WATERFORD STEAM ELECTRIC STATION UNIT 3
REQUEST FOR ADDITIONAL INFORMATION
SUPPLEMENTAL RESPONSES TO GENERIC LETTER (GL) 2004-02
DATED 02/29/2008 AND 10/23/2008

A. Debris generation/ZOI

The following requests for additional information (RAIs) relate to the reduced zone of influence (ZOI) credited for jacketed fiberglass insulation. The staff has not concluded that the testing conducted under WCAP-16710 provides a realistic or conservative estimation of debris generation. The issues listed below are being addressed by the pressurized water reactors owners group. Therefore, Entergy may want to coordinate its response with that effort. Some issues, such as the details of construction of the Waterford Steam Electric Station, Unit 3 (Waterford 3) insulation systems, will have to be provided by the licensee.

1. Although the ANSI/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 (RCS) conditions, specifically the plant hot and cold leg operating conditions. If ZOI reductions are also being applied to lines connecting to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Please provide description and results of any tests conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications.

2. Please describe the jacketing/insulation systems used in the plant for which the testing was conducted and compare those systems to the jacketing/insulation systems tested. Demonstrate that the tested jacketing/insulation system adequately represented the Waterford 3 jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, etc. At a minimum, the following areas should be addressed:

    a. Describe how the characteristic failure dimensions of the tested jacketing/insulation compare with the effective diameter 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. Please describe whether the insulation and jacketing system used in the testing were of the same general manufacture and manufacturing process as the insulation used at Waterford 3. If not, please address the steps that 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 there were generally two very different processes used to manufacture calcium silicate insulation, whereby one type readily

dissolved in water but the other type dissolved 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 or encapsulation systems 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, etc., should be made. For example, scaling the strength of the jacketing was discussed in the Ontario Power Generation report (ML020290085) on calcium silicate debris generation testing.

3. 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 address whether 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.

4. 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, and include the information specified below.

a. In WCAP-16710-P, please explain why the analysis was based on the initial condition of 530^{o}F whereas the initial test temperature was specified as 550^{o}F.

b. Please explain whether the water subcooling used in the analysis was that of the initial tank temperature or whether it was based on the temperature of the water in the pipe next to the rupture disk. Test data indicated that the water in the piping was cooler than the water in the test tank.

c. 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 describe the analytical method used to calculate the mass flow rate.

d. 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, please explain whether the inputs to the standard represented the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second.

e. 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.

5. 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 by providing the information requested below.

a. Please provide the assumed plant-specific RCS 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 degree 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.
b. Please sumamrize the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant loss of coolant accident (LOCA), which was used as input to the standard for calculating isobar volumes.
c. 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. Please explain whether multiple break conditions were calculated to ensure a conservative specification of the ZOI radii.

6. Please provide a detailed description of the test apparatus, specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system, and addressing the information requested below.

a. Please explain how the hydraulic resistance of the test piping, which affected the test flow characteristics, was evaluated with respect to a postulated plant-specific LOCA break flow during which such piping flow resistance would not be present.
b. Please providethe specified rupture differential pressure of the rupture disks.

7. WCAP-16710-P discusses the shock wave resulting from the instantaneous rupture of piping. Please provide the following information.

a. Please describe whether analysis was performed or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions. Please describe and justify whether temperatures and pressures prototypical of PWR hot legs (or pressurizer lines) were considered or not.
b. Please explain whether the initial lower temperature of the fluid near the test nozzle was taken into consideration in the evaluation. Specifically, please explain whether the damage potential was assessed as a function of the degree of subcooling in the test initial conditions.
c. Please provide 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.
d. Please explain how the effect of a shock wave was scaled with distance for both the test nozzle and plant condition.

8. Please provide the basis for concluding that a jet impact on piping insulation with a 45° seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the

insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. Although WCAP-16710-P asserts that a jet at Wolf Creek or Callaway nuclear plants cannot directly impact the steam generator, but will result in flow parallel to the steam generator, the staff has not seen evidence showing that some damage to the insulation could not occur near the break, with the parallel flow then jetting under the surviving insulation, perhaps to a much greater extent than predicted by the testing. Similar damage could occur to other component insulation. Please document a technical basis that the test results for piping insulation are prototypical or conservative relative to the degree of damage that could occur to insulation on steam generators and other non-piping components in the containment.

9. Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation will have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially-oriented pipe significantly beyond the distances calculated by Westinghouse. Please provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative of the degree of damage that would occur to insulation on piping lines oriented axially with respect to the break location.

