REQUESTS FOR ADDITIONAL INFORMATION

DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSES TO GENERIC LETTER (GL) 2004-02

Debris Generation/Zone of Influence

1. a) Identify what zone of influence (pipe diameters) was determined for the new D. C. Cook Rubatex/Armaflex configuration and how it was arrived at from the referenced Wyle Labs test report data.

   b) Were there any potential break locations within this zone of influence? If so, how much debris would be generated from this source, how much would be expected to arrive at the strainers, and what would its contribution be to strainer blockage and head loss?

2. Describe the basis for determining that the results of jet testing with the 2.45 inch diameter jet were prototypical of that which could be expected from the much larger jets potentially experienced during a loss of coolant accident (LOCA)?

Debris Characteristics

3. a) Describe the scaling process used to apply the results of the debris generation testing of the Marinite, Armaflex, fire barrier tape, and other materials to the plant condition. In particular, the staff noted that the size of the nozzle (2.45 inches) used for the testing resulted in a significantly smaller jet than would be created by a large-break LOCA. As a result, large test targets may only have been exposed to the peak pressure at the jet centerline over a limited area due to the radial decay of the jet pressure. Thus, a significant area of the target material could have been exposed to much lower jet pressures than this peak pressure. This effect could be significant, not only with respect to ablation of base material by the impinging jet, but also to applying the total force necessary to rip off insulation jacketing or break insulation banding.

   b) Please describe how the radial decay of the jet pressure was accounted for in the analysis of the test results to demonstrate that the results have been prototypically or conservatively scaled to the plant condition.

4. Please identify which destruction test or tests were used as the basis for the Marinite size distribution given in Table 3c1-2 of the supplemental response.

5. Based upon discussions with manufacturers of calcium silicate, the staff understands that there were several different manufacturing processes used to make calcium silicate insulation in the U.S., and that the calcium silicate produced by the different processes may have significantly different characteristics with respect to exposure to jet impingement and erosion.

   What verification or analysis was done to ensure similarity between the calcium silicate at D. C. Cook and the material tested for both erosion and for the jet destruction testing performed by Ontario Power Generation?

Debris Transport

6. In the D. C. Cook debris transport analysis, both the total quantity of transported debris and the distribution of this transported debris to the main and remote strainers have an impact on the final system head loss.

   Please describe the basis for considering the Loop 4 break to be bounding, not only from the standpoint of transporting the greatest total amount of debris, but also from the standpoint of the degree of uniformity in the debris distribution between the main and remote strainers.

7. The debris transport analysis makes assumptions in deriving the flow and debris distributions between the main and remote strainers that appear to lack adequate basis, including the following:

   a. During pool fill up, the flow resistance on the main strainer is assumed to be negligible, even though a substantive amount of debris is assumed to accumulate there during fill up. Given the reduced water levels along with the fact that static head is the only driving force to move water through the main strainer at this time, the neglect of this flow resistance could have a non-negligible impact on the flow distribution during fill up, resulting in increased flow to the remote strainer.

   b. Ten percent of the area of the main strainer is assumed to remain clean during recirculation, even though large scale test results for D. C. Cook suggest a greater degree of flow resistance. Furthermore, a significant number of head loss tests with a variety of different strainer geometries have demonstrated the potential for debris to form a continuous bed over the entire strainer surface area rather than leaving part of the strainer area open (presuming a sufficient quantity is available). Therefore, a more representative analytical model of head loss at the main strainer during recirculation would likely result in a significantly larger flow and debris fractions arriving at the remote strainer.

   c. Water draining into the containment pool during the fill-up phase is clean. Such a condition is not realistic, and the time dependence of blowdown, washdown, and pool-fill-up transport modes is not well known and can vary significantly from one accident scenario to the next. For this reason, conservatively estimating time-dependent debris transport is very challenging.

