# COMANCHE PEAK STEAM ELECTRIC STATION, UNITS 1 AND 2

## REQUEST FOR ADDITIONAL INFORMATION

## SUPPLEMENTAL RESPONSES TO GENERIC LETTER (GL) 2004-02

## DATED 02/29/2008 AND 11/26/2008

1. The Min-K at Comanche Peak Steam Electric Station, Units 1 and 2 (CPSES) is encased within stainless steel cassettes. The supplemental response stated that the cassettes are equivalent to **of Influence** Transco reflective metallic insulation (RMI), which has a spherical equivalent Zone (ZOI) of 2D listed in the approved guidance report (Nuclear Energy Institute (NEI) 04-07). The response stated that the maximum steel thickness was to be 0.125 inches. A minimum thickness was not provided. The supplemental response indicated that the cassette thickness was 0.50 inches while the Transco RMI tests used samples with thicknesses ranging between 0.024 and 0.062 inches. It is not clear that the Transco RMI destruction tests bound the Min-K cassettes. There is no direct comparison of the properties of the RMI cassettes and the Min-K cassettes. Because Min-K is known to result in high head losses, non-conservative treatment of the generation of this type of debris calls into question the overall conservatism of the licensee's evaluation.
    a. Please provide an evaluation that justifies that the Min-K cassettes are at least as structurally robust as the RMI cassettes, including any influence that the Min-K or RMI foils would have on the structure.
    b. Please address whether the testing methodology considered failure mechanisms that could apply to Min-K insulation, but may not adversely affect RMI or may not have been considered during the original RMI testing. For example, could a cassette located further than the equivalent to 2D from the break be ejected from its component, impact a nearby object, break open, and release the particulate insulation?
    c. Please state what jet impingement angles were considered in the ZOI testing.
    d. Please explain how the jet to target scaling was taken into account. Please explain whether the centerline jet pressure impacted the entire target or was only a portion of the target impacted by the predicted pressure. Having the target too close to the nozzle could result in a significantly non-conservative test.

2. CPSES uses lead blankets with fiberglass covers for shielding within containment. The blankets were tested by Westinghouse to determine an appropriate ZOI for destruction and size distribution. The testing estimated the amount of lead fibers and the amount of fiberglass covering that would be damaged within various ZOIs. Because the lead would likely not transport, it will not be addressed further by the staff. However, the fiberglass cover could potentially contribute to debris loading on the strainer. ZOI testing for CPSES was conducted by Westinghouse and documented in report WCAP-16727-NP. The staff has reviewed a similar Westinghouse report, WCAP-16710, and has reason to believe that similar test practices were used for both reports. CPSES should address the following questions regarding prototypicality of the WCAP-16710 testing, or explain why these questions are not applicable to CPSES. Alternatively, the licensee may choose to demonstrate that the absence of credit taken based on WCAP-16727 would not significantly

impact the debris source term. Establishing the validity of the ZOI assumptions is very important to the validity of the overall approach to determining head loss since the amount of debris assumed to be generated is very sensitive to the assumed ZOI.

a) Although the American National Standards Institute (ANSI)/American Nuclear Society (ANS) standard predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not intuitive that this would necessarily correspond to a generally conservative debris generation result. Please justify the initial debris generation test temperature and pressure with respect to the plant-specific reactor coolant system conditions, specifically the plant hot and cold leg operating conditions. If ZOI reductions are also being applied to lines connected to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Please explain whether any tests were conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications. If so, provide that assessment.

