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SAFETY BOARD

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The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N. W., Suite 700
Washington, D.C. 20004-2901

Dear Mr. Chairman:

STATUS OF ACTIVITY RELATED TO OBSERVATIONS MADE IN DEFENSE NUCLEAR FACILITIES SAFETY BOARD (DNFSB) STAFF ISSUE REPORT ADDRESSING WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) PROCESS ENGINEERING

Reference: DNFSB letter from J. T. Conway to P. M. Golan, DOE, dated September 29, 2004.

The Reference letter provided DNFSB Staff Issue Report dated September 10, 2004, discussing observations made during recent reviews of WTP ion exchange, melter feed equipment erosion, waste blending, process chemistry modeling, test exceptions, and ultrafiltration cleaning topics. The Attachment to this letter provides the status of work related to these topics.

The U.S. Department of Energy, Office of River Protection will continue to work with your staff as the WTP design progresses to assure potential safety concerns are addressed. If you have any questions, please contact me, or your staff may contact William Hamel, Director, WTP Engineering Division, (509) 373-1569.

Sincerely,

Roy J. Schepens
Manager

WED:RAG

Attachment

cc w/attach:
J. Henschel, BNI
R. Tosetti, BNI
E. Aromi, CH2M HILL
M. Sautman, DNFSB
S. Stokes, DNFSB

Response to Defense Nuclear Facilities Safety Board (DNFSB) Staff Issue Report dated September 10, 2004

Cesium Ion Exchange

The U.S. Department of Energy (DOE), Office of River Protection (ORP) has completed its safety evaluation of the Authorization Basis Amendment Request (ABAR) 24590-WTP-SE-ENS 03-1144 that conditionally approves the revised hydrogen mitigation design.

The substantive Conditions of Acceptance (COA) for this ABAR are related to the following technical concerns: displacement of nitrogen in the system by slow leakage, determination of the limiting oxidant concentration (depending on gas composition) and application of associated standards for explosion prevention to ensure it is adequately bounding, determination of bounding bubble size and its transient effect on the siphon break explosivity, and failure probability of system due to component failures on demand. In addition, measured gas generation rates may not conservatively account for the presence of transition and noble metals in tank waste in greater quantities than assumed in the analyses, because the waste simulant used in the laboratory tests die not contain representative quantities of transition and noble metals that are known to be present in the waste to be processed. These metals can act as catalysts in the oxidation of organic materials. Several conditions of acceptance to address these concerns were identified, including a requirement for Bechtel National, Inc. (BNI) to adopt NFPA 69 as a standard for preventing explosions in the system.

In reviewing the determination of the limiting oxidant concentration, DOE's acceptance criteria will be that BNI will apply limit(s) consistent with NFPA 69's requirements, and install sufficient monitoring (consistent with NFPA 69) to confirm the limit(s) are being observed. BNI currently is planning to install continuous monitoring capability for oxidants in the cesium ion exchange collection volume. In addition, the capability for confirmatory measurement of hydrogen concentration in other flammable gas vessels will be installed. NFPA requirements related to oxidant control will not be imposed in those vessels because the flammability of the atmosphere of these vessels will be controlled by limiting hydrogen concentration. DOE will require BNI to ensure that the determination of bounding bubble size includes consideration of bounding generation rates, including the effects of all credible process constituents. This is addressed in the COA referred to in the prior paragraph.

The required resolution of these COAs will vary, as specified in the COA, from completion within 30 days to completion prior to the Documented Safety Analysis submittal, depending on the item, and its dependence, if any, on the maturity of the design. BNI has subsequently committed to implement NFPA 69, and has responded to the short term COAs (CCN 105809 in preparation). DOE is evaluating the adequacy of these responses.

Erosion in Melter Feed Preparation Vessel (MFPV) and Melter Feed Vessel (MFV) Agitators

The staff reviewed the predicted mixing flow velocities and the predicted erosion rates for the MFPV and MFV vessels and internal components such as the mixer agitators. BNI has determined that the agitator assembly (i.e., impeller blades, etc.) are exposed to high erosion rates; whereas, the mixing flow rates adjacent to the vessel wall and bottom will be much lower and thus the erosions rates will be much lower.

To improve MFPV and MFV mixing performance during periods when the agitator is inoperable, BNI has added spargers to supplement mechanical mixing and changed the bottom profile of the vessel interior. The original curved bottom of these vessels remains the same, but a flat bottom profile has been created by welding, to the vessel wall, a horizontal 316 stainless steel plate a few inches below the bottom impeller unit. The spargers consist of multiple tubes coming down within a few inches of the vessel side walls from ring headers at the top of each vessel. In the lower portion of the MFPV and MFV, the sparge tubes angle inward and downward to end with each nozzle tip pointing downward about 1-inch above the bottom plates in a circular array with a 36-inch radius. The BNI design specifies an erosion resistant coating on selected portions of the exterior of the sparger tubes and their respective nozzles, and on the new bottom plates. It is also planned to coat the inner wall surface of each sparger nozzle, about two inches up from the nozzle tip. The current design specifies application of approximately 25 mils of tungsten carbide in a cobalt matrix, to provide erosion protection for the facility 40-year life. Prior BNI erosion analyses, equations, and efforts did not include this tungsten carbide + cobalt matrix coating design.

