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

August 27, 2009

Mr. Adam C. Heflin
Senior Vice President and
Chief Nuclear Officer
Union Electric Company
P.O. Box 620
Fulton, MO 65251

SUBJECT: CALLAWAY PLANT, UNIT 1 – REQUEST FOR ADDITIONAL INFORMATION RELATED 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. Heflin:

By letter dated February 29, 2008 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML080810491), Union Electric 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 Callaway Plant, Unit 1.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the licensee's submittal. 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 "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 that there is a reasonable assurance that GL 2004-02 has been satisfactorily addressed for Callaway Plant, Unit 1. A draft request for additional information (RAI) was sent to the licensee by e-mail on December 18, 2008. This letter documents the RAI e-mail.

The NRC requests that the licensee respond to the enclosed 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 exceptions stated below. If the licensee concludes that more than 90 days are required to respond to the RAIs, the licensee should request additional time, including a basis for why the extension is needed.

The NRC staff considers in-vessel downstream effects to not be fully addressed at Callaway Plant, Unit 1, as well as at other pressurized-water reactors. 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 Callaway, 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 17 by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects have been addressed at Callaway. The specific issues raised in RAI 17 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.

By e-mail dated July 16, 2009, your staff provided a comparison between the enclosed RAIs and those recently issued to Wolf Creek Generating Station (ADAMS Accession No. ML092030628). The Wolf Creek RAIs, though issued before the enclosed Callaway RAIs, were developed after the enclosed RAIs and reflect additional NRC staff review of certain issues pertinent to both plants. Based on a phone conversation with Mr. Thomas Elwood of your staff on July 16, 2009, we understand that you plan to address all the RAIs issued to Wolf Creek because they apply to the two plants, which are very similar. We also understand that both licensees wish to interact with the NRC staff together on the issues raised by the RAIs. Your written response should address all the enclosed RAIs as well as those for Wolf Creek. Where a given item is substantially identical in the two sets, a cross-reference from one set of responses to the other is all that is required.

As part of the written response to the additional RAIs, we request that you include a safety case. This safety case should describe, in an overall or holistic manner, how the measures credited in the Callaway licensing basis demonstrate compliance with the applicable NRC regulations as discussed in GL 2004-02 and should describe your approach to responding to the RAIs. As appropriate, the safety case may describe how the licensee reached compliance even in the presence of remaining uncertainties. The NRC staff views the safety case as informing, not replacing, responses to the RAIs.

If you have any questions, please contact me at 301-415-1476 or via e-mail at mohan.thadani@nrc.gov.

Sincerely,

Mohan Thadani

Mohan C. Thadani, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483

Enclosure:
As stated

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CALLAWAY PLANT, UNIT 1

REQUEST FOR ADDITIONAL INFORMATION

SUPPLEMENTAL RESPONSE DATED FEBRUARY 29, 2008, TO GENERIC LETTER 2004-02,

"POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION

DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

1. Please provide information that verifies that the break selection process was completed considering the reduced zones of influence (ZOIs) based on WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON Insulation, for Wolf Creek and Callaway Nuclear Operating Plants," dated October 2007, or that the originally selected breaks remain bounding from a debris generation perspective after reducing the ZOIs for Min-K and jacketed Nukon.

2. Please explain whether secondary breaks (main steam or feedwater) could require recirculation to supply containment spray. If one or more secondary breaks require recirculation for containment spray, provide information that shows whether the analysis for any loss-of-coolant accident (LOCA) bounds the secondary break(s). If secondary breaks are not bounded by LOCA analyses, please address the impact of such breaks on emergency core cooling system (ECCS) strainer performance, including the method used to determine the limiting main steam line break (MSLB) location.

3. Considering that the Callaway Plant, Unit 1 (Callaway) debris generation analysis diverged from the approved guidance in Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," please provide details on the testing conducted that justified the ZOI reductions for encapsulated Min-K and the jacketed Nukon. The information should include the jacket materials used in the testing, geometries and sizes of the targets and jet nozzle, and materials used for jackets installed in the plant. Provide information that compares the mechanical configuration and sizes of the test targets and jets, and the potential targets and two-phase jets in the plant. Evaluate how any differences in jet/target sizing and jet impingement angle affect the ability of potentially impacted insulation to resist damage from jet impingement. State whether the testing in WCAP-16710-P was bounding for the Callaway insulation systems. If not, provide information that compares the Callaway encapsulation and jacketing systems structure with the system that was used in the testing, showing that the testing conservatively or prototypically bounded potential damage to the insulation materials.

4. In the February 29, 2008, supplemental response (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML080810491), Union Electric Company (the licensee) showed that the Callaway debris generation/ZOI analysis contained three size categories of fibrous insulation debris: small fines, large pieces, and intact. However, as stated in the NRC staff's safety evaluation (SE) on NEI 04-07,

dated December 6, 2004 (ADAMS Accession No. ML043280641), in order to conduct adequate transport analysis and head loss testing, the small fines should be further broken down into fines (suspended fibers) and small pieces (less than 4 inches on a side). Using this categorization system (or justifying a different categorization), please provide additional information on the amounts of fibrous debris predicted to be generated from various breaks. Note that reduced ZOIs generally result in increased percentages of small and fine debris.

