April 10, 2008

MEMORANDUM TO: Michael L. Scott, Chief
Safety Issues Resolution Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

FROM: Joseph A. Golla, Project Manager ***/RA/***
Generic Communications and Power Uprate Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF JANUARY 29, 2008, TELECONFERENCE WITH WOLF CREEK NUCLEAR OPERATING CORPORATION (WCNOC), AMEREN UNION ELECTRIC COMPANY FOR CALLAWAY PLANT, AND PERFORMANCE CONTRACTING, INC. (PCI) CONCERNING CONTAINMENT SUMP HEAD LOSS TESTING

On January 29, 2008, a phone call was held with representatives of WCNOC, Ameren/UE and PCI to discuss follow up questions from a January 16–18, 2008, staff visit to Alden Research Laboratory to witness head loss testing for the Wolf Creek Generating Station and Callaway Plant. The main issues discussed were the following:

1. Staff concerns with the PCI thin bed test procedure:

    a. First, the staff considered inadequate the PCI criterion that, if the debris bed thickness during full-load testing is less than 1/8 inch, then performing thin-bed testing is not necessary. The staff had several concerns with this criterion. One concern is that a significant number of head loss tests observed by the staff at other vendors have shown that thin beds may form at thicknesses significantly less than 1/8 inch, particularly in the presence of fine fibrous debris, chemical precipitates, and microporous debris such as calcium silicate. Another concern is that, in practice, accurately determining the thickness of a debris bed on the strainer would be very challenging. Measured debris bed thickness would further need to be converted to a theoretical bed thickness for comparison to the 1/8-inch standard, which would present challenges in estimating the effects of compression and the variation in bulk density between fine fibrous debris and larger pieces that maintain the as-fabricated structure of the manufactured insulation.

    b. Second, the staff considered PCI's reliance upon observation of spikes or rapid increases in head loss to determine that thin bed formation had occurred to be incomplete. The staff has observed thin bed formation at a number of different vendors without observing head loss spikes. Furthermore, the rapidity of the head loss increase as a thin bed forms is very dependent on the test procedure, and it is

challenging to correlate the rate of head loss increase with the thin-bed thickness that provides a worst-case thin-bed head loss.

c. Third, the staff considered the addition of fibrous debris before particulate debris during one test to have non-prototypically affected the accumulation of debris on the test strainer. Because the measured head loss was so low, the test was terminated prior to the addition of the full loading of particulate and chemical precipitates. However, the staff considered it likely that if a prototypical quantity of particulate had been present in the flume while the fiber accumulated on the strainer, a more uniform debris layer would have formed leading to a higher measured head loss.

2. Staff concerns with the analytical fibrous size distribution used for the Wolf Creek/Callaway testing:

a. A fibrous debris size distribution of 90 percent small pieces, five percent fines, and five percent large pieces was used for the testing. The staff stated that a size distribution with so few fines was unexpected and appeared significantly non-conservative because the expected percentage of fines generated by a LOCA jet is normally within the range of 15–20 percent or higher for plants with reduced zones of influence (ZOIs) such as Wolf Creek/Callaway. Due to erosion of larger pieces and the increased transport of fines relative to larger pieces, the calculated percentage of fines in the fibrous debris distribution that transports to the strainer for most plants would be in the range of at least 25 percent to up to 100 percent. The licensee stated that the low fraction of fines used for the test would be compensated for by the presence of some fine debris mixed in with the larger and smaller pieces of fibrous debris. The licensee indicated that informal examination of the small-piece debris had shown that approximately 30 percent of this debris was actually in the form of fines. Based on the information presented in the phone call, the staff could not conclude that the licensee's response was adequate because of the likelihood of significant agglomeration of fines with larger debris pieces and uncertainty as to how well the pieces of debris would decompose in water. The licensee planned to discuss this issue further in the Generic Letter 2004-02 supplemental submittal. The licensee also verbally agreed to provide a movie of the fibrous debris being added to the test flume during the first test (for which no particulate had been added).

b. The staff stated that assuming 10 percent erosion for all types of fibrous debris was not adequately justified. PCI replied that some testing discussed in NRC public meetings resulted in 10 percent erosion. The staff stated that other testing performed by a different plant with different conditions used a value of 40 percent for the erosion of Nukon. The staff also stated that other types of fibrous debris may erode at faster or slower rates than Nukon. In addition, the staff did not consider the licensee's basis to be adequate for assuming erosion to occur for only large debris pieces and not to occur for small debris pieces, which is contrary to the staff's safety evaluation on NEI 04-07. Finally, the staff stated that justification was also necessary for neglecting the erosion of large and small pieces of debris that settled in the PCI test flume. Since the debris added to the test flume was assumed to transport to the strainers, an analytical allowance was not made to account for the erosion of this debris.

3. Staff concerns with the PCI procedures for debris preparation and addition to the test flume.

    a. The licensee's procedures for preparing fine fibrous debris did not appear adequate to generate individual fibers. The staff considered fines to be individual fibers or several tangled strands of fiber that tend to remain in suspension in fluid with very little turbulence. Based on visual observation of the fibrous fines prepared by the PCI procedure, the staff concluded that the fines were non-prototypically clumpy and agglomerated, which appeared to be the result of over-concentration of the fibrous slurry.

    b. The small pieces of debris prepared according to the PCI procedure did not appear capable of meeting the criterion in the staff's safety evaluation on NEI 04-07 of being capable of passing through standard floor grating. Thus, the excessive size of the small pieces of debris, which was likely due to agglomeration due to over-concentration of debris in buckets prior to addition to the test flume, tended to reduce their transportability.

