# NRC Staff Questions REFORMATTED Into Three Topical Areas

**(Enclosure 3 to ML080510080 phone call summary of October 31, 2007 and November 29, 2007 phone calls with Alion)**

**Enlosure 3**

Alion Follow-Up Issues

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. One means of resolving this issue would be to demonstrate that head loss results from integrated tank testing are approximately equal to head loss results from VUEZ testing prior to the addition of chemicals, 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. 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?

4. 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. At present, sufficient information is not available to the staff to determine that not performing thin bed tests in the future is 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. If a future decision is made that performing thin bed tests is unnecessary, further discussion of the technical basis underlying this decision could help to resolve the staff's questions in this area.

5. While the large VUEZ loop 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.

6. 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 strainer designs, fines may be the only debris size that actually reaches the strainer), and that the surrogate debris used matches the plant-specific size distributions from the debris transport calculation. Observing test practices at VUEZ may provide a basis to resolve this issue.

7. It is important to ensure gas release and boreholes do not disrupt 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. Staff review of additional test results demonstrating these points could provide a basis to resolve the issue.

<u>Chemical Effects</u>

8. 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.

9. Tests are initially conducted for an extended period at 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 low temperature to be conservative. What is the basis for considering that this is conservative with respect to material degradation (e.g., corrosion of aluminum)?

10. 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.

11. 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?

12. 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?

13. Removal of materials from the test tank: (1) By the end of the test, based on the procedures provided, approximately five percent 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?

<u>Test Procedure / Miscellaneous</u>

14. Confidence should exist that the VUEZ tests are repeatable. Alion discussed TMI testing that is currently underway that has shown some evidence of repeatability thus far. Data for slightly varied test conditions can also show evidence of repeatability if it correlates with expected behavior. Staff review of additional VUEZ data could help resolve this issue.

15. 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.

16. 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.

17. 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?