10. WCAP-16710-P noted damage to the cloth blankets that cover the fiberglass insulation, in some cases resulting in the release of fiberglass. The tears in the cloth covering were attributed to the steel jacket or the test fixture and not the steam jet. It seems that any damage that occurs to the target during the test would be likely to occur in the plant. For example, the test fixture could represent a piping component or support, or other nearby structural member. The insulation jacketing is obviously representative of itself. Please provide the basis for the statement in the WCAP that damage similar to that which occurred to the end pieces in not expected to occur in the plant. It is likely that a break in the plant will result in a much more chaotic condition than that which occurred in testing. Therefore, it would be more likely for the insulation to be damaged by either the jacketing or other objects nearby.

B. Debris Characteristics

11. The staff review noted one critical change in the October 23, 2008, supplement versus the February 29, 2008, supplement and the NRC staff's report of its audit of Waterford 3 corrective actions for GL 2004-02. The earlier two documents refer to the metal encapsulated insulation (MEI) debris being 100% fines. However, the October supplement refers to this MEI debris being 20% fines and 80% small pieces. Although the distinction was not used to change the analytical transport results, presumably this information was used to determine debris for head loss testing, and as such is very significant. It is not clear that a debris mix of 20% fines / 80% small pieces is conservative when a 4D ZOI is assumed. The categorization of the debris as 20% fines is based on Drywell Debris Transport Study (NUREG/CR-6369) results from tests with 7–10D ZOIs, and it is an average value, not a maximum value, from these tests. Please substantiate the adequacy of the assumption that no more than 20% of the MEI debris within a 4D ZOI will be destroyed into fines.

C. Debris transport

12. The supplemental response described erosion testing that was used as a basis for the assumption of 10% erosion of small and large pieces of Nukon™ debris.

    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 estimate the quantity of fibrous debris that settled in the test flume and discuss how erosion of this debris was accounted for in the strainer performance analysis. In addition, specific justification should be provided 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 discuss how the erosion testing conducted for Waterford 3 accounts for the erosion of debris that settles in front of the strainer plenum, which may be exposed to a higher velocity than the incipient tumbling velocity.

13. Please identify the size distribution of the metal encapsulated insulation (MEI) calculated as reaching the strainers in Tables 3.e.6.1 through 3.e.6.5. Specifically, identify what fraction of this debris is fines, and what fraction is small pieces. Please also identify the size distribution of MEI added to the head loss tests used for strainer qualification.

14. The supplemental response stated that module testing credited near-field settlement. Insufficient information was provided in the supplemental response dated October 23, 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 the following information regarding the modeling of flow and turbulence in the test and how test flow conditions compared with flow conditions in the plant.

    a. Please provide contour plots of the velocity and turbulence in the containment pool for Break S7 and the limiting (with respect to strainer head loss) large-break case.
    b. Please provide close-up plots of the velocity and turbulence contours in the vicinity of the strainer for these cases.
    c. Please identify the head loss test flume (average) velocity used for the strainer module testing for these cases and the basis for the velocity chosen.
    d. Please identify the turbulence levels simulated in the test flume for these test cases and provide the basis for considering them representative of the plant condition.

15. The supplemental response dated October 23, 2008, stated that the test strainer had 10 disks rather than the 17 disks present on the actual plant strainers. Please describe how this difference in strainer size (and total module flow rate) was accounted for in scaling the velocity and turbulence in the head loss test flume based on geometric similarity.

16. Please identify the distance from the strainer at which debris was added to the test flume. Please justify the conservatism or prototypicality of this distance based on the

transport analysis results for blowdown, washdown, and pool-fill transport. Please specifically discuss consideration of the debris addition in the head loss testing for the fraction of paint chips and other containment debris that would have the potential to wash down onto the strainers from upper containment elevations, and would thus not have to climb over the suction plenum to reach the strainer surface.

17. Please describe how the potential for debris transport in the vicinity of the strainer via floatation was considered in the head loss tests for Waterford 3.

18. The October 23, 2008, supplemental response identifies on page 59 that the assumptions made concerning the settling of particulate down to 100 microns in size were benchmarked against NRC-sponsored settling tests. Please identify the NRC-sponsored tests being referenced in this discussion.

19. The staff does not consider the licensee's response to Open Item 4 from the NRC staff audit to be sufficient because (1) the initial containment pool flows during fill-up will be chaotic and may distribute debris unevenly to the two sides of containment, independent of the relative flow split during recirculation, particularly for breaks such as S7, and (2) the response did not appear to discuss the definition of the starting point for the transport paths used for computing debris transport fractions that had been requested. Please provide a response to these remaining issues associated with Open Item 4 from the audit report.

