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February 8, 2008
261-4779-LTR-01

Mr. Michael L. Scott
Chief, Safety Issues Resolution Branch
Office of Nuclear Reactor Regulation
United States Nuclear Regulatory Commission
Mail Stop O-11A11
Washington, DC 20555-0001

Subject: Resolution of NRC Questions Regarding ALION VUEZ 30 Day Testing Program
Status of Responses

Dear Mr. Scott:

We are sending this letter as a continuation of our discussions regarding NRC questions about the ALION VUEZ 30 Day Testing Program.

As part of the resolution of GSI-191 and Generic Letter 2004-02, licensees are required to address the impact of chemical effects on debris head loss. As an alternate and/or supplemental strategy to WCAP-16530 based precipitate debris head loss testing, ALION Science & Technology (ALION) is performing 30 day chemical effects debris head loss testing at the VUEZ Test Facility for several plants. Based upon a site visit and review of the ongoing test procedures, the NRC staff developed a list of questions/issues on the ALION/VUEZ 30 day test program and requested resolution of their questions to support specific licensee's Supplemental Responses to GL2004-02. The list of 29 questions/issues provided by Mr. John Lehning, of your staff, to Alion via NEI, on January 28, 2008 is summarized and clarified in this letter. Since some of the questions are similar, where appropriate, Alion consolidated the like concerns into a single problem statement in order to provide clarity on each specific issue. The problem statements reflect Alion's understanding of each issue. The result is a list of 20 problem statements. The goal of stating the issue in the form of a problem statement is to facilitate a clear and complete Alion response to Staff's questions. The NRC Staff issues and the Alion problem statements are provided in Table 1.

The NRC has often stressed the importance of quickly addressing and resolving these open issues. Given the importance of this effort, ALION has assembled a response team and a dedicated Project Manager to quickly manage the closure of these items. Also, ALION has established an ALION/VUEZ User Group. The Users Group has granted Alion the right to use the test data from their individual tests, in combination, to resolve the Staff's questions. This working agreement will allow Alion to use all of the testing as a body of knowledge in combination to support clear and complete responses. The responses to the questions can then be used consistently by Owners Group Members in their resolution of the GL.

For background and reference, each of the 29 ALION Follow-Up Issues, provided by the NRC, is also included in this letter as an attachment. These will serve as supporting information relative to the background of the issue/concern and Alion's response to the problem statement.

ALION has established a schedule with the Owner's Group that will resolve all 20 Problem Statements within 60 days. ALION will not wait until the end of the 60 day period to submit responses, but will submit responses as they are completed. The preliminary schedule for the responses is presented in Table 1.

We have been in discussion with your Staff on these questions/issues and look forward to meeting with you and your Staff at NRC Headquarters on or around the first week in March 2008 to facilitate a more effective interaction and resolution of these issues.

As stated, ALION looks forward to resolving these issues in the shortest timeframe possible. If you have any questions or require additional information please contact me at (630) 846-6787 or Steven Unikewicz at (703) 850-1554.

Sincerely,

Robert Choromokos
Manager, Energy Services Division

cc: P. Mast
S. Unikewicz
Owner's Group Distribution

Table 1: ALION VUEZ CE Testing Questions

No.	NRC Issue/Comment	No.	ALION Problem Statement	Completion Date
1 3 4	Prototypicality of poured debris bed Prototypicality of poured debris bed Representativeness of debris size distribution	1	Provide the basis for the debris bed preparation, including the size characteristics and method of formation relative to the prototype debris bed.	Feb 29 2008
5 6	Maximum load versus thin-bed testing Maximum load versus thin-bed testing	2	How are the chemical effects captured for the range of debris loadings possible in the plant specific analysis given the impact of chemical effects could be different for different debris loading conditions?	Feb 15 2008
7	Flat plate representative of filled strainer volumes	3	Why is the debris bed on a flat plate representative of a debris bed on a complex shape and filled strainer volumes?	Feb 15 2008
9	Bypass flow around bed - edge effects	4	Describe the impact of the VUEZ screen configuration and suction piping on the results. The screen may exhibit bypass flow at the edges of the debris bed. How is this prevented or considered in the results?	Feb 29 2008
10	Debris settling in tanks	5	Address the adequacy of the turbulence levels in the tank to ensure adequate circulation around all coupons/materials and material in suspension.	Mar 14 2008
21 20	Flow conditions and material interaction Tank mixing versus time of material interaction	6	Address any material settling inside the tank and the impact on the results.	Mar 14 2008
8	Gas void issues and impact on results	7	Describe the impact of gas void issues under the debris bed on the results.	Mar 21 2008
2	Technical basis of bump-up factor	8	Provide the basis for the bump up factor and illustrate with an example.	Feb 29 2008
11 12 13 14 18	Test parameters ensure a conservative test Basis for temperature correction Basis for timing of acid addition Basis for timing of LiOH addition pH shock and impact on head loss	9	Provide the basis for the selection of the time, temperature, chemistry and materials used for the test to ensure a conservative test is performed with respect to plant conditions.	Feb 15 2008