On December 13, 2004, BNI approved Computational Fluid Dynamic (CFD) mixing flow velocity prediction results, from Philadelphia Mixers. These results predict feed slurry mixing velocities, in the vicinity of the sparger tubes and nozzles that are well below 10 feet per second. The WTP Project provided the DNFSB staff a copy of the Philadelphia Mixer CFD analyses results. At the December follow-up meeting, DNFSB staff requested BNI to check with Philadelphia Mixers as to how their calculation results were bench marked against actual test data to ensure that the calculation velocities are consistent with actual velocities. This information has been sent to the DNFSB. .

Philadelphia Mixers did not validate the CFD velocity results with WTP glass former physical data. Philadelphia Mixers cited examples from the literature that show CFD simulations of impeller mixed vessels can predict velocities within reasonable agreement of experimental data. The CFD simulations that Philadelphia Mixers performed show that for both the turbulent and laminar models, the free stream velocities in the region of the wall and vessel bottom head do not approach the erosion limit. Because of this, exact validation of the CFD models is unnecessary. Literature has shown that CFD does an adequate job of predicting the free stream velocities in impeller mixed vessels.

At the December follow-up meeting, WTP Project representatives provided additional perspective regarding the DNFSB inquiry regarding potential effects from the recycle of MFPV or MFV contents back to Pretreatment. The DNFSB noted that BNI had not yet evaluated the potential impact of such recycle, especially for a feed mixture that includes the glass forming chemicals that will be added during processing in the MFPV. BNI has defined a resolution path, consisting of several tasks, that will resolve this issue by December 15, 2005. Details regarding this path forward have been sent to the DNFSB.

Waste Blending

DNFSB staff reviewed the capability to blend waste both in the tank farms and in the Waste Treatment and Immobilization Plant (WTP). ORP is studying options to blend tank waste to enhance mission completion, improve waste processability, provide margin to potential safety limits, and better utilize tank space for retrieval and tank closure. DOE letter 04-TPD-024, dated March 17, 2004, requested the Tank Farm Contractor to support development of criteria to help guide blending decisions. CHG letter CH2M-0402570R1 dated November 17, 2004, outlined Optimization Studies that are proposed to guide plans for waste optimization for the WTP. These studies include:

- Sludge washing, caustic leaching, and oxidative leaching in tank farms scheduled to be complete in May 2005.
- Separation of strontium and transuranics from Envelope C waste in tank farms scheduled to be complete in July 2005.
- Routing WTP caustic leach solution and tank farm leach solution to supplemental treatment facilities scheduled to be complete in May 2005.
- Use of single-shell tanks for temporary storage scheduled for completion in June 2005.
- Blending of AZ-101 solids scheduled for completion in May 2005.
- HLW blending optimization scheduled for completion in June 2005.

ORP Tank Farm Programs and Project Division has the lead for integrating this work and coordinates with ORP WTP Engineering Division to resolve issues.

The Tank Farm Contractor has demonstrated the positive impact of blending on HLW production using their modeling tool, the Hanford Tanks Waste Operations Simulator (HTWOS). DOE letter 04-TPD-100 dated October 13, 2004 requested the Tank Farm Contractor to further enhance this tool to improve system planning and performance prediction capability. In addition, the Integrated Product Team for Interface Control Document 19 developed a list that provides initial criteria to evaluate blending options to improve tank waste processability in WTP. The Tank Farm Contractor is implementing these enhancements (Letter to the ORP, CH2M-0402572R1) and these will be used for all future model runs.

The HTWOS model integrates ORP's retrieval strategies with all tank waste treatment and immobilization facility strategies. At this time there are no tank wastes identified that cannot be treated in one of the planned Hanford tank waste treatment facilities. ORP's direction to CH2MHill to enhance the HTWOS model includes modeling to account for all tank waste and all treatment facilities. Critical feed parameters associated with each facility are modeled and assessed using the HTWOS model.

The Tank Farm Contractor uses the DQO process to establish requirements for waste characterization. At this time there are no defined needs to update the DQO to obtain additional data to support waste blending decisions. The Tank Farm Contractor uses the Waste Compatibility Program, to ensure that waste remains within acceptable boundaries for every transfer or mixing of waste. This program controls waste chemistry including criteria to protect WTP feed. Some of the initial waste intended as feed to the WTP is on a Feed Control List and the Tank Farm Contractor must demonstrate that criteria are met before any transfer or mixing of this waste is undertaken. The Tank Farm Contractor uses this process to protect all waste transfers. After specific criteria for beneficial blending are developed some may be appropriate for inclusion in the Waste Compatibility Analysis process.

