**Department of Energy**
Washington, DC 20585

March 5, 2012

RECEIVED
2012 MAR -6 PM 1:5
DNF SAFETY BOARD

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

Dear Mr. Chairman:

This letter responds to the January 20, 2012, Defense Nuclear Facilities Safety Board (Board) letter regarding wear allowances in the design of piping, process vessels, and Pulse Jet Mixers (PJM) at the Hanford Site Waste Treatment and Immobilization Plant (WTP). The enclosure provides additional details on plans to address the wear allowances for vessels, piping, and PJM nozzles in the WTP, addressing specific concerns raised by the Board regarding design wear rates, wear models, bounds of the models, and protection of assumptions related to operational parameters.

The Department of Energy (DOE) has reviewed the Board's specific issues and agrees that:

- Many of the assumptions used to extrapolate or scale the relationships for erosion wear are not yet verified. A design basis must be established for waste characteristics after receipt at the WTP. This design basis must account for changes to the waste feed due to process operations (including leaching, filtration, concentration, precipitation, and accident conditions). Test data that represent bounding WTP conditions may be required to supplement current cited literature sources to help verify the assumptions. The project will develop a design basis for waste characteristics due to process operations, review the wear rate algorithm for all expected operating conditions, and determine if sufficient technical information is available to verify the wear rate model.

- Additional work is needed to ensure and quantify conservatism in the wear rate models. The project will complete a revision to its wear rate calculation for WTP waste slurry systems. The revision will include additional erosion test coupon scar depth data obtained from profilometry measurements. The revision will also identify design margins available to accommodate uncertainties in the input data to establish a conservative design basis wear rate model.

- Experimental PJM wear testing data exhibited significant scatter in the scar depth measurements. Additional work is being completed to validate the relationships and assumptions used to establish the wear rate model.

Printed with soy ink on recycled paper

- A means to estimate accumulated and potential in-service wear is required. This estimate of in-service wear will be used to adjust limits on operational parameters, as necessary, to protect the safety basis assumptions and ensure maintenance of the material margin. The project's initial integrity assessment plan will be updated to reflect any new in-service inspection requirements based on the accessible locations where wear from corrosion and/or erosion are expected to be greatest.

The enclosure provides additional details on the issues and the timing to deliver the associated documents. We will provide these documents to your staff as they are completed.

The Department appreciates the Board's awareness of our ongoing efforts to develop a course of action to address wear design issues at the WTP as noted, and that the information contained in the Board's report was provided for use in the development of this plan. We will continue to maintain open dialogue with the Board and its staff as DOE proceeds. As requested in your letter, we will work with the Board staff to schedule a briefing to the Board regarding our approach to resolve these issues and progress on wear allowances testing and analysis.

DOE is committed to maintaining a hold on additional vessel placement until we have confidence that vessel wear allowances are adequate to ensure WTP can operate safely and reliably for its 40-year mission life protecting the workers, the public, and the environment.

If you have any questions, please feel free to contact me or Mr. Matthew Moury, Deputy Assistant Secretary for Safety, Security, and Quality Programs, at (202) 586-5151.

Sincerely,

David Huizenga
Senior Advisor
for Environmental Management

Enclosure

cc: R. Lagdon, S-5
M. Campagnone, HS-1.1
T. Mustin, EM-2
A. Williams, EM-2.1
K. Picha, EM-20 (Acting)
T. Lapointe, EM-41(Acting)
J. Hutton, EM-40

RECEIVED
2012 MAR -6 PM 1:
DNF SAFETY BOA

**Enclosure**

**Additional Detail on the Erosion-Corrosion Wear Allowances Concerns Raised by the Defense Nuclear Facilities Safety Board**

The following responses are in reference to: *Letter from Peter S. Winokur, Chairman, Defense Nuclear Facilities Safety Board to Mr. David Huizenga, Department of Energy, Office of Environmental Management, concerning wear allowances specified by Bechtel National, Incorporated for the design of piping, process vessels, and pulse jet mixers (PJM) for the Waste Treatment and Immobilization Plant (WTP), dated January 20, 2012.*

The Staff Report highlighted specific areas of concern relating to the design approach used by the WTP project team for determining wear allowances. The following responses are specific to those concerns. The information below is intended to clarify the WTP position on those concerns.

**Concern: Basis for Design Wear Rates -** *Source Information Does Not Match WTP Conditions* The project team applied data from sources that do not match WTP conditions. Application of the data required the project team to extrapolate and scale the data. The staff believes that without adequate validation it is questionable to extrapolate and scale the data for multiple studies where many of the experimental parameters are different, the process knowledge is poor, and variables lack independence.