Table 1: ALION VUEZ CE Testing Questions (cont'd)

No.	NRC Issue/Comment	No.	ALION Problem Statement	Completion Date
15	Impact of elevated pH due to debris in DM water	10	What is the impact of the elevated pH due to debris dissolution in demineralized water on the results of the experiment.	Mar 21 2008
16	Impact of sudden temperature drop in HX	11	What is the impact of a sudden temperature drop from a heat exchanger and the potential for thermal cycling?	Mar 14 2008
17	Representativenss of plate for failed metallic coatings	12	What is the basis for representing failed metallic coatings as metallic sheets?	Feb 22 2008
19	Inclusion of fiberglass binder in experiment	13	What is the impact of neglecting the fiberglass binder in the experiment?	Mar 7 2008
22 23	Volume change due to material additions Effect of sampling on chemical concentrations	14	What is the impact of fluid sampling on the experiment?	Mar 7 2008
24	Repeatability of tests	15	Are the tests repeatable?	Feb 15 2008
25	Measurement uncertainties	16	How are measurement uncertainties accounted for in the development of the test parameters and application of the experimental results.	Mar 28 2008
26	Copy of test procedure for large Elisa Loop	17	Provide a copy of the large loop test procedure.	Feb 15 2008
27	Copy of alkyd coatings chemical report	18	Provide a copy of the alkyd coatings chemical report?	Feb 15 2008
28	Quality assurance	19	Provide a summary of any quality assurance issues noted and their impact on results or corrective actions taken.	Mar 28 2008
29	Request for photographs	20	Photographs should be included in the test reports (comment only - no response needed.)	N/A

Alion Follow-Up Issues (11/30/07)

Head Loss and Scaling

1. It is not clear to what extent the poured debris bed formation process can generate uniform/homogeneous debris beds. Previous unexpected test results from SONGS (where no measurable head loss was recorded, in contrast with NUREG/CR-6224 correlation predictions) and TMI (where the measured head loss across the VUEZ flat plate was significantly lower than the head loss measured across a 3x3 array) suggest that the debris bed formation process may not allow the flow through the screen to orient the accumulating debris in a natural arrangement that tends to maximize head loss. Discussion during a teleconference that additional fibrous debris is sometimes added to poured debris beds to fill in visually apparent gaps or non-uniformities further underlines the staff's concern that the porosity of a poured debris bed can be significantly higher than that of a bed that is naturally formed by flow. The small size of the VUEZ loop also implies that any non-uniformity in the test debris bed would tend to have a more significant effect than on a prototype module or plant strainer.

Additional observations made during the staff's trip to VUEZ have reinforced previous observations above that the VUEZ poured beds are significantly more porous and fluffier than beds formed under flow. For example, several of the beds formed (with a quantity of debris more than sufficient to form a thin bed) unexpectedly resulted in essentially zero head loss, several appeared clumpy and non-uniform, and one even had a small amount of open screen area. The staff also visually observed issues associated with pouring the beds, such as disturbances to the bed from the funnel used to pour debris on the screen, clogging of the funnel with clumps of prepared debris, and the use of a stirring rod to reposition clumps of debris that had been poured onto the test screen non-uniformly. Virtually all of the comparisons the staff has observed to date between VUEZ testing and other test methodologies and analytical calculations have shown that the VUEZ head loss test results without chemical precipitates are non-prototypically low (and sometimes not significantly more than the clean screen head loss). The staff considers it likely that the bed pouring process is a significant factor causing these non-prototypical differences. In light of the discussion above, the staff considers it necessary that Alion demonstrate that head loss results from VUEZ testing with poured debris beds prior to the addition of chemicals are representative of non-chemical integrated tank testing head loss results (and/or other results from tests where the beds are formed under flow) after the results are scaled to a common temperature, as appropriate.

