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March 10, 2008
261-4779-LTR-04

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

Reference:
1. Alion Letter 261-4779-LTR-01, Dated February 8, 2008 entitled Resolution of NRC Questions Regarding ALION VUEZ 30 Day Testing Program Status of Responses.
2. NRC Questions – Alion Follow Up Issues – Corrected-Bolded, sent February 13, 2008.

Dear Mr. Scott:

As stated in the Reference 1 letter, the attached is our responses to Alion Problem Statement Nos. 1 and 4. These issues primarily deal with the development of the debris bed. Our original schedule indicated that we would also respond to the development of the chemical effects bump up factor (NRC Issue #8) in this letter. However, we will defer the bump-up factor discussion to a future letter to better focus this discussion on the development of the debris bed.

A table has been included indicating the status of each open item. The NRC comments and questions are taken from Reference 2.

Alion Problem Statement No. 1

Provide the basis for the debris bed preparation, including the size characteristics and method of formation relative to the prototype debris bed.

This response encompasses NRC comment No. 1, 3 & 4.

1. ***Alion should 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.

3. ***Alion should demonstrate (a) why the addition sequence for the VUEZ test debris is representative of the actual plant condition and (b) the basis for using a bump-up approach in light of the fact that a different debris addition sequence was used in the Warrenville array tests and the VUEZ tests.***

4. ***Alion should (a) ensure that debris added to future tests is in a form that is representative of the plant debris described in the debris transport calculation and (b) demonstrate that testing conducted to date with a generic size distribution that led to significant debris clumping is adequately representative of the plant conditions predicted in the debris transport calculation.***

Response:

The VUEZ 30 day debris head loss testing represents a combination of ICET and vertical loop debris head loss testing. The screen installed in the experiment is a horizontally oriented flat plate on which the plant specific debris bed was developed and head loss measured (see Figures 1a through d). The screen is slightly spherical on the bottom to inhibit the formation of voids that may build up underneath the debris bed. The sump solution is circulated in the areas outside the suction plenum and drawn down through the debris bed and recirculated.

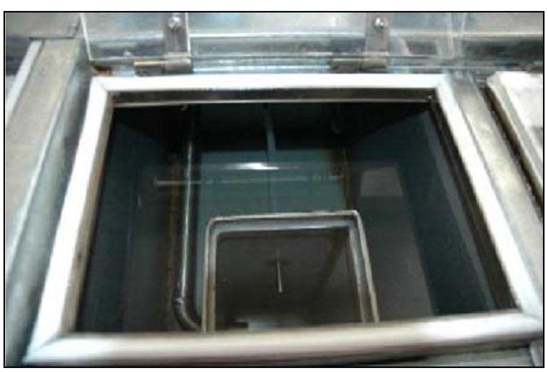


Figure 1a – Inside view of tank

Figure 1b – Inside view down suction plenum

Figure 1c – Screen Element

Figure 1d – Formed Debris Bed

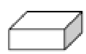
The debris beds developed in the VUEZ test loop provide a representative, average debris bed (bed thickness and composition) on which the impact of chemical effects was measured over the 30 day mission time.

The following sections present the debris size characteristics and bed formation process. Following these sections Alion will discuss the basis for the debris size, bed formation and representativeness of the bed to the non-chemical prototype tank tests.

Debris Size Characteristics

The debris bed composition and thickness selected for the VUEZ chemical effects experiments is based on the range of plant specific debris loads and size characteristics determined in the plant-specific debris generation, transport, head loss analysis and prototype testing. Based on the results of the plant specific debris generation and transport analysis, the expected debris characteristics on the sump screen contain all three (3) sizes of fibrous debris: fines, small pieces (< 6" on a side), and large pieces (> 6" on a side). Although the distribution of these sizes may vary from plant to plant, all three (3) are generally represented in the plant specific debris load at the screen (with the exception of a latent fiber loading which is represented exclusively as fines). While prototype screen testing uses a debris mixture that includes both fines and small pieces, for the VUEZ experiments, a smaller size distribution was selected that is primarily represented by Classes 1 through 5 in Table 3-2 and Figure 3-3 (NUREG/CR-6808). This ensures that the characteristic size of the debris is small compared to the characteristic size of the Vuez screen. Further, this leads on average to a higher debris density, which is expected to maximize the impact of any chemical precipitates that might form.

