DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

April 26, 2011

The Honorable Inés R. Triay
Assistant Secretary for Environmental Management
U. S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0113

Dear Dr. Triay:

The Defense Nuclear Facilities Safety Board (Board) has completed a review of the waste transfer system at the Hanford Tank Farms. This review revealed that current operations and components may not fulfill the required safety function of confining waste. The enclosed report, prepared by the Board's staff, provides a detailed discussion of these shortcomings.

The Board's review was prompted by the upgrade of the functional classification of the waste transfer primary piping system to safety-significant in the July 2008 revision of the Documented Safety Analysis (DSA) for the Tank Farms, and subsequent implementation of this upgrade in March 2010. The Board's staff identified issues regarding the qualification, performance, and maintenance of the waste transfer system, as well as deficiencies in the DSA. These issues include:

- Weaknesses in the qualification process for certifying that the system can perform its safety function and therefore meet the requirements in the DSA;
- Insufficient criteria and controls for identifying and responding to waste leakage, including downgrading the functional classification of the leak detection system from safety-significant to defense-in-depth;
- Inadequately defined leak test requirements for the system;
- Deficiencies in the methodology for extending the service life of hose-in-hose transfer lines; and
- The absence of credited safety controls for particular hazards associated with the waste transfer system.

These deficiencies collectively reduce the safety margin for operations within the Hanford Tank Farms. It is particularly important that the safe operation of the Tank Farms not be impaired given the increased operating tempo that will accompany operation of the Waste Treatment and Immobilization Plant in the near future.

Therefore, pursuant to 42 U.S.C. § 2286b(d), the Board requests a briefing and report within 90 days of receipt of this letter outlining actions taken or planned by the Department of Energy to address the deficiencies associated with the waste transfer system detailed in the enclosed report.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Ms. Stacy Charboneau
Mrs. Mari-Jo Campagnone

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

March 8, 2011

MEMORANDUM FOR: T. J. Dwyer, Technical Director

COPIES: Board Members

FROM: E. Gibson and C. Shuffler

SUBJECT: Waste Transfer System, Hanford Tank Farms

This report documents a review of the Hanford Tank Farms' waste transfer system conducted by the staff of the Defense Nuclear Facilities Safety Board (Board) during January 4–6, 2011. Staff members Z. Beauvais, E. Gibson, S. Lewis, J. MacSleyne, R. Quirk, C. Shuffler, and S. Sircar assessed the capability of the primary piping system and other credited waste transfer system components to perform their respective safety functions.

The staff identified issues related to the qualification, performance, and maintenance of the waste transfer system. The staff also identified deficiencies in the Documented Safety Analysis (DSA) for the Hanford Tank Farms regarding the functional classification of controls for particular hazards associated with the waste transfer system.

Background. The operating contractor for the Tank Farms, Washington River Protection Solutions (WRPS), uses the waste transfer system to retrieve high-level waste from single-shell tanks and to optimize the limited availability of double-shell tank space. Feed preparation and transfer activities in support of the Waste Treatment and Immobilization Plant, currently scheduled to begin full operations in 2019, will lead to an increase in the operating tempo at the Tank Farms. It is therefore critical that WRPS maintain the integrity of the waste transfer system. The system's safety function is to provide confinement of waste, thereby protecting workers from leakage hazards such as fine spray leaks, direct wetting spray/jet/stream leaks, and flammable gas deflagrations in waste transfer-associated structures. Safety-significant components include the primary piping system, hose-in-hose transfer lines, isolation valves for double valve isolation, and pressure relieving devices.

System Qualification. The previous operating contractor for the Tank Farms, CH2M HILL Hanford Group, Inc., upgraded the functional classification of the waste transfer primary piping system to safety-significant in the July 2008 revision of the Tank Farms DSA. WRPS finished implementing this upgrade in March 2010. The Department of Energy (DOE)-Office of River Protection (ORP) and WRPS have exempted primary piping designed prior to October 1, 2008 from the design and quality requirements applicable to safety-significant systems through a

grandfathering process. The staff notes that this exemption applies to the majority of the waste transfer primary piping system.

State and federal environmental regulations specify that an independent qualified registered professional engineer (IQRPE) must periodically assess and certify that the double-shell tank system, including the waste transfer primary piping system, is fit for use. The most recent IQRPE assessment report (2007) defines fit for use as a system adequately designed with sufficient structural strength and compatibility with the wastes to be stored or treated, to ensure it will not collapse, rupture or fail. DOE-ORP and WRPS have based the qualification for the grandfathered primary piping system on the IQRPE's assessment and certification. The Technical Safety Requirements (TSRs) invoke continued performance of the periodic IQRPE integrity assessments as a condition of operability for the primary piping system. The staff identified several issues related to this use of IQRPE certification as the technical basis for qualifying the grandfathered primary piping system.