b) Please describe the jacketing systems used in the plant for which the testing was conducted and compare those systems to the jacketing/insulation systems tested. Please justify whether the tested jacketing system adequately represented the plant jacketing system. The description should include differences in the jacketing, banding, and attachment systems used for piping and other components for which the test results are applied. At a minimum, the following areas should be addressed:
   a. How did the characteristic failure dimensions of the tested jacketing compare with the effective size of the jet at the axial placement of the target? The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system, e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches should be effectively impacted by the pressure for which the ZOI is calculated. Applying test results to a ZOI based on a centerline pressure for relatively low nozzle-to-target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.
   b. Was the jacketing system used in the testing of the same general manufacture and manufacturing process as the insulation used in the plant? If not, what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation? For example, it is known that generally two very different processes were used to manufacture calcium silicate insulation whereby one type readily dissolves in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing as well.
   c. The information provided should also include an evaluation of scaling the strength of the jacketing system to the tests. For example, a latching system on a 30-inch pipe within a ZOI could be stressed much more than a latching system on a 10-inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically-sized target were impacted by an undersized jet it would similarly be under-stressed. Evaluations of banding, jacketing, rivets, screws, straps, etc., should be made. For example, scaling the strength of the jacketing was discussed in the Ontario Power Generation report on calcium silicate debris generation testing.

d. The testing discussed open- and closed-back tests. How did this compare to plant conditions, which testing was used for the CPSES evaluation, and how did this compare to the plant? For example, blowing pieces of debris through an open area in the test condition will not result in further debris fragmentation, whereas blowing debris through a congested containment could easily result in increased fragmentation.

e. If the restraints in the test condition were weaker than the plant condition, the test characterization would be non-conservative for the plant condition. The test debris would be blown away from the high-pressure region of the jet in larger (or intact) pieces, whereas the plant material would be held in the high-pressure region of the jet for a longer period of time by the stronger restraints and consequently be fragmented to a greater degree. This non-prototypicality appears to be the case based on the licensee's statement that the plant material is more securely attached than the test material. Please justify the conservatism of the restraints in the test condition.

c) There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used in the WCAP reports. Please explain what steps were taken to ensure that the calculations resulted in conservative estimates of these values. Please provide the inputs for these calculations and the sources of the inputs.

d) Please describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle. Please include discussion of the following points.

   i. In WCAP-16710-P, the analysis was based on the initial condition of 530$^{o}$F whereas the initial test temperature was specified as 550$^{o}$F. Was this similar for the WCAP-16727 testing? If so, please evaluate the discrepancy.
   ii. Please explain whether the water subcooling used in the analysis that of the initial tank temperature or whether it was it the temperature of the water in the pipe next to the rupture disk. Test data indicated that the water in the piping had cooled below that of the test tank.
   iii. The break mass flow rate is a key input to the ANSI/ANS-58-2-1988 standard. Please explain how the associated debris generation test mass flow rate was determined. If the experimental volumetric flow was used, then please explain how the mass flow was calculated from the volumetric flow, given the considerations of potential two-phase flow and temperature-dependent water and vapor densities. If the mass flow was analytically determined, then please describe the analytical method used to calculate the mass flow rate.
   iv. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first tenths of a second, please explain how the transient behavior was considered in the application of the ANSI/ANS-58-2-1988 standard. Specifically, did the inputs to the standard represent the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second?
   v. Given the extreme initial transient behavior of the jet, please justify the use of the steady-state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

e) Please describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard. Please include discussion of the following points.

i. What were the assumed plant-specific reactor coolant system temperatures and pressures and break sizes used in the calculation? Note that the isobar volumes would be different for a hot leg break than for a cold leg break since the degrees of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard. This affects the diameter of the jet. Note that an under-calculated isobar volume would result in an under-calculated ZOI radius.
ii. Please explain the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant LOCA, which was used as input to the standard for calculating isobar volumes.
iii. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-2-1988 standard and that this parameter affects the pressure isobar volumes, please explain what steps were taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections. Were multiple break conditions calculated to ensure a conservative specification of the ZOI radii?

f) Please describe the test apparatus, specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system. Please also address the following points.
   i. Based on the temperature traces in the reviewed test reports, it is apparent that the fluid near the nozzle was colder than the bulk test temperature. How was the fact that the fluid near the nozzle was colder than the bulk fluid accounted for in the evaluations?
   ii. How was the hydraulic resistance of the test piping which affected the test flow characteristics evaluated with respect to a postulated plant-specific loss of coolant accident (LOCA) break flow where such piping flow resistance would not be present?
   iii. What was the specified rupture differential pressure of the rupture disks?