As presented to the DNFSB Staff on December 15, 2004, ORP is evaluating options to blend high-level waste from double shell tank (DST) 241-AZ-101. Significant benefit may be realized through eliminating specific consideration of this waste in prediction of hydrogen generation rates. ORP letter 04-WED-082, dated January 13, 2005 directed BNI to assume HLW slurry contained in DST 241-AY-102 based on TFCOUP Rev. 5a is the most limiting feed and modify the hydrogen generation rate Design Basis accordingly. Waste from 241-AZ-101 and potentially 241-AZ-102 will be blended to a concentration such that hydrogen generation will be equal to or less than that of 241-AY-102. Benefits associated with this direction include:

- Reduced hydrogen generation rates and associated required vessel vent and pulse jet mixer air demand
- Simplification or reduction of design features required to address hydrogen generation in piping and ancillary vessels concerns
- Potential improvement to WTP waste treatment rates during operations due to large solids mass loss observed during treatment of 241-AZ-101 solids

The Tank Farm operating contractor is performing a study to define the specific approach for blending slurry from DST 241-AZ-101 scheduled to be complete in April 2005.

Process Chemistry Modeling

The DNFSB staff stated they believe the rigor and dynamic nature of the Process Operations Tank Utilization Model and Steady State Flowsheet allow for potentially more accurate results for safety cases and off-normal conditions and encouraged comparisons of output from the WTP Engineering Baseline Process Performance Software (WEBPPS) Process Engineering model with the Process Operations Tank Utilization Model and Steady State Flowsheet. ORP agrees that the Tank Utilization Model and Steady State Flowsheet provide a more rigorous treatment and better prediction of WTP performance. ORP plans to use these models to assess WTP performance and understand how specific wastes planned for processing in WTP will behave. Steady State Flowsheet assessment of the AP-101/AY-102 commissioning feed, AZ-101 and SY-102 will be performed and reported this year.

Two separate informal comparisons have been performed between the Engineering Mass Balance Calculation and the steady state *Aspen Custom Modeler* (ACM) flowsheet. The Engineering Mass Balance was the configuration-controlled calculation platform spreadsheet predecessor to the WEBPPS. The first comparison was performed in November 2001 when the baseline steady state flowsheet model version 1.0 was established and run results were reviewed and compared with the Engineering Mass Balance results for a similar set of conditions. The results aligned favorably with a few differences noted. The differences were evaluated and understood to be the result of input conditions and assumptions. The second comparison was performed in May 2003 during the checking phase of the Maximum Radionuclide (Source Term) calculation. During the checking, a steady state ACM flowsheet run was performed and compared with the Engineering Mass Balance calculation. The results aligned with no differences noted for the same input conditions. For the June 2005 flowsheet updates, BNI will perform a comparison with the WEBPPS.

The WEBPPS is constructed as a mass balance and is a calculated estimate of the WTP Process Stream compositions at various nodes (or points) within the process train. The WEBPPS does not "predict" precipitation reactions in the sense that a model which is based on thermodynamic chemical equilibria would predict reaction products. As such, the WEBPPS calculates the mass of reaction products based on the numerical values input to the model as a simple calculated mass balance based on mole quantities or mass. The WEBPPS takes input from chemical reaction mechanisms and chemical equations developed by the R&T group through laboratory testing on real and simulated waste. This real and simulated waste is treated by the R&T group in process steps which are designed to simulate the actual operation of the completed WTP facility. Additionally, the project evaluates these test results for reconciliation with the steady state ACM process flowsheet. This flowsheet provides insight into the major chemical processes occurring in specific waste streams. The ACM model is used to predict aqueous chemical equilibrium and phase distribution of compounds under varying conditions to identify areas where precipitation may occur.

Validation of the Process Operations Tank Utilization and Steady State Flowsheet models includes consideration of data from all approved WTP R&T reports (~300) including test results ranging from laboratory to large-scale unit operations at the Pacific Northwest National Laboratory, Savannah River National Laboratory (SRNL), Duratek Inc., and Vitreous State Laboratory (VSL) at The Catholic University of America. This includes reconciliation of results from the Semi-Integrated Pilot Plant data at SRNL and VSL. Additionally, operating data is considered from external sources such as the Defense Waste Processing Facility (DWPF), the Hanford Tank Farm, Idaho National Engineering and Environmental Laboratory (INEEL), and from other published data where appropriate. Specific examples include evaporator partition data from the Hanford Tank Farm operation, glass properties data from the DWPF, and filter cleaning data from INEEL. The R&T Data Reconciliation process provides a mechanism for review of all approved reports with a documented process for the disposition of the data with regard to the flowsheet basis and models.

