DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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June 14, 1995

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 (Board) staff review team visited the Savannah River Site on April 26, 1995. This review focused on the In-Tank Precipitation (ITP) safety envelope. Some of the issues that the Board and staff continue to follow include those related to the validity of the ITP safety analysis assumption that the vapor in the tank headspace is well mixed at all times and that the benzene generation rates are conservative.

Westinghouse Savannah River Company is emphasizing the three dimensional vapor space model results, which may be difficult to benchmark. Furthermore, conflicting data have been obtained for benzene generation rates and the differences are not well understood. Additional vapor sampling beyond Cycle 1 and backup mitigation procedures would be prudent to detect and protect against unexpected benzene buildup during normal ITP operations. 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-9
Dr. Mario Fiori, Manager, SR Operations Office

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

May 10, 1995

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: David T. Moyle

SUBJECT: In-Tank Precipitation Facility (ITP) Safety Envelope Review - Trip Report (April 26, 1995)

1. **Purpose:** This report documents a follow-up safety envelope review of the In-Tank Precipitation Facility (ITP) at the Savannah River Site (SRS). The review was conducted by the Defense Nuclear Facilities Safety Board (Board) technical staff (A. DeLaPaz, D. Lowe, D. Moyle, J. Roarty, and R. Robinson) on April 26, 1995.

2. **Summary:** Westinghouse Savannah River Company (WSRC) is continuing to assess the safety of ITP wash cycle operations. Considerable uncertainty exists in benzene generation rates and vapor space mixing during this cycle. A complete evaluation of all benzene generation rate data and an understanding of the conditions that could initiate the formation of a stratified benzene layer are needed to determine wash cycle safety at ITP. Furthermore, defense-in-depth safety measures such as a backup steam inerting procedure would be prudent to mitigate an unexpected buildup of benzene during normal operations.

3. **Background:** The ITP process separates soluble radioactive ions from the aqueous tank farm waste stream by precipitation (of Cs-137) with sodium tetraphenylborate (TPB) and adsorption (of Sr-90 and Pu) with sodium titanate. Gamma radiation causes TPB and water to break down and release benzene and hydrogen, respectively, as major volatile products. A large fraction of the benzene formed at ITP becomes trapped in the crystal lattice of the TPB solids. As excess sodium TPB solids are dissolved during the washing stage, the trapped benzene is released and the benzene release rate is significantly higher during this process step. The current Safety Analysis Report assumes that the vapor space of ITP Tank 48 is well mixed at all times and that the maximum benzene flux is conservative. These assumptions are critical to the safety of normal washing operations, and must be verified.

   This review was a follow-up to issues raised during an ITP safety envelope review conducted on January 31 - February 2, 1995. The trip report for that review was transmitted to the Department of Energy on April 20, 1995. ITP is scheduled to start up in July 1995 and washing operations should commence in mid-1996.

4. Discussion:

a. Safety Basis: The safety basis appears adequate for startup of non-wash ITP operations provided that a procedure for a low rate (i.e., 3 gpm or less) alternative wash is available for implementation if washing is not approved. Benzene and hydrogen fluxes are low during non-wash and alternative wash conditions, and molecular diffusion alone is sufficient to prevent the buildup of a benzene layer above the liquid surface.

During washing operations, the safety basis relies on assumptions of a well-mixed vapor space and conservative benzene generation rates. Higher benzene generation, insufficient nitrogen purge, or lack of thermal mixing could cause a stratified benzene layer to develop which could threaten the safety of the ITP process. WSRC outlined a reasonable approach for resolving these issues, which includes:

1. 3-Dimensional (3-D) modeling efforts to predict bulk vapor space mixing.
2. Confirmatory 3-D modeling by Los Alamos National Laboratory (LANL).
3. Laboratory experiments to determine flammable gas generation rates (G-values).
4. Cycle 1 testing to benchmark the 3-D code and benzene G-values.
5. Peer reviews.