g) WCAP-16710-P discusses the shock wave resulting from the instantaneous rupture of piping. Please discuss the following as they apply to the WCAP-16727 testing.
   i. Was any analysis or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions? Were temperatures and pressures prototypical of pressurized water reactor hot legs considered?
   ii. Was the initial lower temperature of the fluid near the test nozzle taken into consideration in the evaluation? Specifically, was the damage potential assessed as a function of the degree of subcooling in the test initial conditions?
   iii. What is the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping?
   iv. How is the effect of a shock wave scaled with distance for both the test nozzle and plant condition?

h) Please provide the basis for concluding that a jet impact on the tested geometric configuration is conservative with respect to potential installations within the plant. Please justify whether all banding mechanisms of lead blankets used in the plant provide the same measure of protection against a LOCA jet as those of the configuration that was tested.

i) Please provide the expected characteristics of the lead blanket cover fines and provide information that shows that the debris was prepared such that the surrogate characteristics were in accordance with the expectation of the post-accident behavior of these materials. It was stated that the debris surrogate was a fiber cover run through a leaf shredder. What were the resulting debris characteristics? The other fine fibrous debris was stated to be further shredded after putting it through a leaf shredder.

3. The November 26, 2008, supplemental response identifies that an average particle size for Min-K of 29.8 microns was assumed. This particle size was based in part on measurements with a scanning electron microscope. Based on information from U.S. Nuclear Regulatory Commission (NRC) audits of other licensees and a review of the Min-K material safety data sheets, the staff understands that the 0.1-micron distance (taken as the characteristic size for Min-K in NEI 04-07) referred to by the licensee as an air space between adjacent particles is actually the size of elementary particles of titanium dioxide. Similarly, elementary particles of fumed silica could be in the range of < 5 μm, based on information from previous reviews. It is not clear that the sample of Min-K taken by the licensee is representative of Min-K debris after being destroyed by a LOCA jet, particularly given that the 2D ZOI will lead to stagnation pressures of approximately 114 psig. Please justify whether the material for which the licensee made a scanning electron microscope observation is representative of Min-K destroyed by a LOCA jet of 114 psig.

4. From page 68 of the November 26, 2008, supplemental response, it appeared that some miscellaneous debris materials were found to delaminate or be reduced to fibrous pulp after being boiled, and that these materials were subsequently excluded from head loss testing on that basis. Please provide an adequate basis for excluding this material from the head loss testing, considering the following information:
   a. Post-LOCA conditions may exist for which the containment pool will not reach (atmospheric) boiling temperatures. Even if the containment pool were to reach or exceed 212 °F, Section 3.5.2.3 of the safety evaluation (SE) on NEI 04-07 indicates that labels and miscellaneous materials that could degrade under post-LOCA conditions should be modeled as debris in their degraded form (e.g., using an equivalent mass of latent fiber to model labels that fail to a fibrous form), rather than excluded from head loss testing due to degradation.
   b. Please clarify whether the material excluded from head loss testing based upon its degradation under boiling conditions was accounted for through the allocation of an appropriate strainer sacrificial surface area.

5. During the staff evaluation of the sacrificial area determination and miscellaneous debris treatment, inconsistencies and uncertainties were identified with regard to the categorization criteria, assumptions and treatment in testing/analysis of miscellaneous debris (labels/tags). These estimates and assumptions play a role in the sacrificial area determination and final strainer debris load. As described in section 3.b.3, Labels and Tags, of the November 26, 2008, supplemental response, three classifications for labels were selected: Acceptable Labels, Qualified Labels, and Unacceptable Labels. Please provide the quantity of each label type present in the CPSES containments. In addition please discuss the final treatment of each label category with regard to head loss testing and emergency core cooling system strainer debris load. Please clarify the methodology used to estimate the sacrificial screen area and how this area was utilized in relation to head loss testing/net positive suction head analysis.

