DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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February 19, 1997

Mr. Mark B. Whitaker, Jr.
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-1000

Dear Mr. Whitaker:

Enclosed for your information and distribution are nine Defense Nuclear Facilities Safety Board staff reports. The reports have been placed in our Public Reading Room.

Sincerely,

John T. Conway
Chairman

Enclosures (9)

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

December 31, 1996

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: R. E. Tontodonato

SUBJECT: Review of Hanford High-Level Waste Tank Safety Issues, December 2–6, 1996

1. Purpose

This report documents a visit by Defense Nuclear Facilities Safety Board (Board) staff members David Drop, Lisa Jellett, Richard Tontodonato, and Larry Zull to the Hanford Site on December 2–6, 1996. The purpose of this visit was to attend a meeting of the Chemical Reactions Subpanel of the Department of Energy (DOE) Tanks Advisory Panel and review tank safety and characterization issues. A separate report is being prepared to document observations made by the Board staff during this site visit regarding high-level waste retrieval and immobilization.

2. Summary

DOE and the Project Hanford Management Contractor (PHMC) that replaced Westinghouse Hanford Company (WHC) are continuing to work toward resolving safety issues associated with flammable gases and organic compounds in the Hanford high-level waste tanks:

- Work on grounding tank risers to mitigate the effects of lightning strikes and installing lightning protection in some of the tank farms is scheduled to be completed by mid-1997. These actions may not fully mitigate the hazard posed by lightning strikes on equipment grounded directly into the wastes, and no further actions are currently planned.

- A new tank sampling schedule has been developed that de-emphasizes tanks containing ferrocyanide solids, since DOE has resolved the ferrocyanide safety issue. The new schedule will be submitted to the Board in an upcoming Recommendation 93-5 quarterly report.

- Improvements in tank modeling and data from new tank instruments are expected to result in more accurate predictions of potential flammable gas concentrations in the waste tanks. Laboratory studies using waste simulants continue to indicate that high radiation fields drive reactions that oxidize organic species to less energetic forms; however, these studies have not yet reached the point where it can be concluded that organic species have oxidized to inert products in all Hanford tanks.

Additionally, while viewing the jet pump staged for saltwell pumping operations in flammable gas watch list tank 241-A-101, the Board staff found several spots where the steel actuator rod for the foot valve rubs against metallic flanges. DOE plans to evaluate this potential ignition source before the pump is installed in the tank.

3. Background

With the closure of the ferrocyanide safety issue, DOE and the PHMC are concentrating on resolving safety issues associated with flammable gases and organic compounds in the Hanford high-level waste tanks. Tank sampling, testing of waste simulants, and analytical work now focus on these issues. A June 5, 1996, WHC report titled *Probability, Consequences, and Mitigation for Lightning Strikes to Hanford Site High-Level Waste Tanks* concludes that lightning is a credible initiator for flammable gas and organic-nitrate deflagrations. It recommends installing lightning protection on existing poles in the tank farms and improving the grounding of certain tank instruments and risers.

4. Discussion

During the site visit, the Board staff attended PHMC presentations to the Chemical Reactions Subpanel regarding tank safety issues, and held separate discussions with personnel representing the PHMC, Pacific Northwest National Laboratory (PNNL), and the DOE Richland Operations Office (DOE-RL). Key observations are summarized below.

Lightning Protection. Lightning strikes on tank risers and equipment may act as ignition sources for flammable gases or reactive organic materials in the wastes. WHC has completed a survey of lightning vulnerabilities in the tank farms. The report documenting this survey, *Probability, Consequences, and Mitigation for Lightning Strikes to Hanford Site High-Level Waste Tanks*, recommends installing air terminals on existing utility poles in the tank farms to protect nearby tanks from lightning, and upgrading grounding for tank risers and equipment that have been found to be inadequately grounded. The PHMC informed the Board staff that the tank farm upgrades should be completed by mid-1997.

The WHC report also states that 16 tanks contain instrument trees grounded directly into the wastes. It is not clear whether the planned upgrades will fully mitigate the hazard posed by lightning strikes on such equipment. The WHC report acknowledges that further mitigative actions, such as installing grounded metallic sheds over problem risers, may be required in some cases. Unless the tanks with this condition contain inert wastes or will be protected by the new air terminals, or riser grounding improvements eliminate direct grounding into the wastes, further actions may be warranted.

Tank Sampling Schedule. The PHMC has developed a new list of high-priority tanks to be sampled and analyzed by the March 1998 milestone in the Recommendation 93-5 Implementation Plan. The new list removes ferrocyanide tanks (because DOE has resolved the

ferrocyanide safety issue) and increases the priority for tanks of interest to the organic and flammable gas safety programs. DOE will provide the revised list of high-priority tanks to theBoard in an upcoming Recommendation 93-5 quarterly report.

Two high-priority tanks of interest to the flammable gas program require rotary mode core sampling using the retained gas sampler. As currently designed, the retained gas sampler can be deployed only by the push mode core sampling truck. Because of this problem, these tanks may not be sampled and analyzed by the Implementation Plan milestone date.

