REQUEST FOR ADDITIONAL INFORMATION

FORT CALHOUN STATION, UNIT 1

SUPPLEMENTAL RESPONSE TO GENERIC LETTER (GL) 2004-02

By letter (LIC-08-0021) dated February 29, 2008, Omaha Public Power District (OPPD) submitted a supplemental response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized Water Reactors." The staff has reviewed the information provided and determined that additional information is required in order to complete the evaluation.

1. Please describe how the assumed pipe break locations were moved systematically to ensure that the amount of debris created within zones of influence (ZOIs), which are smaller than the entire compartment, was conservative.

2. Please describe how the assumed pipe break locations were moved systematically to ensure that a conservative amount of fine debris was created based on the licensee-created sub-ZOIs used to determine the proportion of debris sizes created.

3. Please identify the source of the test data used to support the debris size distribution assumed for calcium silicate and compare the banding method, jacketing properties, and the manufacturing process for the calcium silicate debris installed at Fort Calhoun to the material used for destruction testing.

4. Please state whether there are any post-LOCA conditions within the plant design basis under which emergency operating procedures (EOPs) would either direct or allow plant operators to actuate containment sprays manually. If such conditions exist, please justify the assumption in the debris transport calculation that the containment sprays would not be operated under design-basis post-LOCA conditions.

5. Please describe how the potential for a low-pressure safety injection (LPSI) pump failing to trip was accounted for in the debris transport analysis. The increased flow rates associated with this pump would be expected to create conditions more favorable to debris transport throughout containment. Since both strainers are located in the same general area, there is a potential for higher transport fractions to both sump strainers than for the normal case in which both LPSI pumps trip following receipt of a recirculation actuation signal (RAS). Also, please state whether conditions could exist in a LOCA for which EOPs would either direct or allow plant operators to operate a LPSI pump in recirculation mode under design basis conditions (e.g., during hot leg recirculation). If such conditions exist, please justify the assumption in the debris transport calculation that a LPSI pump would not be operated under design-basis post-LOCA conditions.

6. Please state the wash down percentage that was assumed for each type of debris that was assumed to be blown into the upper containment. Please justify any deviations from the Nuclear Energy Institute (NEI) Guidance Report and/or the NRC staff Safety Evaluation methodology applicable to this evaluation.

7. Given all the uncertainties involved with condensation wash down over a 30-day period and the distribution of debris in containment following blowdown, please provide the technical basis for the assumption of 5% wash down transport for fibrous debris and coatings from upper containment (and potentially for other fine debris such as calcium silicate particulate). NUREG/CR-6762 Vols. 1 and 4 consider 5% wash down a favorable estimate for minimizing transport and consider 10% an unfavorable estimate. The estimated wash down fractions used in NUREG/CR-6762 as well as Appendix VI to the staff's SE were ultimately based on NUREG/CR-6369, which indicates that directly applicable experimental data for condensate (from steam in the containment atmosphere) drainage transport is non-existent and that the wash down fractions therein are essentially based on engineering judgment. This suggests that use of the 10% estimate might be more appropriate.

8. The supplemental response states on page 47 that 100% transport was assumed for the small-break LOCA case, and Table 17 on page 48 provides the transported latent debris masses broken down into three categories. On page 48, Table 18 indicates that 100% transport was also assumed for latent debris for the reactor vessel (RV) nozzle break, but the transported latent debris masses are twice as large as the latent debris masses in Table 17. In addition, these latent debris transport results for the small-break and RV nozzle break do not seem consistent with the supplemental response's statements that latent debris is analyzed by assuming 90% is in active pools (page 37), of which a fraction of 0.72 transports (page 73), which seems to be the basis for the large-break latent debris transport results in Tables in 15 and 16. Please clarify these apparent inconsistencies.

9. Similar to the previous question, the supplemental response states on page 47 that 100% transport was assumed for unqualified coatings for the small-break LOCA case, and Table 17 on page 48 provides the transported mass of unqualified coatings. On page 48, Table 18 indicates that 100% transport was also assumed for unqualified coatings for the RV nozzle break, but the transported debris mass for unqualified coatings is significantly higher for the RV nozzle break case than for the small-break LOCA case (22 lbm versus 215 lbm). Presumably, based on statements that all unqualified coatings that reach the sump are in the form of chips (e.g., on pages 57, 72, and 75 of the supplementary response), these failed coatings were generated outside of the pipe rupture ZOI. (In a large break LOCA case, more unqualified coatings are destroyed to particulate by the break jet, and therefore there should actually be less unqualified coatings chips failing outside of the ZOI.) Please provide the basis for the difference in the transported masses of unqualified coatings debris for the small-break and RV nozzle break cases.

10. Since the time of the two pilot audits for 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 methodology for fine debris settling. A justification for the settling of fine debris is provided on page 40 of the supplemental response, but this discussion

does not appear complete because (1) it tends to focus on velocity, whereas TKE is more closely associated with the turbulence which suspends fine debris, (2) it assumes a velocity transport metric for fines of 0.01 ft/sec, the basis for which is not clearly explained or justified, and (3) it treats all fine debris the same way, although individual fibers and 10-micron particulate would likely behave differently. Please address the four unresolved concerns above, many of which were documented in previous audit reports for licensees who used a similar methodology, to demonstrate that the credit taken for fine debris settling is technically justified.