5. The licensee's February 29, 2008, supplemental response (page 12 of 81) stated that the Min-K at Callaway is located near the reactor vessel. This raises the question as to whether spherical resizing was done and whether it is appropriate for this location. The NRC staff's audit report for San Onofre Nuclear Generating Station discusses a potentially similar issue (Open Item 1 in Section 3.2, ADAMS Accession No. ML071240024) regarding Microtherm insulation that was located on the reactor vessel, for which spherical resizing was considered inappropriate by the staff due to the constraints imposed by the biological shield wall and reactor vessel. Please state whether a spherical ZOI was assumed in this region for which substantial physical obstructions could result in a significantly non-spherical destruction zone, and, if applicable, provide a technical basis for the use of a spherical ZOI.

6. The WCAP-16710-P ZOI reduction for jacketed Nukon insulation was also taken for Thermal Wrap at Callaway. Please provide information on the jacketing, banding and/or latching, and cloth cover for the Thermal Wrap insulation to provide confidence that it is comparable to the jacketing system for the Nukon insulation system that was tested.

7. The NRC staff has concerns that the size of the nozzle being used for the NUKON destruction testing at Wyle Laboratories may have resulted in non-conservatively exposing only a limited area of the target material to the peak jet pressure, particularly for the tests conducted at the smaller ZOI radii. Since a LOCA jet could be much larger than 3 inches in diameter, the testing may not be representative of an actual LOCA at close ranges where the pressures of the smaller-diameter jet used for the testing would decay significantly more rapidly in the radial direction. This potential non-prototypicality from the debris generation testing affects not only the determination of ZOI size, but also the determination of the size distribution of the debris formed within that ZOI. Appendix II to the NRC's SE for NEI 04-07 indicates that essentially all low-density fiberglass within 7 pipe diameters (7D) of a pipe rupture would become small fines. However, based on the potentially non-conservative NUKON destruction testing performed at Wyle Laboratories discussed above, for Callaway only 60 percent small fines were assumed to be generated within 5 pipe diameters (5D) of a LOCA jet, and 100 percent intact pieces were assumed to be generated between 5D and 7D of a LOCA jet. Please provide additional information to justify why the quantity of small fines debris assumed for Callaway is conservative or prototypical.

8. The NRC staff's SE for NEI 04-07 stated that a maximum of 15 percent holdup of debris should be assumed in inactive holdup regions during pool fill up. For the case of single-train sump operation for Callaway, a two-sump plant, the sump that is not operating essentially becomes an inactive holdup region. From this point of view, the staff observed that Callaway appeared to credit a 15 percent inactive holdup volume in the

containment pool, plus 14 percent holdup in the inactive recirculation sump for single-train cases, for a total of 29 percent of debris held up in inactive volumes for these single-train cases (e.g., the Loop D cross-over break). The staff considers this credit a deviation from the approved guidance in the SE, which stated that the limit for inactive hold up should be 15 percent unless a computational fluid dynamics (CFD) analysis was performed that considered the time-dependent containment pool flows during pool fill-up. Please provide additional basis for the assumed total inactive holdup fraction of 29 percent or revise this value to within the accepted SE range.

9. The licensee's February 29, 2008, supplemental response discusses Stokes' Law, but does not specifically quantify the credit taken for application of this methodology. Please state the quantities of fine debris assumed to settle onto the containment floor by applying the Stokes' Law methodology. If credit is taken for such settling, technical justification is needed regarding the following points: (1) (lack of) experimental benchmarking of analytically derived turbulent kinetic energy (TKE) metrics; (2) uncertainties in the predictive capabilities of TKE models in CFD codes, particularly at the low TKE levels necessary to suspend individual fibers and 10-micron particulate; (3) the basis for 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 basis for theoretical correlation of the terminal settling velocity to turbulent kinetic energy that underlies the Alion Science & Technology methodology for fine debris settling. Please address these points to demonstrate that the credit taken for fine debris settling is technically justified.

10. Please identify the source of the erosion testing used to justify 10 percent erosion of fiberglass in the containment pool for Callaway and specify the velocity, turbulence, and chemical conditions for which the testing is applicable, and the velocity, turbulence, and chemical conditions present in the Callaway containment pool.

