DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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September 29, 2004

Mr. Paul M. Golan
Acting Assistant Secretary for
Environmental Management
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Mr. Golan:

Enclosed is a report detailing observations made by members of the staff of the Defense Nuclear Facilities Safety Board (Board) concerning process chemistry and facility design for the Hanford Waste Treatment Plant. These observations were developed through document reviews and discussions with representatives of the Office of River Protection (ORP) and Bechtel National Incorporated (BNI).

In general, ORP and BNI personnel recognize the need for follow-up actions that would address the issues noted by the Board's staff. A detailed discussion of these issues is provided in the enclosed report, which is forwarded for your information and use, as appropriate.

Sincerely,

John T. Conway
Chairman

c: Mr. Roy J. Schepens
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

September 10, 2004

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: J. Plaue and S. Stokes

SUBJECT: Waste Treatment Plant Process Engineering

This report documents the results of a review of various matters related to process engineering for the Waste Treatment Plant (WTP). This review was conducted August 3–5, 2004, by members of the staff of the Defense Nuclear Facilities Safety Board (Board) S. Stokes, J. Plaue, M. Duncan, and M. Sautman. Also included in this report are the results of a September 2, 2004, follow-up video teleconference on cesium ion exchange hydrogen mitigation.

Cesium Ion Exchange. Bechtel National Incorporated (BNI) completed a revised hydrogen mitigation design for the cesium ion exchange column using a nitrogen inerting system. Overall, the BNI design represents a significant improvement over previous designs. However, the new approach is based on controlling to a limiting oxidizer concentration (LOC) rather than to the hydrogen lower flammability limit (hydrogen may be present in potentially explosive concentrations). An initial review by the Board's staff indicated that BNI's choice of LOC and subsequent calculation of inerting volume may not have been consistent with Chapter 5 of National Fire Protection Association (NFPA) Standard 69, *Explosion Prevention Systems*, and could have resulted in a potentially unsafe condition.

During a follow-up teleconference, the Board's staff was encouraged by BNI's modified calculation, which reflected a more conservative LOC and safety margin for the inerting volume. In addition, the staff awaits the outcome of assessments by both Department of Energy's Office of River Protection (DOE-ORP) and a BNI Integrated Safety Management panel on the applicability of NFPA 69 requirements to the ion exchange system, as well as other flammable gas vessels. In particular, the staff is interested in DOE-ORP's approach to oxidant concentration monitoring, as required by the standard. Technical issues of particular concern regard confirmation of the gas generation rate and oxidizer composition established on the basis of limited research. For example, gas generation information is based on testing of a single simulant of Envelope A waste, which may not adequately bound some waste constituents, such as transition and noble metals. In general, these metals are known to have catalytic effects on oxidation reactions, but without a mechanistic understanding of gas generation, it is difficult to gauge the margin in the limited testing.

Erosion in Melter Feed Preparation Vessel and Melter Feed Vessel Agitators. The staff reviewed the higher-than-anticipated erosion in the Melter Feed Preparation Vessel

(MFPV) and Melter Feed Vessel (MFV) agitators. BNI has determined that the greater erosion rate is restricted to the agitator assembly—not the vessel walls and bottoms (fortunately, the MFPV and MFV are designed to be replaceable). This conclusion is supported by BNI's existing calculations; however, BNI is also performing additional computational fluid dynamic modeling to verify its position. BNI has added sparge tubes for important-to-safety mixing in these tank designs. Since the sparge tubes are located very close to the impeller blades, their wear would reasonably be expected to be greater than that of the vessel itself. BNI's existing calculation does not address wear for these components. The staff pointed this out and suggested that scaled testing would be needed to fully understand sparger wear. BNI staff acknowledged that their calculation does not adequately address vessel internals and requires revision. They also stated that prototypical testing would be considered. The Board's staff also pointed out that BNI had not yet fully evaluated the impact of transferring glass former containing waste to the radioactive waste system. Staff of DOE-ORP indicated that they would perform this evaluation.

Waste Blending. DOE-ORP and BNI have recently discussed blending of difficult-to-treat wastes. For example, non-Newtonian wastes possessing characteristics beyond the current design limit will require blending before treatment, as will certain high-sulfate wastes. The Board's staff reviewed the capability of CH2MHill Hanford Group (CHG) to blend wastes in the tank farms, as well as within the pretreatment facility.