6. Please describe the testing performed to support the assumption of 10% erosion of fibrous debris pieces in the containment pool. Please specifically include the following information:
   a. Please describe the test facility used and demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fibrous material present in the erosion tests to the analogous conditions applicable to the plant condition.
   b. Please provide specific justification for any erosion tests conducted at a minimum tumbling velocity if debris settling was credited in the test flume for velocities in excess of this value.
   c. Please identify the duration of the erosion tests and how the results were extrapolated to the sump mission time.

7. The November 26, 2008, supplemental response indicates on page 43 that some of the debris assumed to be blown to upper containment is not assumed to be washed down subsequently. Please provide the following additional information as a basis for this assumption:
   a. Please identify the types of debris and debris sizes for which retention credit was taken and quantify the credit taken.
   b. Please describe the extent and continuity of the grating where debris capture is credited, and provide a percentage of the cross-sectional area below these breaks where grating is installed.
   c. Please provide adequate basis to justify any credit for small pieces of debris being held up on grating. The Drywell Debris Transport Study cited by the supplemental response considered the retention of small fibrous debris pieces on gratings in upper containment and recommended that no retention credit should be allowed for debris fragments that are smaller than openings in floor grating.

8. The November 26, 2008, supplemental response indicates that a significant percentage of small pieces of fiberglass were assumed to transport to the strainers (i.e., 78%). In addition, 16–17% of large fibrous debris pieces were assumed to transport as well. These analytical assumptions minimized the quantity of settled small and large pieces of fiberglass that were analytically assumed to erode in the containment pool. However, for the strainer head loss testing conducted by Performance Contracting Inc. (PCI), the staff considers it likely that a significant fraction of small pieces that were analytically considered transportable actually settled in the test flume rather than transporting to the test strainer. This issue is exacerbated by the fact that the licensee's head loss testing modeled the 1-foot-high debris interceptor in front of the strainer, whereas the debris transport calculation did not credit this interceptor, over which very few fiberglass pieces would be capable of transporting. The head loss testing did not model the erosion of this debris that was analytically assumed to have transported. The licensee's consideration of debris erosion, therefore, appears to be non-conservative, because neither the analysis nor the head loss testing accounted for the erosion of debris that settled during the head loss testing. Please estimate the quantity of eroded fines from small and large pieces of fiberglass debris that would result had erosion of the settled debris in the head loss test flume been accounted for and justify the neglect of this material in the head loss testing program.

9. No discussion of transport of small or large pieces of debris was provided for the pool-fill phase of the event. The staff expects that velocities in some parts of typical

pressurized water reactor containment pools could significantly exceed the transport metric for debris in these categories during the pool-fill phase of transport. Flow conditions during the pool-fill phase of the LOCA were not considered by the head loss testing, nor was the potential for some types of debris to enter a non-quiescent containment pool closer than one flume-length away from the strainer due to the effects of blowdown, washdown, and pool-fill transport. The lack of modeling of these transport aspects of the head loss testing may result in a non-prototypical reduction in the quantity of debris reaching the test strainer. Please provide the technical basis for not explicitly modeling transport modes other than recirculation transport, considering the following points:

a. As shown in Appendix III of the staff's SE on NEI 04-07, containment pool velocity and turbulence values during pool fill up may exceed those during recirculation, due to the shallowness of the pool.
b. The pool-fill phase will tend to move debris from inside the secondary shield wall into the outer annulus away from the break location and nearer to the recirculation sump strainers.
c. Representatively modeling the washdown of some fraction of the debris nearer the strainer than one flume-length away would be expected to increase the quantity of debris transported to the strainer and measured head loss.

10. Sufficient information was not provided in the supplemental responses dated February 29, 2008, and November 26, 2008, to provide assurance that the flow conditions simulated in the strainer head loss test flume are prototypical or conservative with respect to the plant conditions. Therefore, please provide plots of velocity and turbulence contours in the containment pool for the bounding computational fluid dynamics cases with respect to these two parameters that include the entire pool and which are based on the computational fluid dynamics model used in the debris transport analysis. Please also provide close-up plots of the velocity and turbulence contours (which include a numerical scale with units) in the region of the strainer and its immediate surroundings from the computational fluid dynamics model that was used to determine the flume velocities and turbulence levels for head loss testing. Please identify the bounding break scenario that was used to derive the flow parameters (e.g., velocity and turbulence) that were simulated in the head loss test and identify which of the strainers is modeled in the test.