Table 3-2 Size Classification Scheme for Fibrous Debris[3-2]

No.	Description	
1		Very small pieces of fiberglass material; "microscopic" fines that appear to be cylinders of varying L/D.
2		Single, flexible strands of fiberglass; essentially acts as a suspending strand.
3		Multiple attached or interwoven strands that exhibit considerable flexibility and that, because of random orientations induced by turbulent drag, can exhibit low settling velocities.
4		Fiber clusters that have more rigidity than Class 3 debris and that react to drag forces as a semi-rigid body.
5		Clumps of fibrous debris that have been noted to sink when saturated with water. Generated by different methods by various researchers but easily created by manual shredding of fiber matting.
6		Larger clumps of fibers lying between Classes 5 and 7.
7		Fragments of fiber that retain some aspects of the original rectangular construction of the fiber matting. Typically precut pieces of a large blanket to simulate moderate-size segments of original blanket.


Fiberglass shreds in size Class 3


Fiberglass shreds in size Class 5

Figure 3-3. Fiberglass Insulation Debris of Two Example Size Classes

<u>Debris Bed Formation</u>

The fibrous materials are either dried in an oven or boiled to remove the oils or gasses trapped within the fibers. This process helps to ensure that the materials do not agglomerate, float and simulate aging (lose resiliency). The material is then shredded (Figure 2) consistent with standard head loss testing practices (leaf shredder, cuisenart, etc.) to resemble the size distribution presented in Table 3-2 and Figure 3-3. The particulate surrogates are procured with an average size distribution near 10 micron.

The fiber and particulate mixture is thoroughly mixed in a beaker containing the test solution (Figure 4 a & 4b). The mixture is slowly added through a funnel to ensure an even distribution across the test screen area while the pump is circulating (Figure 5). The bed is constructed to be uniform (minimal clumps, unevenness, etc.) to the extent possible by the technicians. A close up of actual completed bed (witnessed during the NRC visit) is provided in Figure 6.

Figure 2 – Debris Shredding

Figure 4a – Debris Blending

Figure 4b – Debris Slurry

Figure 5 – Debris Bed Formation

Figure 6– Final Debris Bed

Discussion

The concern by the staff appears to be clumpy-ness of the debris bed and technique of forming the debris bed by moving the funnel containing the material around the screen area witnessed during one of the experiments. It was pointed out by the staff that this does not appear to represent the debris bed formed in the non-chemical tank test – thereby questioning the application of any results. The issue boils down to the representativeness of the debris bed porosity at VUEZ compared to that of the non-chemical tank tests. Although the concern is primarily driven by the observed debris bed formation, the staff also eludes to the relatively low head loss results at VUEZ. We'll begin to address this issue first with the comparison of the beds formed during the non-chemical tank testing (e.g., Warrenville Hydraulics Lab, CDI, etc.).

First, the materials are procured by Alion and received at the Warrenville Laboratory; they are subsequently packaged and sent over to VUEZ. The materials (fiber, particulate, Cal-Sil, etc.) therefore are identical between the two facilities and experiments. Alion's process for "destroying" bulk fibrous insulation is to run the fiber blanket through a leaf shredder, which is common industry practice. The fiber is then weighed and boiled to remove oils and trapped gases that may cause the fibers to float when introduced into the tank. The soaked fiber is then poured into a larger mixing container (5 gallon bucket) with more water and particulate. The particulate and fiber slurry is then "mixed" or "beat" using a motorized paint mixer (attached to a drill). The non-chemical test consists of a full tank of water circulating through the prototype screen at the prescribed flow rate and temperature. The 5 gallon bucket(s) are then dumped into the large tank with the prototype screen in the discharge (return) flow to minimize settling. Most of the material accumulates on the sump screen. Some of the material tends to sink and collect in corners of the tank. This material is "agitated" by trolling motor, paddles, stirs, etc., to coax it onto the screen. This process is designed to ensure that the debris accumulates on all surfaces of the screen with minimal gravitational settling. As the debris collects on the screen and develops head loss, additional debris is attracted to those clean screen areas based on velocity. The debris loads or distributes in such a manner as to maintain the lowest possible head loss through the entire surface area. The resulting debris beds are shown in Figure 7.