**Response:** The project agrees that extrapolation of the literature data outside the range of that data without appropriate verification can lead to questions. The project team recognizes that a design basis for post-receipt waste characteristics addressing waste treatment process changes (leaching, no-leaching, filtering, concentration, and precipitation) must be established and that test data representing bounding characteristics is required to establish a bounding wear rate model when extrapolations are outside the range of literature data. The project will develop a design basis for waste characteristics due to process operations (including abnormal and credible accident conditions), review the revised wear rate algorithm for all expected operating conditions, and determine if sufficient technical information is available to verify the wear rate model. The project is reviewing the wear rate model and its use of extrapolation and scaling from multiple studies. Completion of that review will result in a revision to calculation *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004. Completion of the review is forecast for the third quarter of calendar year 2012.

**Concern: Basis for Design Wear Rates -** *Assumptions Not Validated* - The project team used assumptions to justify the extrapolations, scaling, and adjustments. In most cases, the project team based a given assumption on information from a single study in the literature. The project team stated that documentation in the literature obviates the need to validate the assumptions.

**Response:** The project is assessing where additional information may be required to verify the assumptions used in the establishment of its design algorithm in the *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004. All assumptions requiring additional information are required to be verified for confirmed calculations, as required by WTP procedures *Engineering Calculations,* 24590-WTP-3DP-G04B-00037, and *Design Verification*, 24590-WTP-3DP-G04B-00027.

**Concern: Basis for Design Wear Rates** - *Conservatism of the Wear Models* - The project team believes that its wear models are conservative, but cannot quantify the conservatism.

**Response:** The project agrees that better validation of the wear rate model is needed to provide greater confidence that wear allowances are adequate. The project obtained profilometry scar depth data on both sides of the coupons used by Dominion Engineering Inc. (DEI) in the 1/4-scale PJM wear tests. The project is reviewing the data concurrently with IMR Test Labs. The scar depth measurements will be incorporated in a revision to project calculation *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004, and will be compared to an independent report from IMR Test Labs. The calculation revision is forecast for the third quarter of 2012 and will identify conservatism in the wear rate model.

**Concern: Validation of Wear Models** - *Measured Wear is Higher Than Design Wear Rate* - Figure 1 shows a subset of the data collected during the testing to close External Flowsheet Review Team Issue M2. The plot shows the measured erosion rate (E) based on depth measurement as a function of velocity (V). Each datum on the plot represents the wear rate derived from the depth measurements made at one of 13 predetermined locations on each wear specimen. Each wear specimen was exposed to 96 hours of submerged jet flow intended to represent PJM flow against vessel bottoms at a 1/4-scale. Tests were performed using different solid concentration and particle size. For simplicity, the plotted data are limited to tests with a solids concentration of 29.2 weight percent and tests conducted with continuous flow perpendicular to the stainless steel wear coupons. The figure also plots the WTP design basis wear rate for a solids concentration of 29.2 weight percent (black curve). The data from the three different test simulants are shown as black triangles, blue squares, and red circles, which correspond to the 24μm, 39μm, and 54μm test simulant, respectively.

**Response:** The project agrees that the test data scatter does not provide sufficient evidence to validate the design basis wear rate model. Scar depth data obtained from IMR Test Labs will be reviewed to assess this concern. The project will re-assess the scope of the testing and develop a technically adequate approach to validate the wear rate model. Scar depth data has been obtained and the results are currently being review by the project. Completion of the scar depth data review is forecast for the third quarter of 2012.

**Concern: Validation of Wear Models** - *Test Duration and Measurement Methods cause Substantial Uncertainty* - The short duration used for the above testing (96 hours) did not cause enough wear to permit accurate measurement of localized wear. In many cases, the resulting wear was close to or less than the accuracy of the instrument used to measure the wear. The result was unreliable measurements and as shown in figure 1, large data scatter. The staff analyzed the data and found that the mean difference between independent measurements performed by two different analysts was 0.23 mils with a standard deviation of 0.18 mils (which corresponds to a mean difference and standard deviation of 21.1 and 16.4 mils per year [mpy], respectively). This error is substantial considering that, as shown in figure 1, the expected wear for 8 m/s flow is 40 mpy.

**Response:** The project recognizes the accuracy of the instrument used to measure localized wear was inadequate. As previously discussed, the project contracted IMR Test Labs to prepare new depth measurement data using surface profilometry. Surface profiles will replace the depth measurements that were taken at predetermined locations. The surface profiles provided by IMR Test Labs show well-developed jet impingement geometries for most test coupons. Preliminary assessment of the IMR Test Labs data reveals outlier scar depths on the DEI test coupon tested at

8 m/s and the asymmetric scar pattern, which are being evaluated. The DEI manual penetration depth measurements will be replaced by surface profilometry results reducing the data scatter and should support better alignment with the WTP PJM wear rate design algorithm. Calculation *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004, will be revised to incorporate the new test data. After completion of the revision, the project will determine if additional testing is needed to validate the wear rate model.

