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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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September 9, 2002

The Honorable Jessie Hill Roberson
Assistant Secretary for Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Ms. Roberson:

The staff of the Defense Nuclear Facilities Safety Board (Board) recently reviewed the design basis analysis for the Waste Feed Delivery (WFD) transfer system at the Hanford Site. This system will deliver Phase I high-level waste slurries from the 200 East double-shell tank farm to the Waste Treatment Plant.

In a letter dated May 3, 2001, the Board identified the need for early resolution of the appropriate minimum design pressure for the WFD transfer system. CH2M Hill Hanford Group (CHG) has additional analysis to determine this minimum design pressure rating. The Board is concerned about uncertainty in this analysis. It appears that CHG discounted the potential for larger or more dense particles, which could lead to the design of a transfer system that is susceptible to plugging. Plugging of the transfer system would delay stabilization of high-level waste. In addition, line blockages that could not be cleared by flushing could require mitigation strategies with a potential for increased radiation exposure to workers.

CHG is aware of several shortcomings in its analysis, and subsequent to the staff's review suggested that an instrumented transfer of high-level waste be performed to validate the predictions resulting from this analysis. The Board believes this demonstration would be beneficial if performed in time to support design and installation of the WFD transfer system. The enclosed report on these matters, prepared by the Board's staff, is forwarded for your information and use as appropriate.

Sincerely,

John T. Conway
John T. Conway
Chairman

c: Mr. Mark B. Whitaker, Jr.

Enclosure

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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

August 1, 2002

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: J. Malen

SUBJECT: Waste Feed Delivery Transfer System, Hanford Site

This report documents issues identified by the staff of the Defense Nuclear Facilities Safety Board (Board) during a review of the Waste Feed Delivery (WFD) transfer system at the Hanford Site. A video conference on this subject was held between the Board's staff and personnel from the Department of Energy's Office of River Protection and CH2M Hill Hanford Group (CHG) on June 12, 2002. The staff also reviewed a white paper on the selection of the particle size distribution to use in the WFD slurry transport model that was prepared by CHG following the video conference in response to the staff's comments.

Background. The Waste Treatment Plant (WTP) will treat and vitrify high-level waste (HLW) from the Hanford tank farms to create a stable waste form for long-term disposition. CHG plans to use the WFD transfer system to deliver Phase I HLW slurries from the 200 East double-shell tank farm to WTP. Existing infrastructure as well as newly installed pipes, pumps, jumpers, and valves will support the project. The minimum design pressure rating required of transfer system components must be adequate to sustain a critical flow velocity that will maintain insoluble particles in suspension and prevent plugging throughout the WFD transfer system. In addition to postponing stabilization of HLW, line blockages that could not be cleared by flushing could require mitigation strategies with a potential for radiation exposure to workers.

CHG completed a second revision of the *Waste Feed Delivery Transfer System Analysis*, RPP-5346, in March 2002. The previous revision of this analysis established minimum pressure requirements in excess of 900 pounds per square inch, far greater than the pressure ratings of existing system components. Additional laboratory work has since been completed to resolve uncertainties in the physical inputs to the analysis. Revision 2 integrates these results, which include smaller, less dense, and consequently more easily suspended particles. Most significantly, estimates of particle size have been reduced from 110 microns in the first revision to 7 microns in the current revision. The smaller particle size reduces the calculated critical velocity, with the result that the specified pressure requirements have decreased dramatically for Revision 2.

Laboratory Work. CHG and Pacific Northwest National Laboratory (PNNL) performed a Phase I waste characterization study to provide the physical input parameters (particle size and density) needed for the WFD transfer system analysis. PNNL, AEA Technologies (a third-party reviewer), and the Board's staff have identified many sources of error in this study. The principal issues are summarized below.

Particle Size—The particle size distribution within a flowing test slurry was measured using light-scattering techniques. Seven Phase I HLW tanks were sampled and analyzed in this manner. Although the resulting data suggest substantial tank-to-tank variability, a single value for the WFD transfer system analysis was determined by averaging the median particle sizes for each tank. Sieving tests and microscopic analysis were completed on a subset of these tanks to identify particle sizes as undisturbed by flow. These tests identified large particle fractions not detected by light scattering.

The Board's staff believes there is substantial uncertainty in the particle size used in the WFD transfer system analysis—primarily as a result of poor representation of large particle fractions. To quantify the large particle count accurately, preliminary laboratory estimates indicated the advisability of using a sample size of at least 16 grams. The laboratory analysis notes that the 1 gram samples used in the light scattering testing and subsequently chosen to represent Phase I HLW in the analysis may not hold representative fractions of large particles. On the other hand, CHG discounted sieving tests, which analyzed 20 gram samples and identified greater quantities of large particles. CHG personnel believe that large particles measured by sieving tests are composed of fragile aggregates that will break up under operational flow conditions. Shear stresses created by circulating flow within the light refraction instrument can be expected to break up aggregates during extended periods of circulation, potentially contributing to an underestimate of the large particle count. These shear forces were not measured, and the degree to which aggregates will break up within the WFD transfer system is unclear.

Particle Density—No laboratory test measured the effective density of particles in Phase I waste with a high degree of confidence. For this study, the PNNL and the 222-S Laboratory performed settling tests to examine the sedimentation behavior of the particles. Using the particle size distribution and settling rate data, CHG attempted to derive the effective particle density of the fastest-settling fraction. However, CHG considered the analysis inaccurate because the particle size distribution and settling tests were not sufficiently reproducible.

As an alternative, CHG used historical values of solid volume fraction and mass within Phase I tanks to estimate the particle density. This approach assumes that the particles have uniform density, rather than a distribution of densities. CHG believes this assumption is valid because agglomerated particles are formed from the same constituents, making for uniformly dense aggregates within a given tank. Additionally, this approach assumes that the interstitial liquor within the agglomerates will lower the effective density of the aggregate particles, thereby making the density estimate very conservative. No laboratory data have been cited to support these assumptions.

WFD Transfer System Analysis. An expert team, drawn in part from transfer system engineers, reviewed the laboratory data to recommend values of particle size and density for the WFD transfer system analysis. CHG also evaluated several critical velocity and pressure drop correlations. However, these correlations were derived from experiments using simple simulants containing particles much larger than those found in tank waste, with a narrow distribution of particle sizes. It is not clear that these correlations are applicable to tank waste with particles more than an order of magnitude smaller and with sizes varying by more than three orders of magnitude. In addition, using the average of the medians of the particle size distributions of seven tanks may result in underestimation of the critical velocities and pressure requirements for specific tanks with larger particles.

CHG modified the chosen critical velocity correlations to address broad particle size distributions, but acknowledges that the effectiveness of this modification has not been sufficiently verified by experimental data. Conservative modeling practices were followed in the WFD transfer system analysis, but issues remain regarding the applicability of the correlations and the uncertainty of the physical inputs to these models. For example, although CHG added a 30 percent margin to the critical velocities calculated with one particular correlation, a sensitivity analysis performed by CHG indicates that variations in key parameters can lead to results that may exceed this margin.

Conclusion. Discounting the potential for larger or more dense particles could lead to the design of a transfer system that is susceptible to plugging. CHG is aware of several shortcomings in its analysis. Subsequent to the staff's review, CHG suggested that an instrumented transfer of HLW be performed to validate the predictions resulting from this analysis. The Board's staff believes this demonstration would be beneficial if performed in time to support design and installation of the WFD transfer system.