The debris materials for VUEZ are bulk processed the same way in that they are shredded, boiled and then baked as shipped materials need to be dry. VUEZ processes the debris materials further and finer as described earlier in this letter. A sampling of 6 different debris beds is provided in Figure 8. As evident from the two (2) sets of pictures, the VUEZ beds are reasonably representative, and "finer" than those used in the non-chemical tank testing.

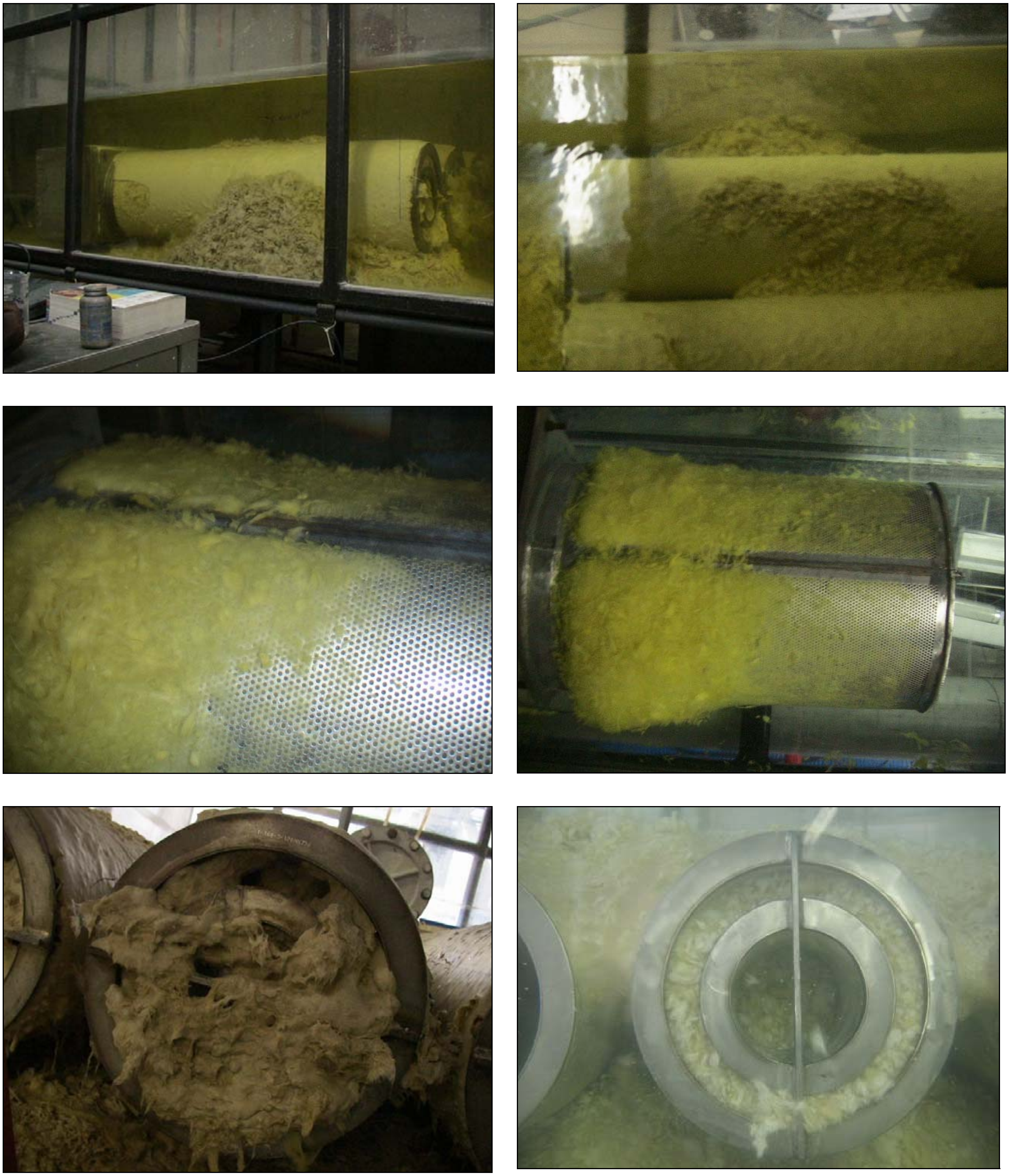


Figure 7: Sample Non-Chemical Tank Testing Debris Beds

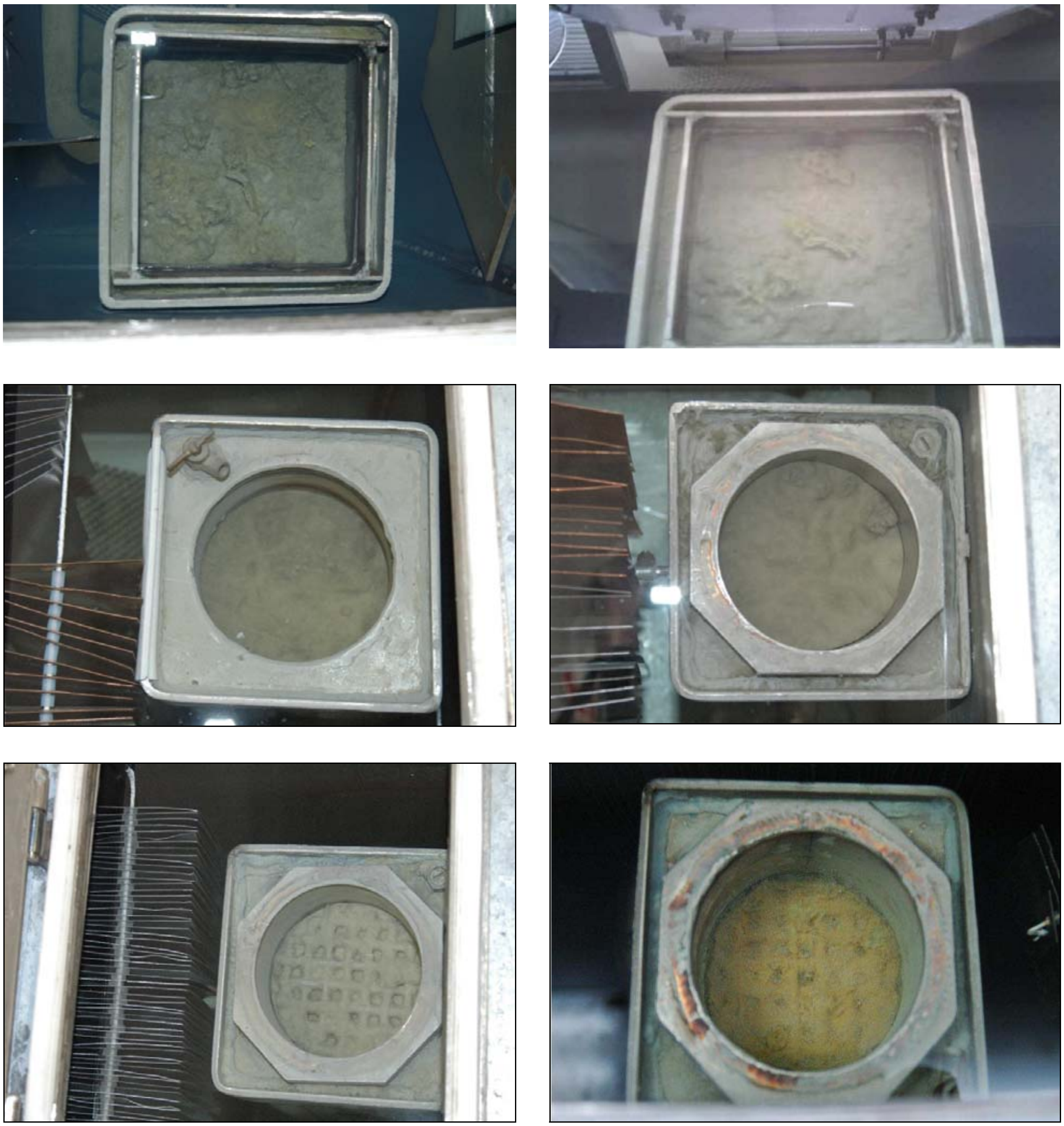


Figure 8: Sample VUEZ Vertical Screen Debris Beds

Secondly, we'll discuss the head loss characteristics (porosity and compression) between the two experiments. Historically, it has been shown that uniform debris beds produce higher head losses than non-uniform debris beds. The competition between the gravitational and hydraulic shear forces can lead to non-uniform velocity profiles on vertical screens. Low velocity, combined with a high specific gravity of debris fragments, can cause debris to preferentially accumulate near the base of a vertical screen, leaving the upper portions of the screen relatively clean. It is for this reason that up to a certain point, uniform beds on a flat horizontal plate yield higher measured head losses than the same quantity of debris (amount per unit surface area) collected on an "advanced geometry" strainer array. The reason for this is the tendency for real strainer hardware to collect debris in a non-uniform manner. Care must, however be taken to ensure that the debris distribution on a flat plate is indeed as uniform as possible.