11. Please discuss any sources of drainage that enter the containment pool near the containment sump strainers (i.e., within the range of distances modeled in the head loss test flume, e.g., 27 ft based on page 62 of the November 26, 2008, supplemental response or 22 ft based on Attachment D to that response, page 7 of 95). Please identify whether the drainage would occur in a dispersed form (e.g., droplets) or a concentrated form (e.g., streams of water running off of surfaces, drain lines, etc.). Please discuss how these sources of drainage are modeled in the test flume to create a prototypical level of turbulence in the test flume. Please discuss how the narrowness of the test flume (roughly four inches at its minimum) affected the level of turbulence generated in the test flume versus the plant condition that typically has much wider flow channels.

12. Please identify the phenomenon or phenomena responsible for the removal of 20% of the latent debris that was assumed not to reach the recirculation sump strainers. If debris settling based on Stokes' Law was credited, please provide justification. If

more than 15% of the latent debris was assumed to be held up in inactive pool volumes, please provide justification.

13. Based on page 63 of the November 26, 2008, supplemental response, it appears that the recent testing using the revised PCI protocol was performed with a static water depth of 4.17 ft. Please describe any testing performed with the revised PCI test protocol in 2008 or later that includes modeling of the transient containment water level or small-break LOCA water level conditions.

14. On page 68 of the November 26, 2008, supplemental response, in a number of areas, statements are made to the effect that, because certain types of debris were shown not to transport at fluid velocities of [x] ft/s, they were removed from testing. In all of the cases, the values of x stated are less than or of the same order as the flume velocities listed on page 63 of the same supplemental response. Please justify these statements. For example, given that the flume velocities are in the range of 0.41–0.62 ft/s, it does not logically follow that debris shown not to transport at 0.1 or 0.2 ft/s should be excluded from the testing. The staff expects that transport testing be conducted at velocity and turbulence conditions that are prototypical or conservative with respect to the plant condition.

15. Please provide a basis to add the majority of the latent fiber to Test 4 prior to the starting of the test pump. It appeared that approximately two-thirds of the latent fiber was added in this manner with no flow in the flume. This step was not a part of the version of the revised PCI protocol that had been reviewed by the staff. Such a quiescent condition does not appear consistent with the expected flow conditions in the containment pool during washdown and pool-fill, as evidenced by the volunteer plant study in Appendix III to the SE. The licensee stated that test 4 was the only test for which this practice was done; however, it was the design-basis strainer head loss test, so it is the only test that is significant for the strainer head loss measurement.

16. Please justify including a sharp turn directly before the strainer in the head loss flume. This sharp turn may have assisted in the removal of debris and in the creation of a non-uniform bed on the test strainer. Please explain how this sharp change in flow direction is prototypical of the plant. Please explain how the debris diverter was modeled in the computational fluid dynamics simulations. The computational fluid dynamics simulations for the plant condition appear to show velocities significantly higher than 0.1 ft/s near a good part of the strainer surface. Furthermore, the computational fluid dynamics simulations also show that flow does approach the strainers directly over a significant part of their surface area, and that such a sharp change in flow direction directly in front of the strainer is not representative of the velocity vectors approaching the plant strainers.

17. From the pictures of the new strainer installation in Appendix A to the November 26, 2008, supplemental response, it is not clear to the staff where the debris interceptor credited in the head loss testing is located. Please state where the interceptor is located, identify whether it surrounds the entire strainer for both sumps, and provide photographs showing its location.

18. Page 63 of the November 26, 2008, supplemental response provides a table of the velocities in the PCI test flume for the recent testing with the revised protocol, which

indicates that the velocities in the test flume ranged from approximately 0.47 to 0.62 ft/s. However, page 7 of Appendix D to that response indicates that the maximum flume velocity was 0.5 ft/s (for clean strainer testing). Please explain this apparent discrepancy.