4. Staff concerns that the PCI test procedure does not model head loss associated with debris transport modes other than suspension and tumbling during recirculation. Alternate modes of transport, including blowdown, washdown, pool-fill-up, and floatation, could also be significant for some plants, particularly those with a pit geometry, such as Wolf Creek/Callaway.

    a. The staff stated that large debris that may not transport via tumbling during recirculation may be transportable through the alternate transport modes discussed above.

    b. The staff stated that alternate transport modes would likely result in debris being scattered throughout the containment pool, which would result in some fraction of the post-LOCA debris entering the containment pool closer than 45 feet (the approximate distance from the strainer at which all debris was to be added for the PCI testing).

    c. The staff stated that assurance is needed for all PCI plants that non-modeled forms of debris transport would not affect the adequacy of the strainer design.

5. Staff concerns with the licensee's extrapolation methodology. PCI's proposed linear extrapolation of the head loss test results was done to the containment sump mission time based upon the number of test tank turnovers to the number of containment pool turnovers. The staff's guidance was that extrapolation should be performed on a time basis out to 30 days. PCI stated that extrapolation based on mission time accounts for the filtration of suspended debris by the strainer debris bed. However, the staff stated that there are also time-dependent effects, such as the degradation of fibrous debris in the debris bed, that are not accounted for in a turnover-based approach. (Subsequent to this phone conference, however, the staff learned that PCI planned to abandon linear extrapolation and adopt an asymptotic model using an exponential function, the justification for which is not clear to the staff.)

In addition to these main issues, several other topics were discussed:

- Regarding the effect of flume water temperature on chemical precipitate generated using the WCAP methodology, the licensee stated that additional data would be provided to the staff to demonstrate that the test temperature would have minimal effects on precipitate solubility for the Wolf Creek/Callaway plant-specific test flume pH. The NRC staff commented that other plant debris mixtures may result in different flume pH values that would need to be evaluated.

- Regarding the results of the Wolf Creek test that was completed after the staff left the test site on January 19, the licensee agreed to provide head loss data showing the incremental effect of the chemical precipitate on the measured head loss.

- Regarding the measurement of the clean strainer head loss of the Wolf Creek/Callaway test strainer, the licensee stated that the measured head losses with and without the end of the core tube blocked off were conservatively bounded by PCI's clean strainer head loss correlation. PCI further agreed to provide the measured clean strainer head loss results to the staff.

- Regarding the procedure for performing temperature extrapolation on the test results to account for the decreased viscosity of the plant containment pool with respect to the colder test fluid, the licensee stated that extrapolation would be performed on the test results. The staff questioned the licensee's basis for determining that boreholes were not present in the debris bed and stated that visual observation of the debris bed after drain down of the flume and visual observation of the head loss trace versus time are not capable of providing high confidence that boreholes are not present in the debris bed. The staff recommended other approaches for verifying that boreholes are not present, such as gradually varying the flow through the debris bed and verifying that the measured head loss responds as expected.

- Regarding the use of computational fluid dynamics (CFD) modeling near the sump strainer as an input to determine target flume velocities during head loss testing, the staff emphasized the importance of selecting representative boundary conditions for the model. The CFD model used by the licensee for determining the test flume velocities for Wolf Creek/Callaway considered only a portion of the containment pool near the strainers. The staff expressed a concern that, the boundary conditions chosen by the licensee for the localized CFD calculation in the vicinity of the sump did not capture the effects of geometric obstacles on the flow upstream of the computational domain. As a result, the boundary conditions spread the incoming flow over a greater cross-sectional area than predicted by the CFD analysis for the entire containment pool. Thus, the localized CFD model of the containment sump vicinity resulted in inlet flow entering the computational domain at a relatively low average velocity, whereas the full-containment CFD model predicted significant channeling flow at a higher velocity. Since the licensee used the lower, averaged velocities as an input for the flume head loss testing, this approach had the potential to non-conservatively reduce the quantity of debris transporting to the test strainer. The staff stated that accurate specification of boundary conditions is essential to determine prototypical flow velocities for use in flume testing.

The licensees of Wolf Creek and Callaway consider their sump screen head loss testing to be complete. The licensees stated they will provide the additional information to the staff as indicated above and will address the staff's concerns in their GL 2004-02 supplemental response letters to the NRC. The staff will review all of the information provided by the licensee and make a holistic determination as to the adequacy of the licensee's testing, analysis, and physical improvements to the plant.

Principal Contributors:
John Lehning (301) 415-1015
Steve Smith (301) 415-3150

Enclosure:
List of Participants

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DATE	03/20/2008	04/3/2008

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DATE	04/07/2008	04/10/2008

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List of Participants on January 29, 2008,
Phone Call

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Matt Brandes	Callaway
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Memorandum to Michael L. Scott from Joseph A. Golla

SUBJECT: PHONE CALL SUMMARY WITH WOLF CREEK NUCLEAR OPERATING CORPORATION AND PERFORMANCE CONTRACTING, INC. ON JANUARY 29, 2008.

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