   As a result of these observations, the staff does not consider the flow and debris distributions to the main and remote strainers (including the time-dependent transport modeling used to determine these distributions) to be adequately justified. The measured flow rates to the main and remote strainers in the large scale tank tests performed at Control Components Inc. (CCI) further provide support to the staff's view that the fraction of flow and debris transport to the main strainer were overestimated by the transport analysis. Since non-uniformity of the flow and debris loading tends to reduce the overall system head loss, this overestimate of flow and debris transport to the main strainer appears non-conservative.

   Please provide adequate justification to support the above assumptions used to support the determination of flow and debris transport to the main and remote strainers.

8. Please provide additional information concerning the erosion testing of calcium silicate insulation and Marinite board, including the following items:

   a. The basis for not accounting for erosion and dissolution effects in combination. The presence of chemicals in the test fluid may enhance the erosion rate, and, conversely, a high erosion rate may lead to increased dissolution.

   b. The basis for not including the plant buffer materials in the test fluid.

   c. The basis for using a velocity of 0.4 ft/s, since calcium silicate pieces larger than those tested (i.e., in the large piece category) would not transport at this velocity.

   d. The basis for considering the turbulence conditions prototypical or conservative, since defining a limiting condition for turbulence is difficult given that a variety of conditions may exist throughout the containment pool at different times following a LOCA.

9. Please identify the basis for the assumed calcium silicate tumbling transport velocity metrics for small pieces (0.33 ft/s) and large pieces (0.52 ft/s). NUREG/CR-6772 identifies the incipient tumbling velocity of 0.25 ft/s for small pieces of calcium silicate.

<u>Head Loss and Vortexing</u>

10. According to the submittal, the debris was added directly in front of the strainer to reduce near-field settling. The staff has found that this debris introduction method can result in non-prototypical bed formation and non-conservative head loss values during testing.

    Please provide justification that the debris introduction methods used during head loss testing resulted in prototypical or conservative head loss results.

11. The submittal stated that the fibrous debris was shredded, and then blasted with a water jet to render it into fine debris. The submittal stated that the fibrous debris was verified to be less than 10 mm in size. It is not clear that the debris was easily suspendable which is the primary consideration for fine fibrous debris. In addition, the submittal did not state the extent to which the fibrous debris was diluted. Therefore, agglomeration of debris could have occurred resulting in non-prototypical debris bed formation and non-conservative head losses.

    Please provide information that shows that the debris preparation and introduction methods used during head loss testing were conducive to prototypical debris arrival at the strainer and resulted in prototypical or conservative head loss results, or evaluate the effects of the non-prototypical debris on the head loss results.

12. Reflective metallic insulation (RMI) debris was added to the head loss tests. In pictures of the chemical testing in the multi-functional test loop (MFTL), the RMI was piled up in front of the strainer and transported into the bottom several rows of the strainer. The staff considers this non-prototypical and it could result in non-conservative head loss values. Pictures of the non-prototypical RMI debris bed can be seen in photos on pages 288-293. With the RMI present, a prototypical fiber and particulate bed could not have been created. In particular, some of the RMI was part of the earlier-transported “pool-fill” transported debris. This resulted in an RMI layer being formed between the fibers and

particulate that was added early representing pool-fill transport and that which was added later representing recirculation transport.

Please address this testing approach wherein the RMI was apparently responsible for reducing head loss but was added to the tank in a non-prototypical way.

13. During head loss testing the flow rate was started at 60% of the maximum flow. The flow rate was then increased to 80%, then to 100% along with debris additions to the same percentages. It is not clear why flow was not maintained at 100% for the entire test. Please provide the basis for increasing the flow rate during the beginning of the test and provide information that verifies that this practice did not result in non-conservative head loss results. Adding debris with the flow rate below 100% is likely non-conservative due to lower bed compression, and therefore, head loss. The following provides additional details on the staff concerns. Forming the bed at reduced flow (60% of debris added at 60% flow), as was done in the large scale extended duration head loss tests, does not appear justified unless a reduced water level is also simulated that could help model the building of the bed from the base of the strainer to its top at a higher approach velocity. The staff also questions whether the addition of 60% of the debris during fill up can be justified, and notes that this overestimates the licensee's calculations. For the large scale event sequence testing, the concern is even more substantial, with 100% of the debris being added at flows representing between 38 and 50% of the scaled plant flow rates. The staff is concerned that the time-dependence of the debris arrival sequence in the plant is not known with confidence, and adding all of the debris at less than 100% of the design flow is non-conservative, unrealistic, and ultimately leads to lower bed compression and lower debris bed head loss than a more conservative methodology that is better aligned with the expected plant behavior. The staff questions whether the time-based addition of debris for the main strainer (i.e., adding the "pool-fill" transported material first) has an adequate technical basis. It appears to be based on arbitrary transport assumptions. Debris addition in this manner may lead to a stratified bed that is non-representative of the expected plant condition. Since the water height in the test tank during the pool-fill debris addition was not prototypical, the local approach velocity during bed formation was not represented accurately until the actual plant water level reached the water level modeled in the test.