20. The supplemental response states that 25% of small debris is treated as lifting onto the sump strainer for one of the computational fluid dynamics scenarios for which less than 25% of the perimeter area around the plenum exceeds the curb lift velocity metric. The staff does not consider the methodology used to determine this percentage of debris lifting over the plenum to be prototypical or conservative because the flow approaching the strainer would be non-uniform. Specifically, most of the post-LOCA debris would approach the plenum from the high flow velocity channel, and very little debris would approach from stagnant regions experiencing low-velocity flows. Please provide a technically defensible basis for the percentage of debris that can be lifted over the strainer plenum for this case.

21. The head loss testing conducted for Waterford 3 credited debris settlement. However, it was not clear that the densities of the Min-K and Microtherm debris used for testing were prototypical or conservative with respect to the corresponding materials installed in the plant. The supplemental response dated October 23, 2008, indicates that the test debris for Min-K could be from 1.1 to 4.8 times denser than the plant debris, and that the Microtherm test debris could similarly be from 1.2 to 2.9 times denser than the plant debris. Since denser debris would tend to settle faster, please either (1) provide additional information that demonstrates that the densities of the Min-K and Microtherm at Waterford 3 are reasonably close to the densities of the surrogate debris tested or (2) justify that the potential for significantly higher densities of the test debris did not lead to non-prototypical settling during the strainer head loss testing.

22. The staff does not consider the licensee's response to Open Item 7 from the NRC staff audit to have fully addressed the item. Please provide additional information to address the remaining points specified below regarding this open item.

a. The response did not provide a technical basis for assuming that plant operators are capable of addressing within 30 minutes the postulated single failure of a low pressure safety injection (LPSI) pump to trip upon the switchover to recirculation. This assumption of 30 minutes to address the single failure significantly affects the determination of debris transport, head loss, and net positive suction head available.
b. Thirty minutes would be sufficient time for about one turnover of the containment pool volume. The licensee noted that, during head loss testing, a significant head loss had not occurred within one pool turnover. Therefore, it was concluded that there would be no effect on the strainer head loss from the failure of a LPSI pump to trip. The evaluation did not consider changes that could occur in the transport of debris to the strainer and higher bed compression that could occur due to higher flow rates through the debris bed.
c. The description of the head loss testing that was used to justify debris bed formation requiring more than 30 minutes did not identify whether all of the debris had been added at the beginning of the test or whether a phased addition of debris had been used. If an arbitrary phased debris addition sequence was used, the time-dependence of the measured test head loss may not correspond to the bounding plant condition.
d. The October 23, 2008, supplemental response stated that no tests were run for vortexing-specific assumptions. At the initiation of recirculation, non-uniform flow will occur, with the highest flow rate at the modules nearest to the suction line. It was not clear from the supplemental response that the additional flow associated with the single failure of a LPSI pump to stop was bounded by the vortex testing performed for Waterford 3.

D. Head Loss and Vortexing

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23. Please provide a general description of the ECCS strainer head loss testing conducted after the Waterford 3 audit. Provide the scope of the test program, a general description of the overall concept of how the testing addressed the audit issues, the location of the testing, and other relevant issues associated with the broad test program. This information is needed because the supplemental responses did not contain adequate detail on the test procedures for the NRC staff to reach conclusions regarding their adequacy. Please include the following information:

a. description of test facility
b. general procedure for conducting the test
c. physical arrangement of the strainer within the pool including any dividers or flow diverters
d. location of the return header
e. location of the stirrers, if used
f. scaling parameters and methodology (for sector and module tests)
g. total debris amounts (each debris constituent) and basis for the amount
h. flow rates
i. whether debris settlement was allowed
j. whether flow sweeps were completed to search for bore holes
k. debris amounts, including chemical debris
l. description and purpose of each test case

m. plots of the limiting test cases including annotation of significant events during the testing
n. comparison and evaluation of pre and post-audit test results (clearly identify pre and post-audit tests)

24. Documentation of fiber size distribution used for post-audit head loss testing and how this compares to the fiber size distribution predicted to arrive at the strainer by the transport evaluation was not provided. The supplemental response stated that fiber used in the testing was shredded five times. Please provide a qualitative size distribution for the fibrous debris used in the testing. Please justify that the methodology used to create the debris resulted in acceptable debris sizing.