Flat plate testing is typically done with a horizontal plate configuration to control the exact amount of debris collected. Because the gravitational settling velocity of the debris as it is being deposited on the strainer plate is high relative to the natural approach velocity of the flow through the strainer plate, care must be taken to ensure that random non-uniformities in debris distribution on the plate surface do not occur. The technique used by the VUEZ technicians is designed to produce to the extent possible a uniform and homogenous debris bed. One way in which this is done is by taking care to introduce debris uniformly above the plate such that even through gravitational settling, a relatively uniform debris layer would result. In addition, the rate of debris introduction is controlled. In this way, any temporary variations in bed porosity (thickness) will result in flow being redistributed to other portions of the strainer such that debris is preferentially collected there. Finally, a visual inspection of the resulting bed is performed to ensure that relative uniformity is achieved. Manual adjustments to the bed may be made for small improvements in uniformity. Any residual non-uniformity in the debris distribution of a poured bed is significantly less than the non-uniformity exhibited in the collection of debris on actual strainer hardware.

In the beginning of the prior paragraph, it was emphasized that flat plate test results yield higher measured head losses than actual strainer hardware up to a point. There are two reasons for this limitation as will be discussed below for the examples cited by the staff. One has to do with the quantity of debris and reduction in effective strainer surface area as filling of any interstitial volume occurs, and the other is the impact of the clean strainer head loss for complex strainer geometries. Thus, the examples cited by the staff relative to SONGS and TMI are not unexpected and can be explained by the following:

