February 9, 2006

Mr. Charles D. Naslund
Senior Vice President and Chief Nuclear Officer
Union Electric Company
Post Office Box 620
Fulton, MO 65251

SUBJECT: CALLAWAY PLANT, UNIT 1, REQUEST FOR ADDITIONAL INFORMATION RE: RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN-BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (TAC NO. MC4671)

Dear Mr. Naslund:

On September 13, 2004, the Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," as part of the NRC's efforts to assess the likelihood that the emergency core cooling system (ECCS) and containment spray system (CSS) pumps at domestic pressurized water reactors (PWRs) would experience a debris-induced loss of net positive suction head margin during sump recirculation. The NRC issued this GL to all PWR licensees to request that addressees (1) perform a mechanistic evaluation using an NRC-approved methodology of the potential for the adverse effects of post-accident debris blockage and operation with debris-laden fluids to impede or prevent the recirculation functions of the ECCS and CSS following all postulated accidents for which the recirculation of these systems is required, and (2) implement any plant modifications that the above evaluation identifies as being necessary to ensure system functionality. Addressees were also required to submit information specified in GL 2004-02 to the NRC in accordance with Title 10 of the *Code of Federal Regulations* Section 50.54(f). Additionally, in the GL, the NRC established a schedule for the submittal of the written responses and the completion of any corrective actions identified while complying with the requests in the GL.

By letters dated March 7 and September 1, 2005, Union Electric Company provided responses to the GL. The NRC staff is reviewing and evaluating your response along with the responses from all PWR licensees. The NRC staff has determined that responses to the questions in the enclosure to this letter are necessary in order for the staff to complete its review. Please note that the Office of Nuclear Reactor Regulation's Division of Component Integrity is still conducting its initial reviews with respect to coatings. Although some initial coatings questions are included in the enclosure to this letter, the NRC might issue an additional request for information regarding coatings issues in the near future.

Please provide your response within 60 days from the date of this letter. If you have any questions, please contact me at (301) 415-1307.

Sincerely,

**/RA/**

Jack Donohew, Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
Request for Additional Information

cc w/encl: see next page

Please provide your response within 60 days from the date of this letter. If you have any questions, please contact me at (301) 415-1307.

Sincerely,

**/RA/**
Jack Donohew, Project Manager
Plant Licensing Branch IV
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# GL 2004-02 RAI Questions

## I. Division of Component Integrity Questions

### Plant Materials

1. Identify the name and bounding quantity of each insulation material generated by a large-break loss-of-coolant accident (LBLOCA). Include the amount of these materials transported to the containment pool. State any assumptions used to provide this response.

2. Identify the amounts (i.e., surface area) of the following materials that are:

   (a) submerged in the containment pool following a loss-of-coolant accident (LOCA),

   (b) in the containment spray zone following a LOCA:

   - aluminum
   - zinc (from galvanized steel and from inorganic zinc coatings)
   - copper
   - carbon steel not coated
   - uncoated concrete

   Compare the amounts of these materials in the submerged and spray zones at your plant relative to the scaled amounts of these materials used in the Nuclear Regulatory Commission (NRC) nuclear industry jointly-sponsored Integrated Chemical Effects Tests (ICET) (e.g., 5x the amount of uncoated carbon steel assumed for the ICETs).

3. Identify the amount (surface area) and material (e.g., aluminum) for any scaffolding stored in containment. Indicate the amount, if any, that would be submerged in the containment pool following a LOCA. Clarify if scaffolding material was included in the response to Question 2.

4. Provide the type and amount of any metallic paints or non-stainless steel insulation jacketing (not included in the response to Question 2) that would be either submerged or subjected to containment spray.

### Containment Pool Chemistry

5. Provide the expected containment pool pH during the emergency core cooling system (ECCS) recirculation mission time following a LOCA at the beginning of the fuel cycle and at the end of the fuel cycle. Identify any key assumptions.

6. For the ICET environment that is the most similar to your plant conditions, compare the expected containment pool conditions to the ICET conditions for the following items: boron concentration, buffering agent concentration, and pH. Identify any other significant differences between the ICET environment and the expected plant-specific environment.

7. For a LBLOCA, provide the time until ECCS external recirculation initiation and the associated pool temperature and pool volume. Provide estimated pool temperature and

pool volume 24 hours after a LBLOCA. Identify the assumptions used for these estimates.

**Plant-Specific Chemical Effects**

8. Discuss your overall strategy to evaluate potential chemical effects including demonstrating that, with chemical effects considered, there is sufficient net positive suction head (NPSH) margin available during the ECCS mission time. Provide an estimated date with milestones for the completion of all chemical effects evaluations.

9. Identify, if applicable, any plans to remove certain materials from the containment building and/or to make a change from the existing chemicals that buffer containment pool pH following a LOCA.

10. If bench-top testing is being used to inform plant specific head loss testing, indicate how the bench-top test parameters (e.g., buffering agent concentrations, pH, materials, etc.) compare to your plant conditions. Describe your plans for addressing uncertainties related to head loss from chemical effects including, but not limited to, use of chemical surrogates, scaling of sample size and test durations. Discuss how it will be determined that allowances made for chemical effects are conservative.