2. The specific methodology and technical basis for using a bump-up factor to account for the head loss due to chemical effects is not clear to the staff. The bump-up approach is based on the theory that the incremental head loss from a given quantity of chemical precipitate (after scaling) will be the same for the VUEZ debris bed as for the plant condition. One of the important assumptions upon which this theory depends is that the VUEZ debris bed and the actual plant debris bed should have sufficiently similar characteristics with respect to filtering out and spatially accumulating the chemical precipitates. Based upon testing conducted to date, it is not clear to the staff that geometric differences and other factors do not influence the debris bed's properties (e.g., porosity, compression, thickness), and thus add significant uncertainty to the bump-up factor approach. It is also not clear how the bump-up approach ensures that boreholes or differential-pressure effects do not adversely affect the scaling approach One means of resolving this issue would be to document the methodology used for the bump-up approach and provide a justification with evidence that this approach is valid in light of the staff's questions.

3. During a series of pre-tests conducted prior to the staff's trip to VUEZ, sensitivity tests associated with the sequencing of debris into the test tank showed a significant difference in head loss associated with varying the arrival sequence of debris on the test screen for the same debris loading. In one case, the debris was added homogeneously, which resulted in a low head loss. However, in the heterogeneous case, the test was stopped

prematurely after the head loss had rapidly increased to a value approximately 20 times greater than the homogeneous case. The staff questioned the basis for such a large discrepancy between these two cases and questioned why the homogeneous addition sequence is representative. Further, because the bump-up approach implicitly assumes similarity between the debris bed formed in the integrated tank to the bed formed in the VUEZ loop, it is not clear why the same debris addition sequence should not be used for both tests.

4. During the initial teleconference, Alion stated that a generic fiber size distribution was used for the VUEZ testing. The staff expectation is that an appropriate procedure for preparing fine fiber be implemented (which is particularly important for the thin bed test, since for many plants, fines may be the only debris size that actually covers the entire strainer), and that the surrogate debris used matches the plant-specific size distributions from the debris transport calculation. The staff's observations at VUEZ showed that the prepared debris contained chunks that seemed to disrupt the formation of uniform debris beds. Further, since a fixed quantity of water was used to form all of the debris slurries, the cases with the highest debris loadings had the most concentrated and agglomerated debris slurries, which resulted in the formation of the most clumpy and non-uniform beds. Also, although a pre-test pour of the prepared debris over a perforated plate was used to determine whether the debris had been adequately fragmented after one of the tests for which a high concentration of chunks had clogged the funnel used to pour the debris onto the test screen, Alion did not generally perform a verification that the size distribution of the prepared debris was adequate prior to adding it to the test loop.

5. Maximum load versus thin bed testing. During the previous call, Alion made the statement that maximum debris cases are chosen for chemical testing based on their causing higher head loss than the thin bed tests during earlier non-chemical testing. Presuming that the bump-up approach is justified, once chemicals are considered, the maximum debris case would continue to be bounding only as long as the thin-bed bump-up factor is not so severe as to overcome the lower thin-bed head loss without chemicals, or

$$\frac{Thin\,Bed\;Bump-up\;Factor}{Maximum\,Load\;Bump-up\;Factor} \leq \frac{Maximum\,Load\;HL}{Thin\,Bed\;HL}$$

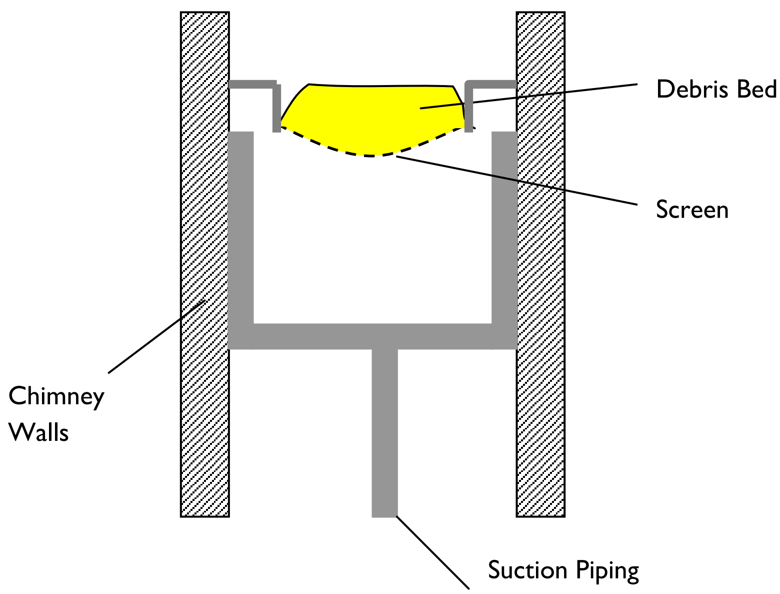
Why is there confidence that this must be the case?