The TMI array head loss was higher than the flat plate head loss. This was expected as the debris bed volume (thickness) begins to fill in the interstitial volume of the prototype array and therefore the geometry effect causes an increase in head loss over that of a flat plate. Also, the TMI array test included a bypass mesh and clean screen head loss. The head losses should have been slightly higher than VUEZ and they were.

The SONGS array head loss was higher than the flat plate head loss because of the impact of clean screen, which results in an additional head loss due to the primarily turbulent flow interior to the top-hat strainer design. The only VUEZ loop that produced no head losses cited by the Staff was the Microtherm loop. This is because there is insufficient fiber to cover the screen and Microtherm (and any chemical precipitates) will pass through the screen. Similar observations were made during the associated array test. During the array testing, only a portion of the screen becomes covered with the latent fibers and the Microtherm is only filtered over that portion of the screen. It is known that Microtherm can cause significant head losses on a fiber bed. As a result of the Microtherm/latent fiber covering the lower regions of the vertical top-hat array screen, the flow was redirected through the upper clean portions of the array (recall that the top hats are oriented vertically in a pit with the flow at the bottom). Redirecting the flow through the upper clean portions of the top-hat array forces the flow to transverse down the full length in the annular regions of the top-hats, which are filled with woven wire mesh. This is a more torturous and turbulent flow path and causes an increase in head loss. However, subsequent introduction of chemical precipitates would not increase the fraction of the screen area covered by debris.