Flammable Gases. The PHMC plans to resolve safety issues associated with flammable gases in the waste tanks by sampling a subset of the tanks directly for retained gas and using these data to develop and validate a method for characterizing all tanks with respect to flammable gas retention and release. The flammable gas evaluation methodology is applied on a tank-by-tank basis to assess both steady-state gas concentrations and the effect of episodic gas releases. Steady-state hydrogen concentrations in the headspace are predicted using estimated rates for gas generation and tank ventilation, and have been checked using vapor samples from each tank. In general, the predictions are very conservative for passively ventilated tanks and have varying accuracy for actively ventilated tanks. Samples have shown steady-state flammable gas concentrations in all tanks to be well below 10 percent of the lower flammability limit (LFL).

In evaluating episodic releases, the PHMC first performs a screening calculation that determines whether there is sufficient waste in the tank to present a hazard under the most conservative gas generation and retention assumptions. If the initial screening indicates a possible hazard, surface-level rise data and observed tank-level changes induced by changes in barometric pressure are used together to determine more accurately whether there is sufficient retained gas to present a hazard if released. There is substantial uncertainty regarding the accuracy of these predictions, and several efforts are under way to improve the input data and models used in both the retained gas and steady-state calculations.

A more accurate tank-level indicator being installed in many tanks should provide better input data to the surface rise and barometric pressure response calculations. Also, a void fraction instrument has been deployed in several double-shell tanks to check some of the assumptions used in retained gas modeling. These measurements indicate that the gas is located closer to the surface of the waste than was previously assumed. This has two principal implications:

- A given quantity of gas will occupy a larger volume when closer to the surface of the waste, because the pressure will be lower there. Therefore, the prior assumption that the gas was lower in the waste may have led to overestimating the potential flammable gas concentration after an episodic release.

- Gas stored closer to the waste surface may be more readily released.

Ventilation rates in several tanks were established using a combination of tracer studies and observation of hydrogen removal rates after gas release events in tanks equipped with Hanford Standard Hydrogen Monitoring Systems. Generally, the measured flow rates are significantly higher for both actively and passively ventilated tanks than was previously assumed. As with the gas retention data, this finding has several implications:

- Steady-state vapor concentrations should be lower than was previously calculated, and episodic releases should dissipate more rapidly.

- Evaporation is occurring at a higher rate than was previously assumed. When this information is incorporated in the surface-level rise model for gas retention, larger amounts of retained gas will be predicted.

- Past episodic releases may have released more gas than was previously estimated from hydrogen monitoring data.

Lastly, PNNL is developing an improved model for more accurate prediction of retained gas volume using measured tank-level changes caused by fluctuations in barometric pressure. The original pressure-response model approximates the gas as a spring layer responding linearly to changes in ambient pressure. This model does not explain the fact that tank-level data display hysteresis with respect to barometric pressure. (As pressure fronts pass through the tank farms, the same ambient pressure results in different waste levels in a given tank, depending on whether the pressure is increasing or decreasing.) The improved model being developed by PNNL allows the waste matrix to deform plastically once the pressure difference between the solid/liquid matrix and the retained gas bubbles becomes sufficiently large. This model explains the observed hysteresis and predicts significantly higher retained gas volumes than does the straight-line regression analysis of the gas-spring model. It correlates well with actual tank-level data, but there are still detectable differences between its predictions and observed tank behavior. PNNL plans to continue refining the model and explore the possibility that small gas releases in single-shell tanks explain some of the deviations.

The safety implications of these changes are not yet clear. The initial results for some of these improvements tend to increase predicted gas quantities, whereas the results for others tend to decrease the predicted values. Overall, the improvements to the methodology will permit a more accurate evaluation of each tank's risk of reaching 25 percent of the LFL.

Aging of Organic Materials. PNNL is studying the degradation of organic waste simulants in a gamma irradiation facility as part of Hanford's effort to characterize the organic-nitrate deflagration hazard. Simulants containing glycolate, citrate, ethylenediaminetetraacetic acid (EDTA), and hydroxyethylethylenediaminetriacetic acid (HEDTA) have been irradiated at high dose rates (approximately 200 times the dose rate in tank 241-SY-101) and elevated temperatures (70°C), and analyzed for organic products and overall energetics. Laboratory results show that the four starting compounds degrade at varying rates into relatively inert products, such as formate, oxalate, and carbonate. Likewise, the overall energetics of the

simulants decline as the absorbed dose increases. These results indicate that radiolytic aging does occur in tank waste simulants. More work is required before these results can be extrapolated to actual tank conditions.

Tank 241-A-101 Jet Pump. The Board staff viewed the jet pump and other equipment staged for saltwell pumping operations in tank 241-A-101, a single-shell tank on the Flammable Gas Watch List. The equipment includes many new features intended to prevent a gas deflagration, including an intrinsically safe exhauster, upgraded flammable gas monitoring, and elastomeric gaskets on the jet pump that are intended to prevent the foot valve actuator rod from rubbing against its metallic supports. The Board staff observed that the rod appeared to rub against metallic flanges at several other spots along its length. The DOE-RL representative present during the tour stated that this potential ignition source will be evaluated before the pump is installed in the tank.

5. Future Staff Actions

The Board staff will continue to pursue closure of the flammable gas and organic safety issues, and will follow up on the specific concerns identified in this report regarding lightning protection and the tank 241-A-101 saltwell pump.