Department of Energy
Washington, DC 20585

AUG 05 2011

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004-2901

Dear Mr. Chairman:

Thank you for your June 7, 2011, letter expressing concerns on the use of the Low Order Accumulation Model (LOAM) by the Waste Treatment Plant (WTP) Project at Hanford. LOAM is a very simple representation of the fluid physics in the WTP vessels. The LOAM model has provided insight into the operation and performance of pulse-jet mixing (PJM) of WTP vessels. WTP is not relying upon the analysis and methodology (i.e., LOAM) previously reviewed by your staff, but is proceeding with Large Scale Integrated Testing (LSIT) in response to the Defense Nuclear Facilities Safety Board's (Board) Recommendation 2010-2, *Pulse Jet Mixing at the Waste Treatment and Immobilization Plant* as the basis for the final WTP PJM tank design.

With respect to the three concerns stated in your letter, each one is addressed separately below:

1. *State whether the Department of Energy (DOE) will continue to use LOAM as the computational model for accumulation of solids in the WTP vessels and for what purpose(s), as well as the technical rationale for each use.*

   The LOAM model has not and will not be used for design work. LOAM was only being used as it relates to closure of the prior External Flowsheet Review Team Major Issue 3 (M3), "Inadequate Design of Mixing Systems" in assessing vessel performance and as a preliminary assessment tool for computational fluid dynamics verification and validation data gap analysis.

2. *Provide an approach for formal verification and validation of LOAM (if DOE continues to use it).*

   The WTP Project has no current plans to perform verification and validation of LOAM since there is no intent to use LOAM as a design tool.

3. *Explain how the issues identified in the staff report will be addressed during large-scale testing for all WTP vessels.*

   WTP project work on LSIT is underway to inform and complete the required design verification activities and to address the Board's Recommendation 2010-2. During LSIT, tests will be performed demonstrating mixing performance, with prototypical equipment and using Newtonian and Non-Newtonian simulants with limiting rheological and particle settling components, in conjunction with Computational Fluid Dynamic calculations for determining mixing performance. The enclosure to this letter responds to the specific issues raised in the staff issue report dated April 12, 2011.

DOE looks forward to working with you and your staff in this area as we develop the Implementation Plan for Recommendation 2010-2.

If you have any further questions, please contact me or Mr. James Hutton, Acting Deputy Assistant Secretary, Office of Safety and Security Program, at (202) 586-5151.

Sincerely,

David Huizenga
Acting Assistant Secretary for
Environmental Management

Enclosure

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Waste Treatment Plant Response to the Defense Nuclear Facilities Safety Board: Low Order Accumulation Model (LOAM)

The Staff Report highlighted specific issues relating to LOAM. The following responses are specific to those concerns, starting with accumulation of solids. With respect to the other three concerns noted in the Board's letter: zone of influence, cloud height, and rheological properties, it was not the specific intent of LOAM to address these parameters. The information below is intended to clarify the WTP position on those topics, but will not to be explored further relative to LOAM, as it will not be used as a computational tool relative to tank design and analysis of these properties in the future.

Concern: ***Accumulation of solids*** - Small-scale test results showed that large particles remained in the test vessel as the pump-out finished and that accumulation of solids over multiple batches should be expected. However, LOAM predicted the opposite behavior. These differences between the predicted behavior and small-scale test results involving the accumulation of large particles can be explained by a fundamental flaw in the mechanics of the LOAM calculations. This modeling flaw artificially influences the predicted removal of rapidly settling particles and makes it impossible to model accumulation of solids in unmixed zones on the vessel bottom.

Response: As noted by the staff, one of the main purposes of the test was to find if there were any differences in the predictions for vessel pump-out between the "chandelier" Pulse Jet Mixer (PJM) array design used in the Non-Newtonian Vessels (NNV) and the Newtonian ring PJM array. Large particle removal was correctly predicted in the Newtonian designs; previous testing in Newtonian vessels, with the same large particles, did not show accumulation and large particles were removed early as per the LOAM prediction.

The main difference in the vessel designs is the location of the pump suction in relationship to the PJM jet convergence zones. In the Newtonian vessels, the pump suction is located in the center of the vessel and at the convergence of the ring of PJM jet flows. In the chandelier arrangement, the pump suction is located near the center of the PJM, and not in a convergence zone. A key assumption in LOAM is that the suction line inlet lies in a region that is well mixed. The suction line inlet in the NNV tests was placed in the downdraft from the central PJM.

The LOAM benchmarking report, *Low Order Accumulation Model Testing with non-Newtonian Vessel Arrangement*, 24590-WTP-RPT-ENG-11-013, issued June 3, 2011, notes that testing demonstrated that LOAM was able to predict the accumulation of the large particles, if the large particles are assumed not to be removed during PJM drive because the particles are being driven past the center pump suction (see section 4.2 and figures 22 and 29 in the report).