11. On page 39 of the supplemental response, a technical basis is not provided to support the assumption of 10% erosion for small and large pieces of fibrous debris, although the response appears to suggest that the NRC accepted this assumption for Fort Calhoun during the pilot audit. However, Section 3.5.3 of the staff's pilot audit report for Fort Calhoun states that "the NRC staff concluded that sufficient justification had not been provided in the course of the pilot audit review to confirm the acceptability of the licensee's treatment of the erosion of fibrous debris." Please clarify the statement made on page 39 of the supplemental response and provide a technical basis to support the assumption of 10% erosion of fibrous debris.

12. Please provide information that demonstrates that the 15% calcium silicate erosion fraction that was based on Alion erosion testing is prototypical of the calcium silicate at Fort Calhoun. Specifically, please provide the Alion test hydraulics conditions and the duration of the Alion tests (for comparison with Fort Calhoun containment conditions), and a material properties comparison of the calcium silicate debris that was tested by Alion versus the calcium silicate installed at Fort Calhoun.

13. Please provide justification that the silicon carbide used as a coatings surrogate has transport properties prototypical or conservative with regard to the coatings debris it represents. Please verify that the mass of surrogate was adjusted to represent the proper volume of debris based on any density differences between the actual coatings debris and the surrogate. (This RAI is applicable only to early testing and only to the extent the licensee uses results of this testing in its final case to support completion of corrective actions for GL 2004-02. Later testing incorporated staff comments and thus was not subject to this concern.).

14. Please provide the physical properties of the sand used in testing and compare them to the sand that is present in containment. (This RAI is applicable only to early testing and only to the extent the licensee uses results of this testing in its final case to support completion of corrective actions for GL 2004-02. Later testing incorporated staff comments and thus was not subject to this concern.)

15. Please provide a justification for the temperature extrapolation method used for head loss test cases where bore holes were present in the debris bed. It is not clear that the bore holes which occurred at the low test temperatures would have actually occurred at the higher temperatures in the actual sump pool.

16. Please state whether the test results were extrapolated to different flow velocities. If such an extrapolation occurred, explain why any such extrapolations would be conservative or prototypical.

17. Please verify that the fibrous size distribution used during testing was prototypical or conservative compared to the size distribution predicted by the transport evaluation.

Specifically, please verify that the testing was performed with representative quantities of fine or suspended fibers. (This RAI is applicable only to early testing and only to the extent the licensee uses results of this testing in its final case to support completion of corrective actions for GL 2004-02. Later testing incorporated staff comments and thus was not subject to this concern.).

18. 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 (batching procedure). Please provide verification that the debris introduction processes did not result in non-prototypical settling of debris as clumps or agglomerations. (This RAI is applicable only to early testing and only to the extent the licensee uses results of this testing in its final case to support completion of corrective actions for GL 2004-02. Later testing incorporated staff comments and thus was not subject to this concern.)

19. The licensee's submittal describes how testing was used to determine the worst-case scenario for strainer qualification. Please justify, given the concerns reflected in other RAIs in this document about the test protocol used by the licensee, that the selection of parameters for final strainer performance testing was conservative.

20. For tests that allowed settling (no stirring), please provide a comparison of the flows predicted around the strainer in the plant and the flows present in the test flume during the testing. Please establish that the test velocities and turbulence levels were prototypical or conservative.

21. Please provide the amount (percentage by type) of debris that settled in the agitated areas of the test tanks for both fully stirred and near-field settling tests. Also please provide the same information for debris that settled in the near-field of the near-field tests.

22. Please provide the test termination criteria and the methodology by which the final head loss values were extrapolated to the emergency core cooling system (ECCS) mission time or to some predicted steady-state value. Please include enough test data that the extrapolation results can be confirmed.

23. Please verify that a small-break LOCA is the limiting break considering that the earlier Fort Calhoun testing for large-break LOCAs and for determination of the limiting break may have been conducted using test protocols that are not considered prototypical or conservative. (In this regard the staff references Waterford 3 Audit Report, ADAMS Accession No. ML080140315 as an example of inadequate testing for a General Electric strainer.)

24. Table 20 provides net positive suction head (NPSH) results for various configurations. Please provide the basis for concluding that these analyzed cases represent the bounding NPSH conditions for Fort Calhoun. The discussion should include clarification as to whether both hot-leg and cold-leg recirculation conditions were analyzed and are bounded by these results. The discussion should also clarify whether single failures were considered for the NPSH calculation other than the failure of a LPSI pump to trip. (The failure of a LPSI pump to trip does not appear to have a substantive impact with respect to the overall NPSH calculation because it does not affect the margins for pumps of the opposite train due to the independent new strainer design at Fort Calhoun.)

