DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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December 12, 1994

The Honorable Thomas P. Grumbly
Assistant Secretary for Environmental Management
Department of Energy
Washington, D.C. 20585

Dear Mr. Grumbly:

A Defense Nuclear Facilities Safety Board staff review team visited the Savannah River Site on November 1-4, 1994, and focused on the In-Tank Precipitation (ITP) safety envelope. The staff noted that there are several unresolved safety issues, specifically the assumption of a well-mixed tank headspace and the uncertainties associated with the generation of benzene in the process. Due to the significance of these concerns, the Board requests that your office make arrangements to brief the Board at an early date.

The enclosed report is a synopsis of the observations made during the review and is forwarded for your consideration.

Sincerely,

John T. Conway
Chairman

c: The Honorable Tara O'Toole, EH-1
Mr. Mark Whitaker, EH-6
Dr. Mario Fiori, Manager, SR Operations Office

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

November 23, 1994

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: David C. Lowe

SUBJECT: Savannah River Site (SRS) - In-Tank Precipitation (ITP) and Defense Waste Processing Facility (DWPF) Safety Envelope Review Trip Report (November 1-4, 1994)

1. **Purpose:** This trip report documents the Defense Nuclear Facilities Safety Board (DNFSB) technical staff (D. Lowe, J. Roarty, T. Arcano, D. Wille, and D. Moyle) November 1-4, 1994, review of the In-Tank Precipitation (ITP) and Defense Waste Processing Facility (DWPF) safety envelope.

2. **Summary:** There are several unresolved safety issues associated with the ITP safety envelope. These include the assumption of a well-mixed tank headspace and the uncertainties associated with the generation of benzene in the process. The Department of Energy - Savannah River Operations Office (DOE-SR) and Westinghouse Savannah River Company (WSRC) strategy for dealing with these issues is to limit the radioactivity in Cycle 1 to a level that they consider safe, taking into account the uncertainties associated with the benzene generation mechanism, and using Cycle 1 operations to validate the safety of the process. However, WSRC is not approaching the Cycle 1 operations as a process test and it is not apparent that the Cycle 1 operations will meet the objective of reducing the uncertainties associated with the safety of the ITP process. Additionally, there is no plan to validate the critical assumption that the tank headspace is well-mixed, given the high density of benzene and the tendency for stratification above the liquid-vapor interface.

3. **Background:** The ITP facility is used to separate high-level waste supernate into a high-level waste and a low-level waste fraction. The high-level waste portion will be vitrified at DWPF and the low-level waste portion will be solidified at the Saltstone facility. The ITP facility and the DWPF vitrification plant are scheduled to commence radioactive operations in March 1995, and December 1995, respectively.

4. **ITP Discussion:** WSRC is developing a new strategy for defining the ITP safety envelope by limiting the authorization basis to only include Cycle 1 operations. Cycle 1 consists of a low activity feed which will result in less of a challenge to the safety envelope.

a. Benzene Generation: Benzene is produced by radiolysis of the tetraphenylborate compounds and is either released immediately or is trapped within the tetraphenylborate salt lattice structure. When the sodium tetraphenylborate (NaTPB) salt is dissolved during the washing step, the trapped benzene is released over a short period of time. The amount of trapped benzene is dependent on several variables and there is a high level of uncertainty associated with these variables. The primary variables are radiation level, exposure time, and benzene production per exposure energy (i.e., G-value). To overcome these uncertainties, WSRC stated that they are taking the following actions:

1. Limit the radioactivity level in Cycle 1 to about a third of the limit in the Safety Analysis Report (SAR) which should reduce the benzene generation rate by a corresponding amount.

2. Install a flow limiting orifice to limit the washwater addition rate which should limit the NaTPB dissolution rate and the benzene release rate.

3. Install spool-pieces to reduce the chance of an inadvertent chemical addition.

4. Modify the Operational Safety Requirements (OSRs) to require immediate operator action at 25% of the lower flammability limit (LFL) instead of requiring taking action within eight hours.

