

## DEFENSE NUCLEAR FACILITIES SAFETY BOARD

November 29, 1995

**MEMORANDUM**  
**FOR:** G. W. Cunningham, Technical Director  
**COPIES:** Board Members  
**FROM:** Richard E. Tontodonato  
**SUBJECT:** Review of Hanford Site High-Level Waste Tank Accelerated Safety Analysis and Flammable Gas Safety Issue, November 6-8, 1995

1. **Purpose:** This trip report documents a visit by the Defense Nuclear Facilities Safety Board's (Board) staff members (Ralph Arcaro and Richard Tontodonato) to the Hanford Site on November 6-8, 1995, to review the Accelerated Safety Analysis (ASA) for the high-level waste tank farms and flammable gas safety issues.
2. **Summary:**
  - a. The Department of Energy's Richland Operations Office (DOE-RI,) no longer intends to issue the tank farm ASA as a complete, stand-alone document. Instead, portions of the accident analysis and corresponding interim operational safety requirements (IOSRs) will be approved as changes to the existing Interim Safety Basis (ISB) for the tank farms. DOE-RL expects to finalize a plan by the end of November 1995 for developing the final safety analysis report (FSAR) for the tank farms in accordance with DOE Order 5480.23.
  - b. In response to recent occurrences at Hanford involving operations outside the authorization basis, DOE's Office of Environmental Management (DOE-EM) has clarified approval authority for the tank farm authorization basis. DOE/EM will retain authority for the tank farm FSAR, but has delegated authority for the existing authorization basis. Implementation of the ASA as changes to the ISB may thus circumvent DOE-EM's intent to approve major changes to the authorization basis.
  - c. Westinghouse Hanford Company (WHC) has not demonstrated that the radiological source term used in the ASA bounds actual tank conditions. As a result of this lack of conservatism, the ASA may underestimate the consequences of tank farm accidents.
  - d. WHC has identified 22 tanks that should be added to the flammable gas watch list, resulting in a total of 47 flammable gas watch list tanks. The Board's staff believes that further actions (e.g., mitigation) should be considered when there is evidence that a tank's vapors may actually exceed flammability limits during episodic releases (e.g., tank 241-AN-105).
3. **Background:** WHC has been developing an updated accident analysis for the high-level waste tank farms for the past two years. The product of WHC's efforts, the ASA,

was submitted to DOE-RL in July 1994. After revision to incorporate DOE-RL comments, the ASA was reviewed by an independent team at the Idaho National Engineering Laboratory (INEL) beginning in March 1995. The INEL team found many significant problems--leading WHC to convene a steering committee of nationally-recognized experts to assist in issue resolution and to provide guidance for incorporating the ASA into a final safety analysis report for the tank farms. The purpose of the Board's staff review was to determine current DOE-RL and WHC plans for the ASA and FSAR, to evaluate the adequacy of the source term used for tank farm accident analyses, and to review recent tank farm flammable gas issues.

#### 4. Discussion:

- a. ***Tank Farm Authorization Basis***: On September 29, 1995, WHC submitted to DOE-RL the *Recovery Plan for Establishing the Tank Farm Authorization Basis and Final Safety Analysis Report Preparation*. WHC recommended incorporating the ASA into the existing tank farm ISB, implementing new IOSRs as soon as possible, and submitting the tank farm FSAR to DOE-RL by September 1996. DOE-RL has not formally responded to WHC's recommendations, but the responsible DOE-RL manager stated that he intended to issue a plan by the end of November 1995.

DOE-RL and WHC stated that the ASA would not be issued in its current form. Instead, portions of the accident analysis and corresponding IOSRs will be approved as changes to the existing ISB for the tank farms. WHC stated that using excerpts from the ASA will provide revised toxicological exposure consequence criteria and methodology, updated radiological exposure consequence determination methodology, and improved tank inventory data. Incorporating portions of the ASA is also expected to eliminate some of the approximately 150 individual safety assessments referenced by the ISB as part of the current authorization basis.

The Board's staff is currently evaluating the adequacy of the new source term proposed by WHC. As discussed in detail (see section c.), WHC has not shown that the source term is conservative, and therefore it is possible that accident consequences have been underestimated. Furthermore, although WHC believes the ASA is adequate for incorporation into the ISB, they recognize several open items that must be resolved for the FSAR:

1. The hazard analysis does not meet the requirements of DOE Order 5480.23, *Safety Analysis Reports*, and DOE-STD-3009-94, *Preparation Guide for U. S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Report*.
2. Safety-related structures, systems, and components (SSCs) have not been identified as required by DOE Order 5480.23.
3. Environmental acceptance guidelines have not been established as required by DOE Order 5480.23 and DOE-STD-3009-94.