**Plant Environment Specific**

11. Provide a detailed description of any testing that has been or will be performed as part of a plant-specific chemical effects assessment. Identify the vendor, if applicable, that will be performing the testing. Identify the environment (e.g., borated water at pH 9, deionized water, tap water) and test temperature for any plant-specific head loss or transport tests. Discuss how any differences between these test environments and your plant containment pool conditions could affect the behavior of chemical surrogates. Discuss the criteria that will be used to demonstrate that chemical surrogates produced for testing (e.g., head loss, flume) behave in a similar manner physically and chemically as in the ICET environment and plant containment pool environment.

12. For your plant-specific environment, provide the maximum projected head loss resulting from chemical effects (a) within the first day following a LOCA, and (b) during the entire ECCS recirculation mission time. If the response to this question will be based on testing that is either planned or in progress, provide an estimated date for providing this information to the NRC.

**ICET 1 and ICET 5 Plants**

13. (Not Applicable).

**Trisodium Phosphate (TSP) Plants**

14. Given the results from the ICET #3 tests (Agencywide Document Access and Management

System (ADAMS) Accession No. ML053040533) and NRC-sponsored head loss tests (Information Notice 2005-26 and Supplement 1), estimate the concentration of dissolved calcium that would exist in your containment pool from all containment sources (e.g., concrete and materials such as calcium silicate, Marinite™, mineral wool, kaylo) following a LBLOCA and discuss any ramifications related to the evaluation of chemical effects and downstream effects.

15. (Not Applicable).

16. (Not Applicable).

**Additional Chemical Effects Questions**

17. (Not Applicable).

18. (Not Applicable).

19. (Not Applicable).

20. (Not Applicable).

21. (Not Applicable).

22. (Not Applicable).

23. (Not Applicable).

24. (Not Applicable).

**Coatings**

Generic - All Plants

25. Describe how your coatings assessment was used to identify degraded qualified/acceptable coatings and determine the amount of debris that will result from these coatings. This should include how the assessment technique(s) demonstrates that qualified/acceptable coatings remain in compliance with plant licensing requirements for design-basis accident (DBA) performance. If current examination techniques cannot demonstrate the coatings ability to meet plant licensing requirements for DBA performance, licensee's should describe an augmented testing and inspection program that provides assurance that the qualified/acceptable coatings continue to meet DBA performance requirements or licensee's should assume all containment coatings fail and describe the potential for this debris to transport to the sump.

Plant Specific

26. Provide test methodology and data used to support a zone of influence (ZOI) of 5.0 L/D.

Provide justification regarding how the test conditions simulate or correlate to actual plant conditions and will ensure representative or conservative treatment in the amounts of coatings debris generated by the interaction of coatings and a two-phase jet. Identify all instance where the testing or specimens used deviate from actual plant conditions (i.e., irradiation of actual coatings vice samples, aging differences, etc.). Provide justification regarding how these deviations are accounted for with the test demonstrating the proposed ZOI.

27. (Not Applicable).

28. (Not Applicable).

29. (Not Applicable).

30. The NRC staff's safety evaluation (SE) addresses two distinct scenarios for formation of a fiber bed on the sump screen surface. For a thin bed case, the SE states that all coatings debris should be treated as particulate and assumes 100% transport to the sump screen. For the case in which no thin bed is formed, the staff's SE states that the coatings debris should be sized based on plant-specific analyses for debris generated from within the ZOI and from outside the ZOI, or that a default chip size equivalent to the area of the sump screen openings should be used (Section 3.4.3.6). Describe how your coatings debris characteristics are modeled to account for your plant-specific fiber bed (i.e. thin bed or no thin bed). If your analysis considers both a thin bed and a non-thin bed case, discuss the coatings debris characteristics assumed for each case. If your analysis deviates from the coatings debris characteristics described in the staff- approved methodology above, provide justification to support your assumptions.

## II. Division of Safety Systems Questions

31. You indicated that you would be evaluating downstream effects in accordance with WCAP 16406-P. The NRC is currently involved in discussions with the Westinghouse Owner's Group (WOG) to address questions/concerns regarding this WCAP on a generic basis, and some of these discussions may resolve issues related to your particular station. The following issues have the potential for generic resolution; however, if a generic resolution cannot be obtained, plant specific resolution will be required. As such, formal RAIs will not be issued on these topics at this time, but may be needed in the future. It is expected that your final evaluation response will specifically address those portions of the WCAP used, their applicability, and exceptions taken to the WCAP. For your information, topics under ongoing discussion include:

    a. Wear rates of pump-wetted materials and the effect of wear on component operation

    b. Settling of debris in low flow areas downstream of the strainer or credit for filtering leading to a change in fluid composition
    c. Volume of debris injected into the reactor vessel and core region
    d. Debris types and properties
    e. Contribution of in-vessel velocity profile to the formation of a debris bed or clog

f. Fluid and metal component temperature impact
g. Gravitational and temperature gradients
h. Debris and boron precipitation effects
i. ECCS injection paths
j. Core bypass design features
k. Radiation and chemical considerations
l. Debris adhesion to solid surfaces
m. Thermodynamic properties of coolant

14. Your response to GL 2004-02 question (d)(viii) indicated that an active strainer design will not be used, but does not mention any consideration of any other active approaches (i.e., backflushing). Was an active approach considered as a potential strategy or backup for addressing any issues?

