an estimate of the amount of debris that settled in the test flume.

15. Evaluate the potential for deaeration of sump fluid as it passes through the debris bed. Compare the results of the deaeration evaluation against the guidance contained in Appendix A of Regulatory Guide 1.82, Rev. 3 to ensure that the limits in the guidance are not exceeded. If deaeration is predicted to occur at limits within the guidance, adjust the net positive suction head (NPSH) required as described in the Regulatory Guide and verify the NSPH margin.

<u>Chemical Effects</u>

16. The Alden test flume utilized by the licensee uses "tap" water, not borated water, for strainer performance testing. This is acceptable to the NRC staff since the precipitate is pre-mixed and added to the test. However, the licensee's debris mixture contains a significant amount of calcium silicate, and dissolution of calcium silicate can cause the tap water pH to increase significantly. High pH can have an affect on the precipitate used to simulate chemical effects (see "Technical Letter Report on Evaluation of WCAP Aluminum Hydroxide Surrogate Stability at Elevated pH," ML090480294). Therefore, provide the ambient temperature pH for the test flume and specify whether the pH measurement was made before or after the WCAP precipitate was added to the test.