There will always be significant uncertainties with the 3-D model because of inherent problems with benchmarking the code. Therefore, the Board staff believes it prudent not to use the modeling effort as an alternative to engineered safety measures. Mitigation procedures for steam inerting, or use of other inert gases are desirable as defense-in-depth protection against unexpected benzene buildup during normal operations. Furthermore, it would be prudent to keep the extra instrumentation for Cycle 1 testing (i.e., thermocouple and vapor sample trees) in place for subsequent ITP cycles as an extra safety measure to detect an unexpected benzene buildup.

b. 3-Dimensional (3-D) Modeling Efforts: A 3-D computational fluid dynamics code, developed by Innovative Research, Inc., is being implemented to model the vapor space of Tank 48 under various conditions. Significant inaccuracies exist in the 3-D computer modeling to date. The following inaccuracies are noted:

1. The model uses calculational grids too large to resolve boundary layer transport and accurately reflect the momentum effects of the nitrogen purge nozzle. Grid sizes of two or more orders of magnitude smaller may be needed to understand boundary layer effects and non-uniformities which may cause benzene to stratify and spread. WSRC has agreed to refine the grid spacing in subsequent studies.

2. The exhaust point is treated only as a mass sink when it is a momentum sink as well. As a result, the output data in that region are questionable because the velocity vectors are unaffected by the exhaust.

3. The model does not attempt to capture non-uniform benzene fluxes off the liquid surface which could cause localized stratification. However, WSRC stated that they will include non-uniform benzene fluxes in future code studies.

4. All computer runs used 395 scfm for the nitrogen purge flow rate when the Operational Safety Requirement (OSR) minimum is 100 scfm, and lower flow rates should promote less vapor mixing. WSRC plans to investigate the effect of lowering the purge rate to the OSR limit.

5. WSRC believes that the main mechanism for mixing is natural convection driven by the temperature difference (ΔT) across the vapor space. However, results show no observable difference in convection cell velocities for a ΔT of 2 or 4 degrees Celsius. Running the code at an even higher ΔT may be needed to assure the code is functioning properly and giving higher magnitude vapor velocities. Additionally, WSRC stated that it does not plan on implementing an OSR for the headspace temperature difference during wash operations, but the Board staff believes that an OSR may be necessary to ensure adequate thermal convection.

6. WSRC will not have LANL investigate cooling coil effects or momentum effects of the nitrogen purge as previously planned to alleviate some inadequacies in the current model. LANL will be used only to validate the results of the Innovative Research 3-D code. The contract for this work was put in place shortly after the Board staff review.

c. Flammable Gas Generation Rates: Wash cycle benzene generation rate data vary widely. In the mid-1980's, the University of Florida experimentally determined a trapped benzene G-value of approximately 7 [molecules/100eV]. Around the same time, experiments at SRS found the G-value to be closer to 1. Therefore, WSRC believed that Florida's data were overconservative, analyzed benzene monitor readings from the 1983 in-tank demonstration, and determined the trapped benzene G-value was roughly 3.4. WSRC has recently completed more laboratory experiments which predict a G-value less than 0.1. In a new series of 12 experiments in 55 gallon drums, Georgia Tech will attempt to better understand washing phenomena and benzene release rates. A committee of WSRC scientists will make the final determination on the G-value.

WSRC does not appear to be attempting to understand the differences in all of the G-value data. Plans were discussed to reproduce the University of Florida experiments, but WSRC does plan to include Florida in the G-value resolution. The new low G-values could solve the vapor mixing problem because a low benzene flux will not be able to initiate stratification. However, thorough investigation and justification are necessary before dismissing any data.

d. Radioactive Operations Commissioning Test Plan: Plans are in progress to provide limited benchmark data for the 3-D model and associated G-values during Cycle 1 operations. Two risers will be used to take temperature and benzene concentration profiles across the tank head space. A small scale simulated wash is planned and samples will be obtained 6 inches above the slurry surface in two locations in an attempt to capture boundary layer affects. Furthermore, the slurry pumps will be "bumped" to shift the slurry and gain information on benzene flux variations over a wider surface area.

   With limited sampling locations, it will be difficult to benchmark the 3-D code. Furthermore, vapor mixing behavior at low benzene fluxes during simulated washing may offer little insight into the behavior at higher wash cycle benzene fluxes.

e. Peer Review: It appears that the two peer review groups involved in the flammability issue resolution at ITP may have differing opinions on wash cycle safety. Dr. Peterson, a member of one review group, has concerns similar to the Board staff. Conversely, WSRC reported that the other review group, the Hamilton committee, is confident that ITP is safe and can startup without results from 3-D modeling or G-value testing.

5. **Future Staff Actions:** The Board staff will continue to perform follow-up reviews as necessary to assure that the flammability issues are properly resolved and that ITP washing operations can be safely conducted.