The Board's staff believes that the problems with the source term and hazard analysis and the lack of SSCs and environmental acceptance guidelines call into question the adequacy of the ASA and the corresponding IOSRs. Furthermore, WHC's September 1995 FSAR plan states that the ASA is incorrect in concluding that all accidents calculated to be below risk evaluation guidelines are acceptable without further controls or remediation, because this approach does not ensure adequate defense-in-depth. Because of these problems, it is essential that any portions of the ASA proposed for incorporation in the ISB receive close scrutiny--particularly if the changes are used to justify relaxing existing tank farm controls.

- b. **Authorization Basis Management**: In September 1995 WHC and DOE-RL realized that transfers of waste with plutonium concentrations above that allowed by the authorization basis had taken place routinely since January 1995. In its review of the occurrence, DOE-RL's Performance Assessment Division identified the following root causes for these operations outside the authorization basis:
1. There is no site process for managing the authorization basis.
  2. There is an inadequate understanding of the importance of the authorization basis.
  3. The relative roles of WHC, DOE-RL, and DOE-EM are not well understood.

These deficiencies indicate that management of the tank farm authorization basis needs significant improvement. Both DOE-RL and DOE-EM have identified actions required to achieve the necessary upgrades. As part of these actions, DOE-EM has clarified the approval authority for the tank farm authorization basis. As stated in a memorandum from DOE-EM dated November 21, 1994, to the manager of the Richland Operations Office, DOE-EM has given DOE-RL authority to approve the current interim tank farm authorization basis (the ISB), but not the FSAR. Approval authority for the FSAR will be delegated to DOE-RL when DOE-EM determines that Hanford has demonstrated sufficient technical competency to perform a comprehensive hazards and safety analysis.

This policy would be reasonable if no major changes were made to the ISB while the FSAR was being developed. However, this policy will allow DOE-RL to replace major accident analyses contained in the ISB with portions of the ASA and implement revised IOSRs without DOE-EM approval.

- c. **ASA Source Term**: WHC did not develop individual source terms for each of the 177 high-level waste tanks at Hanford. Instead, WHC separated the tank wastes into groups and developed composite "Super Tank" source terms intended to bound the contents of the tanks assigned to each group. WHC's basic

approach was to screen all available analytical data for each group and use the highest measured concentration of each radionuclide and toxic constituent as the assumed "Super Tank" composition.

WHC expects this approach to produce a conservative result, because it is very unlikely that any tank is uniformly full of the worst case concentrations of all the radionuclides and toxic constituents. WHC reasons that even if a tank exceeds the ASA source term for one specific constituent, it is unlikely that the unit liter dose for that tank would exceed the unit liter dose used in the ASA, because of the high concentrations assumed for the other constituents. Since not all of the tanks have been sampled for all the radionuclides and toxic constituents important to the ASA, WHC's approach relies on having enough data from enough different tanks to ensure all the different waste types discharged to the tank farms have been analyzed and evaluated for the source term.

The INEL review team commented that WHC's approach was not supported by statistics. WHC is working to resolve the INEL comment. WHC has shown that, if each tank is assumed to contain the radionuclide concentrations used in the ASA source term, the resulting inventory would far exceed the quantity of radionuclides actually discharged to the waste tanks. WHC is preparing a document that summarizes this comparison, compares the ASA source term to tank heat loads calculated from measured tank dome temperatures, and performs simple statistical calculations using the analytical data used to develop the ASA source term.

The Board's staff does not believe WHC has demonstrated that the ASA source term is bounding. Although WHC's basic strategy could be used to produce a conservative source term, the staff has identified several problems in WHC's derivation and justification of the ASA source term. Detailed comments are summarized in the [attachment](#) to this report.

- d. ***Flammable Gas Watch List Tanks***: Based on a May 1995 study by Pacific Northwest Laboratory (PNL), WHC has identified 22 tanks that should be added to the flammable gas watch list--bringing the total to 47 flammable gas watch list tanks. The PNL study correlated waste surface level with barometric pressure to identify tanks that respond to pressure changes in a manner that suggests there is a substantial volume of gas stored in the waste. As confirmation for both this study and the current watch list, 21 of the 25 tanks originally on the watch list were found to respond to changes in ambient pressure. By mid-December 1995, WHC expects to recommend to DOE-RL those tanks that should be placed on the watch list and whether other tanks need further evaluation.