    Please address these concerns.

14. The test sequences that resulted in the maximum tested head losses for the double-ended guillotine break and debris generation break size scenarios were different. The double-ended guillotine break limiting head loss was attained by adding a homogeneous debris mixture in steps of 60%, 80%, and 100% while increasing flow in the same steps. The debris generation break size limiting head loss was attained during a sequence intended to mimic the flows that would occur through the strainer following a LOCA. There is no apparent reason that different test sequences for would result in the limiting head loss for these breaks.

    Please provide the results of the similar tests run for each flow scenario and provide an evaluation/comparison of the results.

15. During the chemical effects testing, non-chemical head losses were significantly greater than large scale non-chemical head loss testing with a similar debris mixture.

    a) Please provide an explanation for this behavior and evaluate how a higher non-chemical debris head loss could affect the calculated bump-up factor.

    b) Provide a justification that the chemical test head loss should not be applied directly to the net positive suction head evaluation.

16. Provide an evaluation of the sensitivity of overall system head loss to various debris loads split between the main and remote strainers as predicted by the transport evaluation. Because it is difficult to determine how much debris will arrive at each strainer, this is an important issue.

17. The submittal (pg 227) stated that the debris-only head loss would be considered to be 1.57 ft after being increased by 50%. It was not clear that the clean strainer head loss was included in this value.

    Please provide the total head loss including the clean strainer portion or confirm that this value includes the clean strainer head loss.

18. The head loss charts for the chemical effects testing show a large rapid increase in head loss immediately following non-chemical debris addition. The increase is followed by an immediate decrease in head loss to a significantly lower value, then a slower decrease until chemical precipitates are added (see pages 303 and 304). This behavior is unexpected.

    a) Please provide an explanation for the rapid increase and decrease in head loss that occurred during this testing.

    b) Provide justification that the chemical precipitates were added at a time such that a prototypical or conservative bump-up factor would be calculated. The staff considers that adding chemicals when baseline head loss is continuing to decrease could result in a non-conservative bump-up factor.

19. The submittal stated that the design maximum head loss is 2.8 ft for a large-break LOCA based on the available driving head of water at the recirculation sump. This limit was based on NUREG-CR-6808 guidance that head loss should not exceed ½ of the strainer height (or in this case submergence above the bottom of the strainer). A slightly lower limit for the debris generation break size was also listed. There was no limit provided for the small-break LOCA and no calculation of potential head losses associated with a small break.

    Provide justification that the strainer will maintain its function under all required scenarios including a small-break LOCA.

20. The basis for the comparison being made on page 306, that the resulting head loss for the large scale head loss on the main strainer only is 3 ft, which compares favorably to the MFTL debris only head loss of 2.67 ft is not clear.

    Please clarify this statement, which helps to undergird the bump-up factor approach.

Address in your response whether the scaling back of this head loss result based on the reduced flow rate can be justified because flow rate determination in the large scale tank was based ultimately on arbitrary assumptions made during the transport analysis. In actuality, the discrepancy in flow rate for this test indicates that too little debris was assumed to transport to the remote strainer (versus the main strainer) and that a higher flow rate would occur at the main strainer, presumably with slightly less debris. In other words, it is a non-converged solution.