6. During the most recent phone call, Alion stated that larger bump-up factors were calculated for maximum load cases as opposed to thin-bed cases based on previous VUEZ testing. Provided that these tests were not unduly influenced by issues such as debris coarseness and bed pouring, and that general principles can be deduced from these results that are applicable to other plants' test conditions, then it may be appropriate to use these tests as a basis to rule out the conduct of future thin bed tests. However, at present, based on unresolved staff concerns such as the debris-pouring process, debris size distribution, and debris sequencing, the staff does not consider omitting thin bed tests in the future to be justified. In addition, the procedure and technical basis for determining the appropriate thickness of the thin beds in the VUEZ tests was not fully clear to the staff during the phone call, and additional discussion of this issue would be beneficial.

7. While the large VUEZ loop potentially offers a means of accounting for circumscribed and partially circumscribed (transitioning) debris beds, it is not clear whether the flat plate in the small loop can be scaled for these conditions (e.g., modeling effective bed thicknesses, circumscribed / partially circumscribed flow areas and approach velocities). As discussed in a previous teleconference, these geometric effects may be partially responsible for reduced head loss seen for TMI test conditions in the VUEZ loop as compared to the large tank with the 3x3 array.

8. It is important to ensure gas release and boreholes do not disrupt the debris bed structure. Alion has stated that improvements have been made to address this issue for the small VUEZ loops, and that the limited experience to date has not shown there is a gas issue with the large VUEZ loop. Following the improvements to the small loops, observations made during the staff's trip to VUEZ showed that significant portions of two of the four beds formed floated away within several hours of formation. The buoyancy of parts of these beds may have been the result of gas evolution from the Temp-Mat binder; however, this explanation could not be verified during the staff's visit. Staff review of additional test results demonstrating that gas issues have been addressed could provide a basis to resolve the issue.

9. In two tests that were completed during the staff's visit, inward warping of the upper surface of the debris bed away from the walls of the "chimney" was observed, as shown below in an idealized cross section (not to scale). Such warping of the debris bed could result in a significant amount of the flow passing through the thinner cross section of the debris bed nearest the chimney walls.



10. During the staff's trip to VUEZ, corners of two tanks that had been run for several weeks contained small piles of debris, and a thin film was observed on the tank floor. This debris may be part of the material that was supposed to form the debris bed, material that leaked out of sample baskets, or settled chemical precipitates. Alion should understand the sources of any debris found on the floor of the tank, and, if significant settling of debris is observed, justify why the settling is acceptable. For tests where a large number of baskets of material and coupons have been added, additional areas of low flow may be created, thus further facilitating settling of debris. It is not clear that informal transportability tests performed in the past have accounted for the obstacles created by sample baskets and coupons, and, in addition, the staff noted that some of the testing observed during the trip had been conducted at tank flow rates that were lower than previously considered desirable (i.e., 1 L/min).

<u>Chemical Effects</u>

11. The NRC staff is interested in how a given licensee determines that the test parameters selected for the VUEZ loops provide test results that are conservative with respect to chemical effects. This is particularly important since test results may show that certain dissolved species remain in solution instead of forming precipitate in the time frame of interest. For example, as was described by Alion in a previous phone call, the early part of the test may be conducted with temperatures representative of the upper range of post-LOCA temperature profiles for a plant to favor dissolution of materials. The latter part of the test may be conducted at temperatures representative of the plant's lower temperature profile to favor precipitation of dissolved materials. With respect to test pH, higher pH conditions may favor greater dissolution of important materials, such as aluminum, while near neutral pH values would provide conditions that favor precipitation of aluminum hydroxide type species. Additional information that describes how licensees determine that a given set of tests provides for a conservative chemical effects evaluation could provide a basis to resolve this question.

12. Tests are initially conducted for an extended period at an intermediate temperature and low pH to account for the test equipment's inability to test at the short-term, peak post-accident temperatures. Alion considers the extended period at a lower temperature and lower pH to be conservative. What is the basis for considering that this is conservative with respect to material degradation (e.g., corrosion of aluminum)?