**Concern: Validation of Wear Models** - *Measurement Locations Do Not Support Validation of Localized Wear Rates* - The project team understood that wear resulting from PJM flow will not be uniform and determined that localized wear will be the predominant failure mode resulting from erosion. Consequently, their original test plan stated that the wear rate would be determined by measuring erosion depth. However, the test plan did not provide a method for ensuring that the depth measurements coincided with areas of maximum wear. Rather, the test plan identified predetermined locations for measurements.

**Response:** The project recognizes that the predetermined locations for measurement did not ensure the maximum erosion depth was captured in the data collected. The project has contracted IMR Test Labs to perform profilometry measurements on 8 diameters spaced at 22.5° on both the worn surface and the unworn surface of each remaining DEI PJM test coupon. The mean and standard deviation of the maximum differences between the worn and unworn surfaces will be used to determine the maximum scar depth on each coupon. The project believes the IMR Test Labs profilometry results will address this concern. Test data from IMR Test Labs has been received by the project and is currently in review. A revision of calculation *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004, will be prepared for review to determine if enough test data is available to sufficiently bound the wear rate model. The project will determine (after revision of the Wear Allowance calculation) if additional testing is needed to validate the wear rate model.

**Concern: Wear Design of Some Vessels and PJM is Nonconservative** - *Evaluation of Existing Material Margins* - The staff studied the design to determine whether it includes adequate material margin to accommodate uncertainty in waste composition and operating parameters, or allows for operational flexibility. "Operational flexibility" is the ability to increase mixing durations, waste concentrations, PJM velocities, or mission life without redesign, repair, or modification of the affected components. Such flexibility would allow for processing modifications to resolve unexpected problems that might emerge after completion of the facility. For example, although the project team addressed variations in concentration within the WTP vessels, the project team still needs to review recent studies regarding waste stratification that indicate that the fraction of large particles present in the Hanford tank waste may be greater than previously identified. Subsequent modifications to the current wear rate calculations may be required to account for particle size stratification within the vessels that could result in wear greater than currently estimated in and under PJM nozzles.

**Response:** The project agrees that operational flexibility and operational limitations need to be clearly defined. The project is working to develop operational parameters and limitations on a vessel by vessel basis using current design basis process data that consider process solution characteristic changes (leaching, no-leaching, and solids concentration) after waste feed receipt. This effort will update Process Corrosion Data Sheets (PCDS), Corrosion Evaluations, and individual vessel wear calculations based on the revised *Wear Allowance for WTP Waste Slurry Systems*, 24590-WTP-M0C-50-00004. These documents will include defining design margin in erosion and corrosion rates, assess their interactive effects, accommodate uncertainties in input

data and operating parameters, and provide input into the vessel margin calculation as part of the design verification process.

**Concern: Wear Design of Some Vessels and PJM is Nonconservative -** *Evaluation of Variation in Input Parameters* - The staff performed a sensitivity study to evaluate the relationship between the erosion allowance and variations in waste properties and operational parameters. This study revealed that relatively small variations in a single parameter could eliminate available material margin for both PJM nozzles and vessels. Even smaller variations in multiple parameters would have the same effect.

**Response:** The project agrees and will review the interactive effect of the multiple variables that affect erosion wear rates and document the review in the next update of *Wear Allowance for WTP Waste Slurry Systems,* calculation 24590-WTP-M0C-50-00004.

**Concern: Tracking of Estimated Wear and Identification of Controls -** The project team has not determined how to protect the design basis assumptions in the safety basis documents so that they remain valid. Establishing an effective surveillance program that links to the safety basis will be difficult given the limitations imposed by the black cell design. The project team stated that it expects to measure wear on hot-cell jumpers and extrapolate the results of those measurements to estimate wear on black cell piping. The project team stated that it intends to monitor the abrasivity of waste going into the plant in order to estimate and track wear on vessels and PJMs. The staff pointed out that this will be difficult since there is no direct correlation between abrasivity and impingement wear. The lack of experimental wear data for Hanford waste adds further uncertainty to the comparison. Consequently, additional laboratory testing may be required to establish valid relationships between abrasivity and wear rates to support this effort.

**Response:** The WTP integrity assessment plan, including in-service inspection is outlined in 24590-WTP-PER-M-08-002, Rev. 0, *Integrity Assessment Program and Schedule for DWP Regulated Equipment in the Pretreatment Facility and High-Level Waste Vitrification Facility.* This document provides the details for the integrity assessment program of high-level waste and PTF vessels, piping and equipment operating in black cells. It will be updated to reflect any new requirements arising from revisions to the wear rate model as the plan is further developed.

The project recognizes the difficulty in establishing a relationship between abrasivity and wear rates. If additional testing is required to establish the relationship, the project will perform that testing.