25. Page 71 of the GL 2004-02 Supplemental Response references Electric Power Research Institute (EPRI) report #1011753, "Design Basis Accident Testing of Pressurized Water Reactor Unqualified Original Equipment Manufacturer Coatings" dated September 2005. This report states that unqualified original equipment manufacturer (OEM) coatings will only fail as particulate debris. The supplemental response further states on page 72 that a Boiling Water Reactor Owners Group (BWROG) report titled "Failed Coatings Debris Characterization, Prepared for BWROG Containment Group Committee, ITS Services, Duke Engineering and Services" dated July 21, 1998, provides data to support treatment of unqualified OEM coatings as flakes. These references are in direct conflict. The Fort Calhoun analysis described in the GL 2004-02 Supplemental Response treated OEM coatings as chips. The NRC staff accepts the EPRI report that OEM coatings fail only as particulate and not as chips. In addition, the staff has neither reviewed nor accepted the BWROG report. Please provide justification for treating unqualified OEM coatings as chips at Fort Calhoun despite the contradictory data presented in EPRI report #1011753

26. Please provide a copy of the BWROG report cited above (BWROG report titled "Failed Coatings Debris Characterization, Prepared for BWROG Containment Group Committee, ITS Services, Duke Engineering and Services" dated July 21, 1998)

27. Please provide the mass and volume amounts of all coatings debris generated in containment for the worst-case piping break. (These values are presumably in References 1 and 2 of the GL 2004-02 Supplemental Response.) Please distinguish between values for unqualified coating debris, degraded qualified coating debris, and coating debris generated within the ZOI.

28. The Revised Content Guide for GL 2004-02 requests a summary of the design inputs, loads, and load combinations utilized for the sump strainer structural analysis. The submittal which was provided contains a pointer or reference to a GE calculation which contains this information, but none of the actual information was summarized or provided. Please provide this summary information.

29. Table 24, *Stress Summary for Welds based on Service level D Load*, shows a stress ratio of 1.01 for the Perforated Plate to Frame weld. The values specified in the table are 9722.50 psi for the Weld Stress and 9342 psi for the Allowable Stress. Utilizing this data, the stress ratio is actually calculated to be 9342 / 9722.5 = 0.96 < 1.0. Please address this apparent overstress. With regard to this apparent overstress, please justify the Allowable Stress values of Table 24 by providing the calculations used to determine these values.

30. The Revised Content Guide for GL 2004-02 requests a summary of the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks. The submittal which was provided states that, "…strainers are located in areas where there are no pipe whip loads or missile loads…." Please provide a summary of the rationales leading to this conclusion (e.g., protective barriers, the absence of missile sources, separation distance, administrative operational restrictions, etc.).

31. In response 3m, it is stated that additional testing of the high-pressure safety injection (HPSI) pump cyclone separators is required to determine if they will function properly

under LOCA sump pool conditions. Please confirm that the cyclone separators have been shown to perform satisfactorily, or that they have been replaced with cyclone separators of proven design.

32. The licensee should show that in-vessel downstream effects are resolved for Ft. Calhoun. The licensee may do this by showing that plant conditions are bounded by the final in-vessel downstream effects WCAP-16793-NP "Evaluation of Long-term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculation Fluid" and the corresponding final NRC staff Safety Evaluation (SE), including the conditions and limitations in the SE. The licensee may alternatively resolve this item by demonstrating, without reference to WCAP-16793-NP or the staff SE, that in-vessel downstream effects have been addressed for Ft. Calhoun. The staff recognizes that the licensee has made a commitment in this regard in its supplemental response.

33. In Section 3n, the licensee states that 5.59 lbm of fiber may bypass the sump strainers. This mass of fiber equates to over 2.3 ft^3 of as-manufactured fiberglass insulation. Please provide the results of an evaluation that shows whether this amount of fiber in the vessel can cause unacceptable blockage of flow to the core. Please either provide information that resolves this question, or establish that this question is bounded by the analysis of the final WCAP-16793-NP and the NRC staff Safety Evaluation on this WCAP.

34. Please provide details concerning the use of silicate inhibition of aluminum corrosion including the following: (1) which breaks credited silicate inhibition; (2) the type and amounts of plant debris assumed to provide the source of silicates; (3) the dissolved silicate concentration assumed to inhibit aluminum corrosion and the time assumed to reach that concentration for each break; (4) for cases where silicate inhibition was credited, a discussion of other breaks that produce less calcium silicate which were considered to ensure that these breaks did not produce a more challenging head loss test by having a greater amount of chemical precipitate; and (5) a description of by how much the chemical precipitate test load was reduced by silicate inhibition for the head loss tests performed.

35. Please provide details concerning how aluminum solubility was credited, including any temperature, pH, and aluminum concentration criteria that were used to credit solubility. Please discuss how solubility credit was implemented during testing and during evaluation of test results. Please provide the amount of precipitate reduction achieved by crediting solubility.

36. Please estimate the percentage of chemical precipitate that settled away from the strainer for the large break and small break LOCA tests.