25. Please verify, for thin bed testing and testing that allowed near-field settling, that all fine fiber was added prior to the addition of coarser fibrous debris. Waterford 3 has predicted sufficient fine fibrous debris to be created, such that all thin bed testing should be conducted with only fine fibrous debris to establish a bounding condition, consistent with the NRC staff's 3/28/08 review guidance (ML080230038), unless the licensee can justify otherwise. This item is associated with audit open item 8, which applied to both thin-bed and higher debris load testing.

26. Audit open item 10 stated that adding all debris prior to starting the recirculation pump could result in agglomeration and excessive settling, and to the formation of a bed that is less dense than one formed by a more gradual arrival of debris. The licensee's supplemental responses did not provide sufficient information for the NRC staff to conclude whether this concern, and others related to the potential for nonconservative debris settling and agglomeration, applied to the post-audit testing. Please provide the following information regarding debris additions during the post-audit testing, including their impact on agglomeration and settling of debris:

a. fibrous concentration during addition and method of addition to flume that justifies that debris was not agglomerated
b. location(s) of debris additions.
c. amount of each debris constituent in each batch including chemical batches
d. order of debris batch addition to the test
e. time between batches
f. whether the recirculation pump was running during debris additions

27. Please provide and justify the method for extrapolation of test results to mission times for the post-audit tests. Note that the tests reviewed during the audit were found to have acceptable final values. Therefore, if the same approach was used during the later testing, and similar head loss trends at the end of the test were observed, a simple statement to that effect is sufficient to address this question.

28. Please provide and justify the test termination criteria. Please provide data to show that the updated testing met these criteria. Note that the testing conducted prior to the audit was found to be satisfactory in this area. Therefore, if the same approach was used during the later testing, and similar head loss trends at the end of the test were observed, a simple statement to that effect is sufficient to address this question.

29. Please provide the methodology used to revise the plenum portion of the clean strainer head loss to 0.063 ft from 0.41 ft.

30. The audit found that stirring, in combination with the inadequate preparation of fibrous debris, may have affected the test results non-prototypically. Please provide information as to whether stirring was used during post-audit testing and how it was employed, including the duration of the stirring. If stirring was used, provide justification that the testing was conducted in a manner that would prevent non-prototypical debris transport. Also justify that stirring did not prevent debris from collecting naturally on the strainer.

31. Pre-audit thin-bed testing was based on a break that resulted in much lower amounts of particulate debris than other identified breaks. The NRC staff's's 3/28/08 head loss and vortexing review guidance states that thin-bed testing should identify whether the full-particulate load, with varying fibrous loads, will result in the limiting head loss for the plant. The guidance also states that thin-bed testing with less than the full-particulate load is not generally considered to be conservative. Please provide documentation that shows that the updated thin-bed testing was prototypical or conservative.

32. The supplemental response dated 10/23/08 included a scaling equation that included scaling for debris bed thickness and flow velocity, as well as temperature. The scaling of results to different flow velocities or debris bed thicknesses may not follow the scaling equation presented in the supplemental response. Please provide details for any scaling to different velocities or debris bed thicknesses including the test conditions and results, and the plant condition being scaled to. Please provide the same information for any temperature scaling conducted.

33. The supplemental response dated 10/23/08 stated that flashing at the strainer would not occur because the strainer submergence is 8 inches and the maximum head loss is about 6 inches. This is true for a large-break LOCA, but does not address a small-break LOCA, which has a bounding submergence of about 2 inches. Please provide an evaluation for flashing during a small-break LOCA at the most limiting condition. This may require an evaluation of head loss versus submergence over time or credit for accident-generated pressure.

34. In the head loss table on page 32 of the supplemental response dated 10/23/08, case S7, the pressurizer surge line break is bounding. Page 8 of the supplemental response states that the debris from the S7 break is insignificant. Please provide an evaluation of how the debris generated from the S7 break could result in a higher head loss than a thin bed case from other breaks, considering the much higher particulate debris generation. Based on observations of many strainer head loss tests and theoretical predictions of head loss, the staff believes that a thin-bed test for other break conditions, that would have a comparable amount of fiber plus a significantly larger particulate source term (including microporous insulation), would likely result in higher head losses if testing is conducted in accordance with the existing guidance.