An estimate of the fraction of solids mobilized is required to determine the concentration of the lofted solids and is calculated based upon the area mobilized on the bottom floor. The Defense Nuclear Facilities Safety Board (Board) staff report correctly points out that if an infinite number of steps were used, this could drive the concentration to zero. LOAM does not allow an infinite number of steps because it is used between the upper

batch limit and lower batch limit and the minimum size of a step is limited to a PJM cycle, so there are a finite number of steps that can be used during a pumpout. LOAM uses the particle settling velocities, the height of the pump suction, and the area cleared to predict particle removal. If a particle settles below the pump suction before the next pulse, it stops being removed from the vessel. Using the finite number of steps, LOAM can show accumulation.

Finally, with respect to aspect of zone of influence (ZOI) impacts, the PJM velocity increases as the batch volume decreases, and at the higher velocities, the ZOIs increases. As the vessel batch is emptied, if there were un-cleared areas at the beginning of the batch, they may clear by the end of the batch pumpout. It is not possible to confirm that the slow growth of dead zones would continue to increase without batch to batch testing. Multi-batch testing was not performed. However, based on analysis (*Evaluation of Batch to Batch Pumpout,* 24590-WTP-RPT-ENG-11-146) if the removal efficiency is constant the potential accumulation of large particles is limited. Multi-batch pumpouts will be completed as part of large scale testing.

The Waste Treatment Plant (WTP) Project is exploring mitigation of the large particle accumulation in the chandelier arrangement as part of Large Scale Integrated Testing (LSIT).

Concern: ***Zone of influence***-Small-scale test results showed that the radius of mobilized solids on the vessel bottom under each PJM - the zone of influence - was significantly smaller than predicted by the LOAM calculations. Thus, LOAM over predicts the amount of material that is mobilized. The Board has no confidence that LOAM uses a technically valid approach for predicting zone of influence.

Response: The purpose of LOAM was to estimate accumulation from pumpouts, not to provide a ZOI model. LOAM did not match the visible clearing area for ZOI, but for estimating cumulative solid removal it provided acceptable results. Changing the ZOI coefficient to provide a better match to the visible ZOI would be possible, but would be at the expense of cumulative solids removal result as discussed in section 4.1 of the LOAM benchmarking report (24590-WTP-RPT-ENG-11-013).

As LOAM will not be used in further design work, no further work on the model is planned to address the ZOI coefficients or modeling results.

Concern: ***Cloud height*** - The Board's analysis showed that the equations in LOAM used to predict cloud height (and subsequently the solids concentration at the tank transfer line inlet) is based on a conceptual model that lacks a sound physical basis. LOAM predictions for cloud height do not properly account for increasing energy requirements at increasing tank dimensions. Accordingly, the Board has no confidence that LOAM can reliably predict cloud height and solids concentration at the pump inlet for the actual WTP vessels.

Response: LOAM does not make an independent calculation of an overall cloud height, but tracks the particles by size and density in up to 10 bins. The upwash model is based on simple fluid physics, namely conservation of momentum equations for the confluence of the radial wall jets, tank dimensions and jet velocities, and upon the energy/power

input to the vessel. As it is a Low Order Model, it may not account for all phenomena of particles interactions that may resist upwell. It also does not include hindered settling which may keep particles suspended longer. The LOAM upwash model was not augmented in order to avoid altering accumulation results.

As LOAM will not be used in further design work, no further work on the model is planned to address the cloud height modeling results.

Concern: ***Rheological properties*** - Bechtel National Inc. testing used a Newtonian fluid to assess the performance of process vessels that will contain non-Newtonian fluids. The Board believes that, without definitive supporting test data for PJM vessels at a sufficient scale, this practice is technically unjustified.

Response: Since the time of the on-site review referenced by the Board staff, WTP has issued the following report; *Determination that Non-Newtonian Vessels Can Be Evaluated Using Newtonian Techniques*, 24590-WTP-RPT-ENG-11-001, issued June 3, 2011. This report was reviewed by representatives from Pacific Northwest National Laboratory and Savannah River National Laboratory and their input was accepted and contractor comments were resolved prior to issuance. A follow up meeting with the Board staff may be useful after they have had an opportunity to review the report.

Appropriate scaling of PJM vessels is part of the LSIT work, and will include Newtonian and non-Newtonian fluids with varying rheological properties.

Conclusion: In closing, WTP project restates that it is not intending to use LOAM beyond M3 closure and to inform future Computational Fluid Dynamic (CFD) data analysis. WTP project believes that the commitment of the existing designs is appropriate but that testing and calculations for design completion are necessary and are currently planned to be conducted during both the LSIT work and using CFD calculations.