Further model development to assess post WTP commissioning waste feeds and further Semi-Integrated Pilot Plant or other integrated testing will be required. In addition, conversations with Savannah River Laboratory (SRL) have confirmed there are no current plans to dismantle the Semi-Integrated Pilot Plant. SRL agreed to notify ORP if plans to dismantle this equipment are identified. Specific requirements for further pilot testing and model development will be defined after Tank Farm Contractor retrieval actions progress over the next few years and will be addressed by the future operating contractor.

Disposition of Test Exceptions

DNFSB Staff observed several instances where documentation of test exceptions appeared to contain insufficient technical justification. ORP completed a design oversight of the exception process in November. The test exception oversight makes the following observations and recommendations based on a 20% sample of test exceptions:

1. The technical staff interviewed was familiar with the application of the Test Exception Procedure and followed the procedure in developing Test Exceptions and establishing an evaluation of impact;

2. No formal procedural guidance is incorporated into the test exception process in the case where specific Steering Groups assure the coordination and distribution of research results and test exceptions. Procedural changes should be made to assure appropriate notification of safety and design organizations if an integrated product team is relied upon to jointly approve change (much like the Interface Control Document process);

3. Project Document Control distribution sheets are accessible but due to changes in the document control scanning process they are no longer readily obtainable, making the traceability of the distribution of Test Exceptions less convenient; and

4. BNI should provide ORP a periodic listing of test exceptions.

Based on discussions with the DNFSB Staff, DOE is now reviewing 100% of test exceptions specifically for technical adequacy and cost benefit. A review of the adequacy of past test exceptions will be conducted in the next quarter through a sampling process.

Ultrafiltration Cleaning

DNFSB Staff stated ORP needs to address potential ultrafilter cleaning problems implied in test report INEEL-EXT-03-00886, Revision 0, *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).* This test report evaluated cleaning reagents for simulants with beaker tests and Cells Unit Filter (CUF) tests. The report provided several recommendations including continued use of nitric acid as the baseline cleaning reagent for Envelope A and C solids, further testing with organic acids to improve cleaning after filtering Envelope D solids, and investigation of backpulsing in addition to chemical cleaning.

The INEEL-EXT-03-00886 used an AZ-101 simulant for Envelope D. Actual AZ-101 waste was processed through the CUF and reported in WTP-RPT-043, Revision 1, *Filtration, Washing, and Caustic Leaching of Hanford Tank AZ-101 Sludge*, dated September 2003. In WTP-RPT-043, the CUF was cleaned with dilute caustic rinses and 2M nitric acid. The clean water fluxes for the CUF after cleaning were noticeably less than prior to testing, but they were still an order of magnitude above what is required. This work demonstrates that while the nitric acid may not restore the filter to "pristine" condition, this degree of cleaning is not required to achieve desired filter flux.

Preliminary data from the SIPP tests demonstrate that nitric acid (if required) is acceptable as a cleaning solution for the hot commissioning feed. The SIPP consisted of four ultrafilter campaigns. The first campaign consisted of the hot commissioning feed simulant without recycles while the final three campaigns consisted of the hot commissioning feed simulant with recycles. Cleaning of the filters consisted of a dilute caustic rinse, followed by three 2M nitric cleanings, followed by two more dilute caustic rinses. For all campaigns, the "clean water" filter fluxes were lower post-filtration and cleaning than they were pre-filtration (e.g., "pristine" conditions). However, the observed filter fluxes for the simulant with and without recycles were nearly identical for all campaigns. This demonstrates that even though nitric acid does not restore the filter fluxes to "pristine" conditions, this level of cleaning is not required to obtain the required filter fluxes during processing. In addition, it was also observed that the third nitric cleaning did not have a significant impact on the observed filter fluxes. Therefore, two acid cleanings were probably sufficient.

BNI has included a risk in its Risk Management Database that addresses the failure of ultrafiltration to meet throughput requirements (WTP-PT-048). This risk is forecast to be closed based on the SIPP testing data once the reports are issued. In the meantime, the ORP will continue to monitor ultrafilter design and research and technology data reconciliation. The current data (including preliminary data from the work with the SIPP) indicates ultrafilter flux can be managed with the use of caustic, nitric acid, and backpulsing.

The ultrafiltration vessels are currently equipped with two 316L stainless steel reagent lines each for oxidative leaching. Oxidative leaching is expected to only use one of the lines. This would leave the second line for the addition of alternative cleaning reagents if required. The UFP vessels have been procured and are constructed with 304L stainless steel. BNI is in the process of identifying alternative cleaning reagents that would be compatible with UFP system materials of construction. Any future decision to use cleaning reagents outside of process condensate, nitric acid, and caustic would require evaluation through the integrated safety management process.