Comparing the array non-chemical prototype debris head losses with the flat plate debris head losses without chemical effects illustrates the impact of strainer geometry and non-uniform flow fields on debris accumulation and resulting head loss. The impact of chemical effects alone is seen through a comparison of flat plate debris head losses with and without chemical effects.

Therefore, in response to the NRC questions,

1. **Alion should 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.**

The previous sections have provided the basis for the use of the debris bed formed in a vertical loop as appropriate for determining the impact of chemical effects. The basis that the debris beds formed at VUEZ are representative of the debris beds in the non-chemical tank test is that 1) the materials are procured, received and processed in an identical manner through procedure, 2) the debris materials shipped to VUEZ are further processed to a smaller size distribution based on the smaller screen size, 3) the beds visually look similar and exhibit similar head losses and 4) the uniform horizontal debris bed is a conservative representation of a non-uniform bed.

Also it should be pointed out that all debris is deposited on the screen in the VUEZ loops. Although every attempt is made to ensure all debris is deposited on the screens in the non-chemical tank testing, it is physically impossible due to tank hydraulics – however this amount is not significant. Under the Alion test programs, whether VUEZ or Warrenville, all debris is deposited at or on the screens. Alion does not credit near field settling in the non-integrated tank testing and consequently the staff's term "formed under flow" is a misnomer as the intent of the Warrenville tank tests (or any vendor that does not credit near field) is to accumulate all debris as uniformly as possible on the screen surfaces thereby producing the highest possible head loss. We do this through sweeping, trolling motors, paddles, etc. This technique has already been deemed conservative by the staff. The technique used by the VUEZ technicians is implementing the same requirement: ensure all debris is accumulated on the screen in a uniform and homogenous manner.

Alion has provided a comparison in ALION Letter 261-4779-LTR-02 between a temperature corrected head loss as measured in a vertical loop experiment in Alion's Warrenville Laboratory and that measured in the VUEZ loop (in this case the Indian Point loop). The differences between the loops is negligible and thusthere is high confidence in the development of a uniform debris bed by the VUEZ technicians. Alion has performed similar comparison of the beds formed for TMI, PSL-1, PTN-3 and others as part of our pre-test activities, with similar agreement.

3. **Alion should demonstrate (a) why the addition sequence for the VUEZ test debris is representative of the actual plant condition and (b) the basis for using a bump-up approach in light of the fact that a different debris addition sequence was used in the Warrenville array tests and the VUEZ tests.**

As stated above, the addition sequence used at Vuez is consistent with the integrated tank testing, whereby the debris is homogenously mixed external to the tank and added in close proximity to the screen to ensure no near field settling. In the larger Warrenville tank, technicians implement external measures (trolling motors, diffusers, paddles, etc.) to move the debris onto or near the screen to promote accumulation. In the VUEZ tank, technicians control the introduction of debris to ensure uniform accumulation. As stated earlier, this addition sequence is designed to ensure all the debris accumulates on the surface of the screen and provide the highest possible head loss. In the actual plant condition, the debris load would be much more non-uniform and for reasons cited produce a lower overall head loss. In fact, the overall approach of ensuring all the debris is resident on the screen is conservative as this neglects the effects of gravitational settling of the debris. It should also be noted that the simultaneous addition of fibrous debris and particulate is consistent with the expected simultaneous transport of these materials in an actual LOCA event.

The development of the bump-up factor will be presented in a future letter. It is our recommendation that the staff not attach one issue to another. The concern presented in these questions should be limited to debris bed formation as there is already another question on the development of the bump-up factor.

4. **Alion should (a) ensure that debris added to future tests is in a form that is representative of the plant debris described in the debris transport calculation and (b) demonstrate that testing conducted to date with a generic size distribution that led to significant debris**

clumping is adequately representative of the plant conditions predicted in the debris transport calculation.

As stated earlier, the debris size distributions selected for the VUEZ tests is based on smaller than required debris size distribution. There is no evidence that testing conducted to date with this small size distribution leads to significant clumping. It should, however, be noted that some clumping of fine debris is observed in these and all head loss tests that have been conducted by Alion. This is simply as a result of the natural agglomeration tendency of fibrous debris.