19. Floating debris (e.g., duct tape, bumper sticker material, and radiation tape) was excluded from the strainer head loss evaluation. Please address the following points concerning debris floatation:
    a. Please provide information that justifies that debris that floats cannot transport to the strainer and occlude portions of the strainer area, considering that recirculation begins prior to the strainer being fully submerged. In some cases, the strainer has a large portion of its surface area above the flood level when the switchover to recirculation occurs. The supplemental response indicates that a transient large-break LOCA case was tested and verified to be acceptable; however, this test was performed to an earlier PCI protocol that the staff considers non-prototypical. Furthermore, the test case did not examine long-term operation of the strainers at reduced water levels representative of a small-break LOCA.
    b. The November 26, 2008, supplemental response states on page 42 that Alion performed testing of miscellaneous debris including tape, labels, and coatings. Please describe whether the potential for transport via floatation was examined in this series of tests.

20. Please address the following items concerning the addition of large pieces of fibrous debris to the head loss tests, particularly the design-basis head loss test (Test 4).
    a. Considering the presence of a 1-foot high interceptor, it appears to the staff unlikely that large debris pieces would have been capable of climbing over such an obstruction. Examination of the transported debris in sensitivity tests or earlier head loss tests that used large pieces would have allowed this hypothesis to be verified. Please state the basis for considering the transport of large pieces to be credible under the test flume conditions with the 1-foot debris interceptor and identify whether transport of large pieces was observed during head loss tests or transport sensitivity tests that were performed with the interceptor installed.
    b. In addition, it is unclear to the staff how transport of large pieces could have been prototypically modeled in a flume having a width of the same order as typical large debris pieces. Please identify the distribution of sizes of the large pieces of debris added to the test flume and state whether any of the pieces became stuck in the narrow test flume due to non-prototypical interactions with the flume walls
    c. In light of the observations above, please identify whether the addition of large debris pieces under such conditions resulted in a non-prototypical means of filtering out chemical precipitate subsequently added to the head loss test

21. Please state whether the sump is vented to the containment above the minimum water level at which the strainer becomes submerged. If it is, please evaluate failure modes such a condition potentially introduces.

22. The vortexing, air ingestion, and void fraction evaluations were not performed at the minimum containment flood level. The potential for a partially submerged strainer was not fully addressed. Please provide information that shows that the strainer will

perform adequately with respect to vortexing, air ingestion, and void fraction at the most limiting submergence value and flow rates for the strainer. One potential issue is that the licensee assumed that containment sprays will actuate in a maximum of 25 minutes and soon flood the strainer. For a small-break LOCA, spray actuation need not occur immediately or at all, such that the strainer could be operating for a significant period of time at a reduced water level (with only emergency core cooling system flow for small-break LOCA conditions). Analysis has not been presented to demonstrate acceptable strainer performance under this condition. The partially submerged strainer issue is particularly critical because the strainer core tube is only submerged by 2.2 inches at emergency core cooling system switchover for a small-break LOCA. In other words, if the head loss from the outer perforated plate and any accumulated debris on the outer surface of the strainer exceeds 2.2 inches, the core tube would be uncovered, which could adversely and significantly impact the performance of the strainer. The situation is complicated further by the fact that, even if the head loss across the perforated plates is low when a uniform flow calculation is used, if the perforated plate clean strainer head loss plus debris head loss is not small compared to about 2 inches, then reduced flow is going to reach the pump suctions from the plates that are farthest away (i.e., the PCI strainer will have increasingly non-uniform flow as this value is approached and potentially exceeded), since only a 2.2-inch margin in driving head is available to move water through the strainer surface prior to core tube uncovery.