E. Net positive suction head

35. The supplemental response dated October 23, 2008, stated that the minimum water level calculation did not specifically include the potential RCS volume reduction due to cooling of the fluid (part of Audit Open Item 13). Instead, this phenomenon was considered to be bounded by the lack of credit allowed for the reduction in RCS level in the steam generators and pressurizer due to flow from the pipe break. It is not clear to the staff that the credit for RCS inventory can be reasonably assumed for all breaks. One example is that a small break near the top of the pressurizer could result in a condition where the loss of inventory from the RCS is eventually made up for and exceeded by incoming flow from the high-pressure safety injection system. In such cases, the RCS could be a net hold up volume, due to the RCS cooldown after the LOCA and/or due to the potential for the ECCS to refill the RCS to a pressurizer level beyond the normal operating condition. Please provide information that justifies that neglecting RCS shrinkage due to fluid cooling can be offset by the uncredited margin associated with the RCS inventory from the pressurizer and steam generators. The evaluation should determine the magnitude of the sump level change due to RCS cooling and verify that there is adequate RCS spillage to the containment for all breaks that credit the spilled volume, accounting for the concerns discussed above.

36. The sump level calculation assumes that no holdup occurs in the refueling canal. Audit Open Item 16 requested that the licensee provide information justifying that the drain lines would not block and provide a holdup volume. The evaluation provided in the supplemental response dated October 23, 2008, was based on judgment and lacked technical basis or any information beyond that provided during the audit. Holdup in the refueling canal will affect sump level, and therefore, net positive suction head margin. Please provide additional information that justifies that the refueling canal drains cannot become fully or partially blocked so that no hold up will occur. Waterford 3 has hundreds of cubic feet of fiber, as well as miscellaneous debris and other materials. It is not clear that the upper guide structure lift rig and an access ladder (diver stairs) are sufficient to keep larger debris out of the drains for the refueling canal. The supplemental response does not address why large pieces of debris cannot be blown into the upper containment. If such debris ends up in the refueling cavity, it is not clear that temporary floatation, transport by surface currents over the drain, and subsequent soaking with water, can be ruled out. If drain blockage can be ruled out, then please identify whether any water buildup is necessary to create sufficient driving head for flow to occur through the drain for a clean condition. Alternately, if drain blockage cannot be ruled out, then please evaluate the potential holdup in the refueling canal and its effect on pool water level.

F. Coatings Evaluation

37. In the submittal, a 4D ZOI was used for inorganic zinc coatings. Topical report WCAP-16568-P recommends using a 5D ZOI for untopcoated inorganic zinc. Please either confirm that the inorganic zinc is topcoated or justify using a 4D ZOI for untopcoated inorganic zinc coatings.

G. Downstream effects/in-vessel

38. The NRC staff does not consider in-vessel downstream effects to be fully addressed at Waterford 3, as well as at other pressurized-water reactors (PWRs). Waterford 3'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 safety evaluation (SE) for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for Waterford 3 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 WCAP16793 or the NRC staff SE that in-vessel downstream effects have been addressed at Waterford 3. Please 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.

J. Chemical Effects

39. The supplemental responses provided insufficient information for the NRC staff to conclude that chemical effects have been satisfactorily addressed at Waterford. Please provide the results from chemical effects tests considering the NRC staff guidance for chemical effects dated 3/28/08 (ML080380214).

40. The supplemental response dated 10/23/08 states that 30-day integrated chemical effects testing performed by Alion Science and Technology will be used to determine to head loss contribution due to chemical precipitates. Please describe the methodology for applying the integrated chemical effects testing results to the hydraulic head loss test results.

41. The staff has had extensive interaction with Alion regarding the integrated chemical effects testing in the VUEZ loops. During these interactions several technical concerns have been raised. For example, the staff questioned whether a poured debris bed provided a representative baseline head loss from which to calculate a bump up factor. For a complete list of issues see ADAMS accession number ML080510657. Please describe the test protocol for the VUEZ testing conducted for Waterford 3 and address the outstanding staff concerns with the Alion/VUEZ test protocol as applicable to the Waterford 3 testing.

42. Please clarify or justify the statement: “The 30 day integrated testing and analyses concluded that no aluminum-based precipitates would form in the Waterford 3 environmental conditions with a pH less than 8.1.” Lower pH would tend to favor precipitation since the aluminum solubility would decrease as the pH decreased below a pH of 8.1.

43. Please provide the expected Waterford 3 equilibrium pH range, the projected Waterford 3 aluminum concentration, and the post-LOCA temperature profile used to reach the conclusion that aluminum-based precipitates would not form.

44. Please explain what test parameters were measured to determine that no aluminum-based precipitates were formed above 140 °F, and explain whether it is possible that precipitates formed at temperatures above 140 °F but were not detected during the test.