11. The licensee's February 29, 2008, submittal indicated that its analyses and/or testing were substantially incomplete in the head loss and vortexing area. The NRC staff will review the remaining information when the licensee submits it and, as a result of such review, the staff could request additional information in this subject area. Among items that should be addressed are:

    a. At the beginning of recirculation for a small-break LOCA, the strainer stacks are not submerged by about 6 inches. This condition should be evaluated for vortexing, air ingestion, and failure of the strainer to pass adequate flow.

    b. The air ingestion evaluation should include an analysis of the potential for de-aeration of the sump fluid as it passes through the debris bed and strainer. If de-aeration can occur resulting in entrained air reaching the pumps' suctions, a correction to the affected pumps' $NPSH_R$ should be calculated as described in Appendix A to NRC Regulatory Guide 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," dated November 2003.

c. The Callaway strainer testing was witnessed by the NRC staff. The staff observed that significant agglomeration of debris occurred during testing. The staff also noted that the amount of fine debris predicted to reach the strainer was extremely low compared to other plant evaluations that used test methods the staff has found to be generally acceptable. Because the testing was designed to credit near-field settling, these issues could have significantly affected the results of the testing in a non-conservative manner. It was noted in the debris characteristics section of the February 29, 2008, supplemental response that the small debris contained about 30 percent fines. However, if the fines were not separated from the smalls prior to addition, it is likely that they would become entangled or agglomerated with the larger debris. This would reduce fine debris transport and the ability of the fibrous debris to create a thin bed. In fact, in PCI testing witnessed by the staff after the Callaway testing, high head losses occurred with the addition of only particulate and fine fibrous debris.

d. The February 29, 2008, supplemental response states that no containment accident pressure is credited with regard to head loss, vortexing, air ingestion, or void fraction determination. Considering the small strainer submergence for a large-break LOCA (relative to the head loss across the strainer screen) and lack of submergence for a small-break LOCA, it is not clear to the staff what pressure prevents flashing across the debris bed and strainer.

12. The licensee's February 29, 2008, submittal indicated that its analyses and/or testing were substantially incomplete in the net positive suction head (NPSH) area. The NRC staff will review the remaining information when the licensee submits it and, as a result of such review, the staff could request additional information in this subject area. Among items that should be addressed are:

a. the completed NPSH analyses with the quantitative results for the NPSH margins,

b. both cold-leg and hot-leg recirculation scenario NPSH margins for all pumps taking suction from the recirculation sump,

c. the NPSH margin values for the small- and large-break LOCAs,

d. the pump vendor's criteria for determining the NPSH required ($NPSH_R$) data for the pumps taking suction from the recirculation sump,

e. the specific methodology used for computing friction head loss in suction piping, and

f. a summary of the single-failure analysis for the NPSH calculation (single-failure scenarios considered should be identified, and NPSH margin results should be presented).

13. For degraded qualified coatings, the Keeler and Long Report report, "Design Basis Accident Testing of Coating Samples from Unit 1 Containment, TXU Comanche Peak SES," dated April 13, 2006 (ADAMS Accession No. ML070230390), and industry testing are cited as justification of epoxy chip sizes. The NRC's "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," dated November 21, 2007 (ADAMS Accession No. ML073110389), has accepted use of the Keeler and Long Report, which results in smaller chip sizes than those described in table 3h-2. Please provide justification for using chips larger than those determined in the Keeler and Long report. In addition, please summarize methods and results of the industry testing reference used to determine the size distribution of degraded qualified coatings.

14. Please describe how the quantity of curled chips is determined. In addition, please justify the simplification of the size distribution of the curled chips to a 1.5 inch chip size.

15. Please clarify the weight distribution of coating debris surrogates used in head loss testing. Please explain whether it is consistent with table 3h-2 in the submittal. If so, please explain the basis for the distribution in table 3h-2.

16. Please provide the quantities of each type of coatings surrogate material used in head loss testing.

17. The licensee's February 29, 2008, submittal indicated that its analyses and/or testing were substantially incomplete in the downstream effects, components and systems, fuel and vessel area. The NRC staff will review the remaining information when the licensee submits it and, as a result of such review, the staff could request additional information in this subject area. When submitted, please provide the information requested under item (n) in the NRC's Revised Content Guide. The NRC staff considers in-vessel downstream effects to be not fully addressed at Callaway as well as at other 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." The NRC staff has not issued a final SE for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for Callaway 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 or the staff SE that in-vessel downstream effects have been addressed at Callaway.

18. Please provide the basis that demonstrates that chemicals leaching from insulations and other containment materials that are sprayed but not submerged (i.e., located above the flood plane following a LOCA) are not significant to chemical precipitate formation.

19. Please identify and justify the assumptions related to phosphate inhibition of aluminum corrosion. For example:

    a. What is the threshold concentration of phosphate assumed to passivate aluminum?

b. What time is assumed to reach that phosphate concentration in the pool?

c. If phosphate inhibition is credited for aluminum in the spray zone, what amount of containment spray time is assumed (after the pool reaches an inhibition threshold of phosphate) before the aluminum is passivated?

the final SE. The licensee may also resolve RAI 17 by demonstrating, without reference to WCAP-16793 or the NRC staff SE, that in-vessel downstream effects have been addressed at Callaway. The specific issues raised in RAI 17 should be addressed regardless of the approach the licensee chooses to take.

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If you have any questions, please contact me at 301-415-1476 or via e-mail at mohan.thadani@nrc.gov.

Sincerely,
/RA/
Mohan C. Thadani, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-483
Enclosure:
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