15. In the area of break selection, the licensee performed a review of piping directly attached to the reactor coolant system (RCS) and identified LOCA boundary isolation points based upon flow and valve position. The licensee concluded that LOCA's outside of the secondary shield wall are not included within the current licensing basis, are not evaluated for debris generation, and will not lead to emergency containment sump recirculation. Please provide a description of the piping systems being addressed by this conclusion and clarify the technical basis for not considering piping outside of the secondary shield wall. Do the applicable piping systems all have isolation points (i.e., normally closed valves) within the secondary shield wall?

16. The licensee evaluated a mainsteam line break (MSLB) scenario; as such, a break may rely on ECCS sump recirculation. For postulated LOCA break locations, the licensee did not necessarily evaluate breaks at 5-foot intervals, but rather plotted the ZOI along the RCS piping to maximize major targets that fall within the perimeter of the ZOI sphere. Was this similar approach applied for the MSLB break analysis? If not, please discuss the approach taken to determine the limiting MSLB location.

17. The licensee states that for materials which have no experimentally-determined ZOI, a conservative assumption was made and the lowest available destruction pressure and ZOI were adopted (28.6 D). Please provide a listing of the materials for which this ZOI was applied and the technical reasoning for concluding this is conservative.

18. What fractions were used to quantify each of the four categories of fibrous debris discussed in the September 2005, response to GL 2004-02?

19. What fractions were used to quantify erosion for small pieces and large pieces of fibrous debris? What is the basis for the fractions assumed?

20. Has debris settling upstream of the sump strainer (i.e., the near-field effect) been credited or will it be credited in testing used to support the sizing or analytical design basis of the proposed replacement strainers? In the case that settling was credited for either of these purposes, estimate the fraction of debris that settled and describe the analyses that were performed to correlate the scaled flow conditions and any surrogate debris in the test flume

with the actual flow conditions and debris types in the plant's containment pool.

21. Are there any vents or other penetrations through the strainer control surfaces which connect the volume internal to the strainer to the containment atmosphere above the containment minimum water level? In this case, dependent upon the containment pool height and strainer and sump geometries, the presence of the vent line or penetration could prevent a water seal over the entire strainer surface from ever forming; or else this seal could be lost once the head loss across the debris bed exceeds a certain criterion, such as the submergence depth of the vent line or penetration. According to Appendix A to Regulatory Guide 1.82, Revision 3, without a water seal across the entire strainer surface, the strainer should not be considered to be "fully submerged." Therefore, the NRC staff requests that, if applicable, the licensee explain what sump strainer failure criteria are being applied for the "vented sump" scenario described above.

22. What is the basis for concluding that the refueling cavity drain(s) would not become blocked with debris? What are the potential types and characteristics of debris that could reach these drains? In particular, could large pieces of debris be blown into the upper containment by pipe breaks occurring in the lower containment, and subsequently drop into the cavity? In the case that large pieces of debris could reach the cavity, are trash racks or interceptors present to prevent drain blockage? In the case that partial/total blockage of the drains might occur, do water hold-up calculations used in the computation of NPSH margin account for the lost or held-up water resulting from debris blockage?

23. What is the minimum strainer submergence during the postulated LOCA? At the time that the re-circulation starts, most of the strainer surface is expected to be clean, and the strainer surface close to the pump suction line may experience higher fluid flow than the rest of the strainer. Has any analysis been done to evaluate the possibility of vortex formation close to the pump suction line and possible air ingestion into the ECCS pumps? In addition, has any analysis or test been performed to evaluate the possible accumulation of buoyant debris on top of the strainer, which may cause the formation of an air flow path directly through the strainer surface and reduce the effectiveness of the strainer?

24. The pool debris transport calculation assumed that the debris washed down by containment sprays would remain in the general vicinity of the washdown location until recirculation starts. Please explain how you modeled the remaining debris in the general vicinity of the washdown location.

25. The pool debris transport calculation assumed a uniform distribution of latent debris at the beginning of recirculation with the exception of latent debris that washed to the sump



strainers or inactive cavities during pool fill-up. Please explain how you accounted for the latent debris that washed to the sump strainers during pool fill-up.

26. The pool debris transport calculation assumed a uniform distribution of fine debris in the lower containment at the end of the blowdown with the exception of debris that washed

directly to the sump strainers or inactive areas.  Please explain how you accounted for the fine debris that washed directly to the sump strainers.

27. In GL 2004-02, item 2.d.iv, the NRC requested licensees to provide the basis for concluding that the water inventory required to ensure adequate ECCS or Containment Spray System (CSS) recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flowpaths.  Callaway responded that the upstream effects evaluation confirms that all water holdup areas are included in the containment minimum water level calculation, and that Callaway will confirm the accuracy of these results during site acceptance of the vendor analysis package.  Is Callaway planing to write a supplemental response to this GL?  If so, when will the NRC get the response?