13. The acids HCl and HNO3 are added early in the test sequence; however, in the actual accident scenario they will build in slowly over the mission time due to the degradation of cables and other sources. At a plant for which the primary precipitates are aluminum-based, the staff generally expects that a conservative test would attempt to produce an upper-bound pH early in the test sequence to maximize the corrosion of aluminum, and to produce a lower-bound pH later to encourage precipitation. Therefore, why is it acceptable to add all of these acids generated in a 30-day period in an addition during the early stages of the 30-day test?

14. For the tests observed by the staff, the majority of the LiOH was added with the buffer, with only a small portion (one tenth of total) being added with the boric acid. At VUEZ, the buffer and larger portion of LiOH are added over a period spanning several hours after boric acid injection in the tank; however, in an accident scenario at a plant, the LiOH would be present from the onset of the event. Why is the delayed injection of LiOH acceptable? Would the presence of the LiOH early in the test allow for a higher starting pH and therefore increased corrosion of materials such as aluminum?

15. In several of the tests observed by the staff, the debris bed materials (Nukon, TempMat, calcium silicate, surrogate dirt, etc.) were allowed to sit in the baby loops for roughly 8 to 10 hours prior to other materials and chemicals being added. This resulted in the de-ionized water climbing in pH from 7 to 9.6 prior to addition of other materials. This phenomenon would not exist in an actual accident scenario because of the boric acid and buffer in the pool. What is the impact of this initially high pH? Does it create a more conservative or less conservative scenario when considering dissolution of materials early in the test sequence and precipitation of materials later in the test? In addition, has benchmarking been done to discern whether similar amounts of materials that have been packed into sample baskets can result in similar impacts on the pH?

16. The existing VUEZ testing does not address the effect of a sudden temperature drop from a heat exchanger and the potential for thermal cycling. During the teleconference, Alion stated that equipment was being procured to analyze this effect. Additional detail on how these tests will be conducted and their results could provide a basis to resolve the issue.

17. Zinc and aluminum coatings are being represented by increasing the surface area of zinc and aluminum coupons. Is the dissolution of large pieces of these metals representative of the dissolution of significantly

smaller chips or particles of failed coatings debris (e.g., in terms of surface-area-to-volume ratio)? Could the corrosion rate be different for different sizes of materials?

18. As discussed during the recent phone call, the rapid addition of buffer to the VUEZ test loop has been shown to cause a temporary increase in head loss. What is the cause of this observed increase in head loss?

19. The protocol for the tests observed at VUEZ was to boil the Temp-Mat and Nukon fibers to drive off the binder material prior adding the fiber to the tanks. In a similar fashion, some of the Temp-Mat material was baked to help drive off any binder material. The staff agrees that in a traditional head loss test (one not considering chemical contribution from the test materials) it may be preferable to prepare the fibers in this way because it simulates the interaction of the fibers with hot surfaces during service and the hot reactor fluid after an accident. However, in an actual accident scenario some binder material could be present in the sump pool and could potentially contribute to chemical effects. In contrast, at VUEZ, the water used to boil the fibrous debris is drained off and never added to the test tank. Why is it acceptable to not include the binder material in the test tank? What is the composition of this material and what is the potential impact on chemical effects?

20. For the tests observed by the staff, care was taken to thoroughly mix the tank fluid (by mechanical mixing) after the addition of the boric acid. This was done because, as VUEZ personnel indicated, it can take longer than 4 hours for complete mixing of the test tank fluid. This same procedure is not used when the buffer, the HCl, the HNO3, and the last portion of LiOH are added later in the test. This is due in part to the inability to get a mechanical mixer in the tank due to physical limitations caused by the volume taken up by coupons and baskets of material in the tank at the time of those additions. The mixing of these chemicals into the bulk fluid will take even longer due to the complex geometries and uneven flow zones created by the coupons and baskets. The reason that this is a potential concern to the staff is that the timed removal of coupons and baskets is based on the time allowed to interact with these chemicals. If the chemicals are not well mixed then the coupons and baskets may not be getting the chemical interaction they are assumed to get prior to removal. As an example: An aluminum coupon is placed in the tank at time zero. The chemicals are then added and the time of interaction of that coupon, as modeled based on the time of exposure to containment spray, begins. After 4 hours of interaction the coupon is removed. However if the chemicals, or the coupon/basket, were isolated in a low flow / unmixed zone of the tank, the actual time of interaction may be far less. How is this potential phenomenon accounted for?