DOE-ORP is currently urging CHG to empty single-shell tanks and maximize the contents of double-shell tanks (DSTs), which could severely limit any opportunity to blend wastes in the tank farms. A review of the proposed DST tank inventory clearly shows that little if any blending capability will exist in the tank farms by 2007. The staff pointed out that CHG currently screens waste transfers using a compatibility data quality objective (DQO) based only upon safe storage requirements. Expanding this DQO to deal with treatment issues could effectively address waste blending concerns, thereby avoiding potential safety issues during WTP processing. DOE-ORP staff indicated they have the lead for waste blending and subsequently committed to working with BNI and CHG to develop a revised compatibility DQO. In addition, DOE-ORP staff appeared to understand the value of performing an analysis of the current DST inventory to determine whether wastes exist, or could be created by transfers, that could not be treated at WTP or via other proposed closure paths (i.e., orphan wastes), as well as to identify the infrastructure requirements (e.g., tank space, mixer pumps) for addressing the blending issue.

Process Chemistry Modeling. Process chemistry for WTP is modeled in several different ways. The process engineering model, which is used for all design and safety basis purposes, is derived from contractual specifications for feeds and throughput requirements. The spreadsheet-based calculations then use simple partition coefficients to determine the fate of individual elements through each unit operation. Partition coefficients have been chosen on the basis of literature values, operating experience (i.e., tank farm evaporators), or specific analytical data in support of WTP design development. Because this model is not thermodynamically based, the validity of this approach relies heavily on the choice of appropriate coefficients, as well as the intended purpose of the model run. For example, the model should utilize bounding coefficients for radionuclide, nitrate/nitrite, and organic concentrations for the purpose of determining bounding hydrogen generation rates. The staff plans to carefully review the appropriateness of values used for those modeling runs with impacts on safety.

The process operations model uses species-specific thermodynamic data in a variety of more sophisticated programming environments. This model is a contract deliverable intended as a tool for use by DOE-ORP to determine WTP capabilities for wastes beyond the commissioning feeds. It is also currently being used by BNI to determine management risk and to reconcile BNI's Research and Technology (R&T) data. The Board's staff believes the rigor and dynamic nature of this model allow for potentially more accurate results for safety cases and off-normal conditions, and therefore encourages comparisons with output from the process engineering model. However, the staff noted that verification of the model for more realistic, scaled operations was constrained to the limited scope of the Semi-Integrated Pilot Plant and selected R&T data. This raises some question about the ability of the model to evaluate future needs.

Disposition of Test Exceptions. BNI has developed a process for modifying existing R&T test plans and specifications to accommodate needed changes that arise. The staff reviewed and discussed with BNI staff a survey of approximately 10 percent of the 195 test exceptions issued to date. In general, it appears that the system has been implemented as intended, using input from the appropriate data design and safety groups. Within the reviewed sample, however, the staff observed several instances in which the documentation appeared to contain insufficient technical justification.

In one example, a procedure was modified to allow for the removal of cesium from a supernate sample to meet dose limits for a rheological measurement performed in a glovebox. The test exception approved the use of a crystalline silicotitanate ion exchange column; however, no justification was provided regarding the obvious potential for removal of solids in the column and the subsequent effect on the measurement. DOE-ORP staff stated they would perform a surveillance on the test exception process to identify any exceptions with inadequate technical justification and determine the impacts on safety and design.

Ultrafiltration Cleaning. The staff has continued to express concern regarding the adequacy of the baseline technology for cleaning ultrafilters using nitric acid. Several recent presentations by BNI to the staff have indicated that this baseline technology is adequate for the commissioning feeds. In contrast, R&T reports have noted problems with nitric acid for some feeds. For example, test report INEEL-03-00886, *Development of an Ultrafiltration Chemical Cleaning Sequence for Hanford Simulated Tank Waste, Env. A (AN-105), Env. C (AN-102), and Env. D (AZ-101)*, specifically cites problems with nitric acid cleaning of Envelope D wastes, and the authors recommend pursuing further testing of organic acids (e.g., glycolic or citric acids). It appears that DOE-ORP needs to address this potential problem now, since the capability to use alternate reagents is not currently reflected in the design, and could be difficult or impractical to implement after construction. Limits on waste throughput or restrictions on the ability of WTP to process certain wastes could result, particularly if process systems within black cells are impacted.