Also, since the core tube slots are likely designed for full flow, having less than the design flow will lead to greater flow at the near modules. Thus more flow (and debris) will concentrate on the nearest module to the suction, and the head loss through these nearby disks will increase. Assuming uniform debris distribution in this case may not be conservative. In addition, vortexing could occur inside the strainer disks above the core tube slots. Please explain whether core tube performance testing has been done with only 2.2 inches of submergence to verify no vortexing or flashing at the slots. Furthermore, based on Page 15 of 20 in Attachment E, there appear to be sources of drainage nearby the strainers, which could potentially disturb the water surface near the strainers and core tube slots and result in air entrainment. Please provide the assumptions used in the air ingestion and void fraction calculations, and information that justifies the assumptions. Alternately, for the air ingestion issues, please provide test data, taken under conservative conditions, that show that air ingestion will not occur for the strainer as installed in the plant. Note that, with the strainer only partially submerged, air entering the core tube may not be identified visually so that alternate means of identifying air entrainment may be required. The response to this item should also consider that any debris that is considered to transport to the strainer under partially submerged conditions would accumulate on the reduced strainer area.

23. Please provide the margin to flashing considering that a more limiting condition may occur at the minimum water level, with the core tube covered only by a small amount of water. The flashing evaluation may have to be performed for several conditions in order to provide assurance that the limiting condition has been identified. With only a small amount of water covering the core tube, it is possible that the clean strainer head loss alone could result in flashing of the fluid within the strainer if some overpressure is not credited in the evaluation.

24. It is not clear that the main steam line break case was bounded by the testing that was conducted with a procedure that the staff considers to be acceptable in principle. The reference for the testing was dated August 2006, which is prior to the time at which the staff largely accepted a PCI/AREVA test methodology. In fact, trip reports from staff observations of the early testing identify several non-conservative aspects of the testing. The more recent testing, conducted with the upgraded test procedure, did not appear to bound the debris loading for the main steam line break (e.g. fibrous and Min-K debris). Please provide information that justifies that the testing used to bound the main steam line break case was conducted in a manner that would result in prototypical or conservative results and that it was conducted with debris representative of that break.

25. The staff could not determine whether some of the fine fibrous debris was blended into non-prototypical debris. The test photos in attachment D (pages 10 and 29) to the November 26, 2008, supplemental response appear to show clumps of debris that are larger and more agglomerated than would be expected of prototypical fine debris. The debris could have been blended excessively or into a form that is not prototypical of debris created by a steam jet. Please provide information that shows that the fibrous debris had prototypical characteristics when added to the test tank and that the debris was not agglomerated when added. In general the staff considers class 1-3 fibers (reference NUREG/CR-6808, Table 3-2) to be acceptable as fine fibrous debris with the majority being class 2 or 3. In addition, information should be provided that justifies that excessive agglomeration of debris did not occur during the debris addition process.

26. One of the test photographs shows 1.66 $lb_m$ of fine fibrous debris. This would correlate to 56.8 $lb_m$ of debris in the plant. It was unclear what fibrous debris this represented. It appears that the fine debris should have been 30 $lb_m$ of latent fiber (although one place shows 24 $lb_m$) and 33 $lb_m$ of fine LDFG debris. The total fine fiber would then be 63 $lb_m$. Please clarify the amount of fibrous fines predicted to reach the strainer and verify that the test amount was scaled correctly.

27. Staff review of the November 26, 2008, supplemental response identified that the debris addition practices and sequence used during the testing may not have been conservative. Please provide information that justifies that the debris addition sequence and practices did not result in non-conservative debris transport to the strainer during testing. Examples of potential non-conservative practices include adding more easily transportable debris after adding less transportable debris. It appears that the addition of 6 mil paint and lead blanket cover fines in the second batch of debris is contrary to adding the most transportable debris first. From the supplemental response it was difficult to determine how the debris was actually added. For example, was each debris type added separately or were the debris added as one addition? If added separately, please provide the order of addition.

28. It was unclear that the extrapolation of the test data to the strainer mission time was conservative. Please provide information that justifies that the exponential curve fit results in a conservative estimation of head loss at the end of the mission time. Please include adequate data so that the staff can verify the results of the extrapolation. Please provide information on how the linearly extrapolated value is used in any analyses or provide the reason that it was included in the supplemental response.