21. The staff had several questions concerning the modeling of the interaction of the test fluid with the debris samples and coupons in the test tanks. Many of the debris sample baskets used for the testing are shaped like a tray, allowing for fluid interaction with the material in the basket only through one open "screened" surface. Thus, due to the geometry of the sample baskets, there is only minimal flow of water past the samples, which reduces the ability of the test fluid to interact with the sample materials. This problem is compounded when the baskets are densely packed with debris, which the staff observed for several tests with large debris quantities, including cases where one material was densely packed on top of a second material inside the basket, providing this material a shielding effect from the test fluid. In addition, several of the tests observed by the staff required large quantities of debris that filled a significant fraction of the available test tank volume. Stacked or closely spaced baskets have the potential to limit further the interaction of the test fluid with the sample materials in the baskets. In addition, the staff observed in one test that a sample coupon was inserted in the test tank with one side very close or adjacent to the wall of the test tank, which appeared to prevent significant flow of the test fluid to approximately half of the coupon surface area. All of these issues are tied to the staff's larger concern that the sample materials added to the test tank may not be able to interact with the test fluid in a representative manner. As a result, fewer chemical species could be dissolved into the test fluid, and therefore there may be a non-representative reduction in the potential for formation of chemical precipitates in the VUEZ test loop.

22. In the tests observed by the staff, several liters of test fluid had to be physically removed in order to add all of the debris and buffering chemicals. This removal results in the fluid volume of the test tank being reduced and the concentrations of the chemicals in the loop being varied from the test specification. How is the physical volume change due to addition of debris accounted for in the modeling of chemical concentrations?

23. Removal of materials from the test tank: (1) By the end of the test, based on the procedures provided, approximately 5% of the loop volume could be removed through the process of sampling the test volume (including any dissolved and suspended species). (2) Small quantities of particulate that are considered non-transportable are not included in the test for their chemical impacts (e.g., ALION-CAL-SONGS-4194-03, Rev. 2, Pg 29 of 35). How much of these materials may be removed without significantly affecting the test results?

Test Procedure / Miscellaneous

24. Confidence should exist that the VUEZ tests are repeatable. Alion discussed TMI testing that is currently underway and stated that it has shown some evidence of repeatability thus far. The staff expects that data for slightly varied test conditions should also be capable of providing evidence of repeatability if it correlates with expected behavior.

However, based upon the staff's observations from the trip to VUEZ, evidence for the repeatability for the debris bed formation process was not conclusive. Although some of the tests appeared to demonstrate repeatability, other tests demonstrated significant variability. Among the tests observed by the staff included two pre-test cases, four test cases, and two repeat test cases that became necessary when significant portions of two debris beds floated away.

25. How are measurement uncertainties accounted for / propagated through the analysis? Between the flow rate measurement, flow control, head loss measurement, and temperature measurement, there could be a relatively high uncertainty associated with the head loss results. (Variances of independent random variables are additive.) In addition, uncertainties associated with temperature could affect the timing of the corrosion process – for example, Alion approximated in its test procedure that corrosion rates double about every 18 °F – and thus the timing of precipitate induced head loss.

26. The staff requests a copy of the test procedure for the large VUEZ loop and is interested in any experience from this loop with regard to debris bed formation and other issues discussed above regarding the small loops, such as a comparison of head loss results to prototype testing, settling, and circumscribed scaling. Based on the staff's observations of a pre-test conducted for one plant in the large loop, a number of the issues described above may similarly apply to testing in the large loop.

27. What is the schedule for providing a copy of the report on the deterioration of alkyd coatings in post-LOCA containment pool to the NRC?

28. The staff noted several quality assurance issues associated with the testing. During one of the tests that was nearly completed the staff observed a sample material basket that had been resting screen-side down (presumably for the duration of the test), such that no basket surfaces were open for fluid interaction with the test fluid. As a result, no leached material from the debris samples in this sample basket could have participated in the test. During tests for a different plant, the procedure required that boiled Temp-Mat be added to the tank; however, the Temp-Mat that was added to the tank did not appear to the staff to have been boiled. After significant parts of 2 of the 4 formed debris beds floated away, the vendor then stated that it was not clear that the Temp-Mat had been boiled and attributed the partial floatation of the two debris beds to the

Temp-Mat not having been boiled. Why is there confidence that these sorts of quality assurance issues have not occurred during previous tests and will not occur again in future tests?

29. Very few photographs were taken by the vendor during the staff's visit. The staff considered it beneficial for Alion to consider documenting key steps in the test procedure (e.g., the prepared debris, the process of adding debris to the test tank, the quantity of settled debris in the tank, the formed debris bed, the removed debris bed and sample coupons, etc.) with photographs and/or video, because such tools provide a valuable record of how a head loss test was conducted.