Coatings Evaluation

21. In the submittal, non-original equipment manufacturer alkyds and epoxies fail as chips in accordance with Keeler and Long Report No. 06-0413. The Keeler and Long report is only applicable to degraded qualified epoxies and not unqualified epoxies or alkyds.

    Please provide additional justification for the unqualified non-original equipment manufacturer alkyd and epoxy coatings assumption to fail as chips.

22. a) Please provide the characteristics of the paint chip surrogate including the density and type of paint used.

    b) Please clarify how the paint chip surrogate simulates the expected coating debris.

Downstream – in vessel

23. Based upon the information provided in the response, it appears that the potential exists for a break location to be submerged by the water in the containment pool, potentially resulting in a flow path for unfiltered pool water to enter the reactor vessel. The centerline for the reactor inlet nozzle is at 614 ft elevation. The maximum containment pool water level is also 614 ft elevation.

    a) Please address whether the potential for debris bypass into the reactor vessel through this pathway has been analyzed.

    b) Are there any adverse debris effects from submerging other RCS break locations?

NPSH

24. The submittal stated that the minimum water level calculation included ½ of the RCS volume and the volume of the accumulators. It is not clear that these volumes should be credited for all breaks. For example a small-break LOCA could result in the accumulators remaining full for an extended period and the RCS maintaining more than ½ of its volume. In addition, the RCS would tend to refill as it cooled off. Based on these observations it is not clear that the levels used in the vortexing evaluation are conservative. It was not clear that the increasing density of RCS inventory as it cooled was considered in the sump level calculations.

    a) Please provide information that justifies that the sump pool level calculations resulted in realistic or conservative levels for the large- and small-break LOCAs.

b) Please provide the basis for concluding that there are no small breaks near the top of the pressurizer that should be analyzed for sump performance.

c) Verify that operators have the ability to cooldown and depressurize in sufficient time to prevent switchover.

d) How is a single failure accounted for in this analysis?

e) If the currently calculated minimum water levels require revision, please provide updated vortexing and air entrainment evaluations using conservative submergence values.

Chemical Effects

25. D. C. Cook uses both sodium tetraborate in the ice and sodium hydroxide in the containment spray. Tables 3o1-1 and 3o1-2 indicate that only sodium tetraborate is added to the multi-functional test loop for in-situ chemical precipitate formation in the chemical effects head loss testing.

Please provide a justification for not including sodium hydroxide in these tests.

26. Please explain why the later batches of chemicals have no apparent impact on the measured head loss. The staff is concerned that the addition of extra chemicals may not provide a significant degree of conservative if the phenomena behind why later batches of chemicals in the testing don't seem to have a noticeable impact on head loss is not understood and known to be present in the plant condition also.

VUEZ Testing

The NRC staff performed a detailed review of the test procedures used by Alion at the small loops at the VUEZ test facility in Slovakia. The staff concluded that it was unlikely that the plants relying on this testing could use it as a basis for demonstrating strainer design adequacy to resolve Generic Letter 2004-02. The staff's review did not specifically address testing performed in the larger loop at VUEZ that was used for the D. C. Cook testing. Although some similarities existed in the small-scale and larger-loop test programs, there were also some significant differences. If VUEZ testing is being used as part of the basis to demonstrate the adequacy of the D. C. Cook strainers, then please address the following requests for additional information on this testing below:

27. Please provide the following additional information concerning the modeling of debris transport for the VUEZ testing:

a. Please explain the basis for the minimum flowrate of 1 L/min to preclude stagnant regions in the test tank.

b. Please provide a basis for the statement on pages 56 and 64 of 100 of the VUEZ appendix that states that the water volume was much smaller than the actual plant condition, and therefore the turbulence and velocity in the (test) pool is higher. The relative size of the fluid volumes does not appear to the staff to be directly related to the velocity and turbulence.