29. It appeared that the extrapolation of test results to different temperatures assumed that the flow through the debris bed was fully laminar. However, the supplemental response stated that there was clean strainer area at the end of the test. With clean strainer area, the flow through the strainer may not have been fully laminar. If this is the case, a straight viscosity correction should not be applied for temperature correction. Please provide the methodology and initial conditions used to calculate the debris head loss at higher temperature conditions. Also provide information that justifies the use of a straight viscosity correction for the debris head loss if one was used.

30. Please describe the testing and analysis performed on the declassified coatings in order to re-classify them as acceptable. Also please describe maintenance activities on the declassified coatings in the period before being upgraded to acceptable.

31. The discussion of coatings in the November 26, 2008, supplemental response is unclear in that on page 93, the licensee mentions that steel coatings within 10D of a break are assumed to be unqualified for a design basis accident, and that 10-micron particles were assumed for such debris. However, in the bounding debris load tables for the LOCA and main steam line break, there are no entries for unqualified coatings within a ZOI, only for various unqualified coatings outside the ZOI, while the only entries for ZOI coatings are for acceptable coatings. Please state what quantity of unqualified coatings is destroyed in the ZOI, and how were they handled in the bounding debris loading.

32. Please provide the hole size for the strainer that is installed over the 4-inch drain in the upender area that is described on pages 124–125 in the November 26, 2008, supplemental response. Please identify the potential debris loading that could reach this strainer, state whether the strainer can become plugged or partially plugged by debris, and provide a basis that blockage will not occur if this flow path is necessary to satisfy assumptions in the analysis. Please identify what hold up assumptions are made in the upender area in order to generate sufficient driving head to overcome the clean strainer head loss and any head loss due to a debris layer that could form on the strainer's surface. If any hold up of water is analyzed to occur, then please address the effect of this holdup on the minimum containment pool water level calculation.

33. The NRC staff considers in-vessel downstream effects to not be fully addressed at CPSES Units 1 and 2, as well as at other pressurized water reactors. The CPSES 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 CPSES 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 CPSES. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793.

34. Integrated chemical effects head loss testing was performed in the flume at Alden Labs., i.e., the PCI/AREVA methodology. The WCAP-16530 methodology was used to estimate the chemical precipitate load. The licensee used refinements to the base model methodology (i.e., credits using WCAP-16785-NP) without specifying which refinements were used, how they were used, or the overall reduction in calculated precipitate load based on using these refinements. Since the licensee had some margins in the amount of precipitate load that were tested (compared to the calculated load), the staff is uncertain if these margins bounded the reduction in precipitate due to "refinements." Please address the use of these refinements.

35. The flume tests were performed with chemical precipitates added after other non-chemical debris. Credit was taken for settling of debris, both non-chemical debris and chemical precipitates in the flume approaching the strainer test section. These tests were performed at a maximum flume fluid temperature of 120 °F. The total head loss in the integrated chemical effect head loss flume tests was acceptable. The licensee makes a statement on page 150 of 351, "Because chemical precipitates were first observed at and below 140 °F, the head loss was calculated in accordance with RG 1.1 and RG 1.82." Please address what this means and how this statement factors into the chemical effects evaluation.

36. The licensee’s response notes that the CPSES also has a buffer license amendment but has not made any commitment concerning a buffer change. Please address whether or not such a change will be made, including schedule.

37. The November 26, 2008, supplemental response indicates that plans do not exist to update the CPSES licensing basis for secondary pipe ruptures to include analysis of sump performance using mechanistic criteria consistent with Generic Letter 2004-02. Please address the following points regarding this decision:
    a. Please identify the regulatory requirement(s) that resulted in crediting operation of the containment spray system in recirculation mode following a secondary line break inside containment in the CPSES licensing basis. Although, as the supplemental response noted, Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46 was one of the applicable regulatory requirements identified in Generic Letter 2004-02, the generic letter was also based on a number of other regulatory requirements listed therein.
    b. Although aspects of the licensee's secondary pipe rupture analysis are consistent with NEI 04-07, Section 3.3.4.1, the staff stated in its SE for NEI 04-07 that the NEI 04-07 positions in this section were unacceptable. The staff's SE discussion indicates that the same guidelines should be applied for secondary line breaks as for LOCAs. Please justify use of this section of NEI 04-07.