WHC is continuing to implement actions in response to the August 21, 1995, gas release event in tank 241-AN-105 (a double-shell tank on the flammable gas watch list). The tank's recently installed hydrogen monitor measured a peak hydrogen concentration of 1.7 percent, which WHC estimates to be about 40 percent of the lower flammability limit (LFL) for these vapors. This gas release was accompanied by less than half the historical maximum surface level drop, so

it is likely that future releases could exceed the LFL.

WHC's immediate corrective action was to increase the ventilation rate for this tank from an estimated 30 cubic feet per minute (cfm) to 170 cfm. WHC stated that the higher flow rate is not likely to significantly reduce the peak hydrogen concentration in the vapor space after a gas release event. However, it will remove the vapors faster, so the tank will be at risk of a deflagration for a shorter period of time after a gas release. Future actions planned by WHC include performing in situ viscometer and voidmeter tests, obtaining core samples using the new retained gas sampler deployed on the push mode sampling truck, installing improved gas characterization systems on this tank and on 241-AW-101 to determine the actual flammability limit for the released gas mixtures, and upgrading the ventilation system to provide better flow control.

Since this tank was on the flammable gas watch list, controls intended to eliminate all potential ignition sources are already in place. WHC personnel stated that WHC has begun an evaluation of potential ignition sources for flammable vapors in the high-level waste tanks in an effort to determine whether the current controls are adequate.

The Board's staff is concerned that WHC's corrective actions will not prevent this tank from periodically achieving a flammable state. Very little energy is required to ignite hydrogen gas mixtures, and it is difficult to prove with the degree of assurance required of a nuclear facility that millijoule-scale ignition sources are not available in the tank farms. It would be prudent to consider taking action to eliminate or mitigate the hazard instead of relying on controls on ignition sources--particularly for tanks that have demonstrated the ability to exceed WHC's safety limit (25 percent of the LFL) and have a strong potential to exceed 100 percent of the LFL.

5. **Future Staff Actions:** The Board's staff will continue to assess the adequacy of the ASA and any portions of it submitted for incorporation in the tank farm ISB. Particular emphasis will be placed on concerns regarding the source term used for accident analyses and WHC's approach to analyzing and controlling tanks that exhibit significant flammable gas releases.

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Attachment

**Detailed Board Staff Comments  
on Accelerated Safety Analysis (ASA) Source Term**

1. Valid analytical data were excluded from the source term for reasons that have not been adequately justified. A key example is that all data from 55,000 gallon high-level waste tanks were excluded based on the unsupported statement that the waste in those tanks is not representative of the waste in larger tanks. Additionally, data for material

now overlaid with other wastes in the specific tank sampled were excluded. This does not address the possibility that similar waste could be present without substantial overburden in other unsampled tanks, and relies on accident analysis to prove that such wastes cannot be released.

2. The source terms for 15 "minor" radionuclides were derived from a single reference containing limited data without further validation.
3. For the 11 radionuclides and 24 toxic constituents that were thoroughly evaluated, the quality of the data was assessed only for the maximum reported concentration of each species within each tank group. While investigating the laboratory reports for those specific analyses, Westinghouse Hanford Company (WHC) discovered assorted errors, including unit conversion errors that changed the reported value by several orders of magnitude. Since WHC only investigated the maximum reported concentration of each species, errors that decreased the reported value by orders of magnitude would not be detected. It is therefore possible that the large mass of unevaluated data falling below the ASA source term values may contain incorrectly reported samples that are more concentrated than those chosen for use in the source term

Several steps could be taken to address this concern. Rejected laboratory reports for key species could be evaluated to determine whether there is any pattern to the errors. It is possible that specific time periods, laboratories, or analyses were more error-prone than others. This would allow focusing further data validation on reports that are more likely to contain significant errors. Also, sample data reporting abnormally low concentrations of key species for particular waste types could be checked for errors.

4. The draft document WHC is preparing to further support the ASA source terms does not evaluate the reduced source terms derived for the single-shell and double-shell flammable gas watch list tanks (19 tanks and 6 tanks, respectively, at the time the ASA was being prepared). This is particularly important because the source terms assigned to the single-shell and double-shell flammable gas watch list tanks are significantly smaller than the source terms derived for the remainder of the single-shell and double-shell tanks. It is possible that these smaller source terms are valid and resulted from excluding certain highly concentrated non-watch list tanks. However, WHC has not considered the possibility that they may instead result from inadequate characterization of the flammable gas watch list tanks
5. The draft document being prepared by WHC to further support the ASA source terms does not evaluate the adequacy of the toxicological source terms.
6. WHC's comparisons of the ASA source term to total tank farm inventories do not prove that individual tanks do not exceed the ASA source term.