Please compare the test tank flow characteristics to the velocity and turbulence contour plots for the plant condition provided in the February 2008 supplemental response.

c. Please state whether agitation or manual stirring of the tank was performed during the testing, and please describe the direction that the recirculation discharge flow entered the large tank relative to the opening of the pocket strainer.

d. Please state whether photographs were taken of the tank floor at the completion of the test and whether the quantity of debris that settled on the tank floor was estimated. What is the estimated quantity of the debris that settled? Was any of the settled debris manually pushed into the strainer pockets?

e. Please discuss how the reduced velocities used during debris bed formation affected the settling of debris in the test tank. For instance, the response (e.g., page 74 of 100) indicates that debris settled in tank, particularly prior to the initiation of full recirculation flow. What is the basis for allowing debris settlement at strainer approach velocities that are significantly less than the prototypical value?

28. Please explain how the containment spray flow for the first 25 minutes of the experiment was scaled, and the basis for the flow rate that was chosen.

29. Debris does not appear to be prepared as fines in the photograph provided in the Alion test report (pg. 66). Fiber is conservatively expected to be only individual fibers because it is all latent debris. Calcium silicate insulation at the strainer is analytically expected to be 86% fines and 14% small pieces. Similar observations can also be made for Marinite debris. These important debris sources do not appear to have been prepared per the plant-specific debris transport results.

Are there photos of the as-prepared debris slurries or close-ups of the debris during the addition process that show the form of this debris immediately prior to the addition to the tank, which would demonstrate that these debris sources were eventually prepared into a representative form?

30. Debris predominately entered the bottom row of pockets as evidenced in the photo on Page 67 of the Alion test report. The debris used for this testing should have been very nearly 100% fines (although some calcium silicate is small pieces). Although there may be some bias toward the bottom pockets during a LOCA even for fines, based on the photo, the biasing toward the bottom pockets seems much more pronounced than expected by the staff. Such significant non-uniformity can be attributed to either non-representative debris preparation or the introduction of the debris so close to the bottom strainer pockets that it approached the strainer on a non-representative flowstream into the bottom pockets nearest the debris addition line.

a) Please provide additional photos of the debris accumulation on the strainer to clarify the situation.

b) Please identify the level the water was when the debris was being added, and identify whether the water level was representative of the plant condition at that time.

31. Similar to the CCI testing, all of the debris for the VUEZ test appeared to be added during the pool-fill phase. The staff is concerned that this approach is non-conservative because of the lower velocities during the fill-up phase (2/3rds of the value during recirculation). This lower flow rate through the strainer would lead to reduced debris bed compression. Furthermore, it is not clear whether a representative water level modeling was used. The use of a non-representative water level would further reduce the velocity during bed formation and further contribute to reduced bed compression. Additionally, due to pump cavitation, the flow in the VUEZ loop had to be substantially reduced during the debris bed formation process, which resulted in a bed being formed at velocities substantially lower than even the reduced velocities during pool fill.

    a) Please address the potential for a resultant non-uniform debris distribution on the 2x2 pocket strainer module, with more debris going toward the bottom pockets as well as some piling of debris at the pocket openings rather than the formation of a thin bed.

    b) Please also address the potential for reduced debris bed compression due to non-representative test conditions that had the potential to underestimate the potential limiting head loss for the plant condition.

32. Similar to a staff observation for the small-scale VUEZ test loops, when taken in aggregate, uncertainties are not negligible on the VUEZ large scale test apparatus:

    a. Approximately 1% of volume is discarded due to sampling

    b. Approximately a 3% reduction in head loss because less calcium silicate debris was added to test than revised calculations showed.

    c. Temperature uncertainty is +/-5°F

    d. Flow measurement uncertainty is 5%

    e. Pump flow uncertainty is 5%

    How have uncertainties been accounted for in the application of the head loss results from the VUEZ testing?

33. a) Why did the head loss increase early in the head loss test to a fraction of a kPa (see figure 7.2-14) before the official start of the test?

    b) What was the reason the head loss subsequently increased fairly rapidly to 11 kPa?

34. Please identify the concentration of the debris slurry used for the VUEZ tests and the degree to which agglomeration of the debris in the slurry affected the prototypicality of the test debris.