5. Develop a limit on the exposure time after NaTPB addition. This limit will require the addition of water to dissolve all the solid NaTPB salt and release the trapped benzene once a yet to be determined time is reached. This limit will require conduct of these potentially hazardous operations independent of the facility condition. For example, this operation will be necessary even if the facility is shutdown because of safety concerns.

6. Conduct additional laboratory experiments in addition to the Cycle 1 operations to better characterize the benzene G-values in order to reduce their uncertainty.

b. Tank Headspace Natural Convection Mixing: The ITP safety analysis is based on the fundamental assumption that due to inherent thermal gradients within the tank headspace, the tank headspace is well-mixed in all situations (i.e., nitrogen purge and ventilation operating or secured) by natural convective currents. The safety analysis assumption is based on calculations using a linearized double-diffusive convection model developed to model the behavior of a salinity layer in water when heated from below.

The WSRC calculations used to justify the well-mixed assumption assume that the limiting condition is when nitrogen purge and ventilation are secured, but no justification for this assumption is provided. During normal operations, the primary tank headspace mixing mechanism is believed to be natural convective currents, but cooling at the tank walls may reduce the effectiveness of natural convection and possibly result in stratification. Also, the WSRC calculations assume that the tank walls are well insulated (i.e., no heat loss) and that the only heat loss is from the tank top (i.e., through approximately four feet of concrete). There have been no tests to validate this model for the actual conditions at ITP or for a benzene-nitrogen system. Nevertheless, WSRC concludes that the tank headspace will be well-mixed in all situations. This conclusion drives the safety analysis, OSRs, Process Requirements (PRs), and operating procedures which define the safety envelope. The DNFSB staff considers the assumptions and model used to reach the well-mixed conclusion as unproven and suspect.

c. Process Test: The DOE-SR/WSRC philosophy is to use Cycle 1 operations as a means to validate their assumptions and reduce the uncertainty related to benzene generation and release. However, it appears that WSRC is approaching Cycle 1 as a normal operation instead of a full-scale process test. In both cases, the safety envelope would have to be maintained, but the process test approach would require a well thought out test plan for the Cycle 1 operations in order to validate the major assumptions and reduce the uncertainties associated with the safety of the process. The following examples illustrate this point.

1. The test plan has not been developed, but the Cycle 1 operational plans have already been prepared.

2. There is no plan to validate the well-mixed assumption, either prior to or during Cycle 1 operations. For example, WSRC is not planning on taking vapor grab samples at different heights and locations throughout the tank headspace in order to obtain a three-dimensional concentration profile which would help establish the validity of the well-mixed assumption.

3. WSRC stated that there are no plans to increase the temperature monitoring capability (e.g., thermocouples near the top of the tank and near the liquid-vapor interface) in order to accurately measure the temperature differential that is believed to drive the mixing of the tank headspace.

4. WSRC stated that there are no plans to enhance the monitoring capability of the tank headspace during Cycle 1 operations in order to accurately measure the benzene released and reduce the uncertainty associated with the benzene release mechanism. Currently, there is a single flammable gas monitor which has an uncertainty of $\pm$12% of the LFL. This means that if the flammable gas monitor reads 25% of LFL, the Limiting Condition for Operation (LCO), the uncertainty is about $\pm$50%. This will add little value in reducing the uncertainty associated with the G-value, which is

$\pm$50%. WSRC also stated that two benzene monitors which are used for environmental compliance may also be available to monitor benzene release rates. However, it was not clear how these monitors will be used and if their accuracy is adequate to meet the objectives of reducing the uncertainty associated with the benzene release mechanism.

5. **DWPF Discussion:** WSRC is in process of defining and implementing a Confinement Assurance Program at DWPF. This program is resulting in the reclassification of several systems as safety-class, including ventilation and nitrogen purge systems. This program should result in a major upgrade in the DWPF safety posture. The DNFSB staff will follow the implementation of this program.

6. **Future Actions:** The DNFSB staff will perform follow-up reviews as required to pursue the issues raised in this trip report.