Alion Problem Statement No. 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?

This response encompasses NRC comment No. 9.

9. **Alion should (a) demonstrate that flow diversion through the thinner debris bed cross section caused by circumferential warping has not had a significant adverse impact on testing conducted at VUEZ and (b) describe measures taken to prevent or minimize this observed phenomenon in future testing.**

Response:

As a result of void formation in the earlier experiments, ALION/VUEZ modified the suction piping in the intake plenum to bring the suction closer to the voids and enhance the ability for these to become entrained in the annular region surrounding the test screen. To date, there has been no evidence of circumferential warping as this condition cannot occur from the piping suction at two diametrically opposed points above the bottom of the screen. There may be an apparent warping or depression in the debris bed, but this is caused by the spherical shape of the screen.

Alion has seen a few debris beds that may shrink under the high temperature and environmental aging associated with the chemistry and pull away from the sides of the debris cup (Figure 7). Although the debris beds still exhibit appreciable head loss, there is a concern regarding by-pass flow around the edges of the debris bed. This condition was identified by Alion and the NRC during their visit. To preclude any apparent issues associated with by-pass flow due to environmental effects (shrinkage), ALION/VUEZ modified the test screen by welding a seal ring in near the bottom. This essentially creates an o-ring to prevent by-pass flow. The bed is compressed down onto and under the seal ring to provide a more effective seal in the event of bed shrinkage at the perimeter.

The results to date have not changed appreciably with and without the metal o-ring. Alion has not identified any bypass flow in the earlier testing. The change to install the o-ring was an improvement to remove any concern that might arise. The installation of this o-ring does not in any way imply that by-pass flow was observed in the past or question the results of the earlier work.

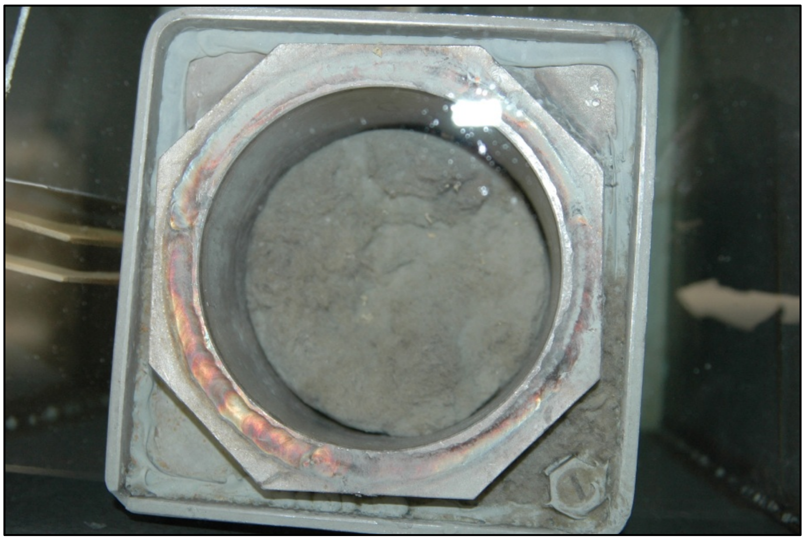


Figure 7 – Example of Bed Shrinkage

Figure 8 – Modified Screen with Seal Ring

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	Status
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.	Mar 10, 2008	LTR-04
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	LTR-02
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	LTR-02
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?	Mar 10, 2008	LTR-04
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	

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

No.	NRC Issue/Comment	No.	ALION Problem Statement	Completion Date	Status
2	Technical basis of bump-up factor	8	Provide the basis for the bump up factor and illustrate with an example.	Mar 14, 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	LTR-02
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	LTR-03
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	LTR-02

No.	NRC Issue/Comment	No.	ALION Problem Statement	Completion Date	Status
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	LTR-02
27	Copy of alkyd coatings chemical report	18	Provide a copy of the alkyd coatings chemical report?	Feb 15 2008	LTR-02
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	