The IQRPE's certification that the double-shell tank system is fit for use is based on operating practices, as well as the collective capabilities of multiple systems. Examples include the primary piping system, encasement piping system, cathodic protection system, leak detection system, and material balance procedures. With the exception of the primary piping system, however, the safety basis does not credit and therefore cannot rely upon these features to prevent or mitigate significant waste leak events. Further, because nuclear safety requirements are beyond the scope of the environmental regulations driving the IQRPE process, the IQRPE assessment does not explicitly factor in the unique safety requirements of the DSA (i.e., assessing pipe integrity with respect to preventing pressurized spray leaks, flammable gas deflagrations, and chemical exposures). Without focusing on credited systems and addressing the unique safety requirements of the DSA, it is not clear how WRPS can rely on the IQRPE's assessment and certification alone to provide adequate assurance that the primary piping system can perform its safety function.

The most recent IQRPE assessment for double-shell tank systems highlighted several past failures of the primary piping system in which corrosion was the suspected failure mode. The assessment also cast doubt on corrosion rate projections supporting estimates of remaining life for the primary piping system. However, the assessment concluded that erosion-accelerated corrosion-induced "failures within the life of the mission are not expected." Since the IQRPE's assessment in 2007, DOE has significantly extended the mission life for the double-shell tank system from 2028 to 2048 to accommodate a revision to the operating plan for the Waste Treatment and Immobilization Plant. Also, the staff noted that the extent of piping inspection to support the IQRPE's conclusion was limited to visual examination of two in-service carbon steel lines and a small section of stainless steel pipe removed for laboratory examination. Only one inspection included an elbow, where corrosion rates would likely be highest. WRPS could not provide the basis for the number and locations of these inspections. Considering historical failures, the absence of a defensible corrosion rate estimate, limited in-service piping inspections, and the extended mission life for the waste transfer system, the staff does not support WRPS's conclusion that the IQRPE certification ensures a corrosion-induced failure of the piping system does not present a challenge to the system's safety function.

The 2007 IQRPE assessment report documented numerous recommendations for resolving observations, findings, and other issues. For example, the IQRPE recommended that the contractor conduct inspections to collect more data on piping corrosion to support future integrity assessments and estimate the remaining useful life of the primary piping system. Compliance with the TSRs is not contingent upon WRPS personnel implementing the IQRPE's recommendations. The staff believes, however, that implementing these recommendations is key to ensuring that the primary piping system can fulfill its safety function. During the staff's review, neither ORP nor WRPS could provide the status of actions taken or planned to implement the recommendations. In subsequent discussions with the staff, WRPS personnel said they had recently assigned a responsible manager to track the recommendations. The staff believes this a positive step.

In conclusion, the staff does not believe that the qualification process for the grandfathered primary piping system provides adequate assurance that the safety requirements in the DSA can be met. The staff suggests that one potential option for addressing this shortcoming would be for WRPS to develop a qualification plan for the system that clearly articulates the basis for its ability to perform its safety function.

System Performance Criteria. The DSA credits the primary piping system components (underground piping, valves, jumpers) and hose-in-hose transfer lines as safety-significant to confine waste. The DSA, however, allows these components to exhibit drip-wise leakage, which "...shall not be a continuous flow or spray of material." WRPS personnel explained that drip-wise leakage is anticipated during operations and does not pose a significant risk to workers, and that prohibiting such leakage in the DSA would result in a TSR violation and inhibit operations.

The staff generally agrees that limited drip-wise leakage from certain components is not a significant safety concern. The DSA, however, does not identify and credit appropriate administrative programs and controls for leak detection to ensure that drip-wise leakage is promptly detected and prevented from degrading into the hazard of concern (i.e., continuous-flow or spray leaks). Further, the DSA does not establish a clear definition for drip-wise leakage, including restricting where such leakage may occur. The staff identified the following deficiencies with the criteria for drip-wise leakage:

- WRPS does not implement a formal leakage inspection program to ensure prompt detection of drip-wise leakage. Leaks can therefore persist unobserved for extended durations. WRPS personnel explained that they may detect waste residue or small volumes of pooled waste in pits by visual inspection after a transfer. Such inspections, however, are incidental and not part of a governing leakage inspection program.

- Larger volumes of waste leakage may be detected during a transfer by the leak detection system. This system is the only non-administrative control capable of detecting a waste leak during a transfer. The staff therefore believes it is prudent to upgrade this system to safety-significant based upon its significant contribution to

defense-in-depth. The staff notes that the Board previously expressed its concern to DOE regarding downgrading the functional classification for the leak detection system from safety-significant to defense-in-depth in a letter dated August 5, 2010.

- Prompt corrective action is important to ensure that a drip-wise leak does not degrade into a more significant hazard. In the event a drip-wise leak is discovered, the TSRs should restrict waste transfers through the degraded component until the contractor repairs the leak or implements compensatory measures to preclude or detect further degradation. An example compensatory action is real-time video monitoring of a leaking component that allows operations to promptly shutdown a transfer if the leak worsens.

- Limited drip-wise leakage at anticipated locations, such as mechanical jumper connections or valve stem seals, does not present a significant hazard to workers if promptly detected and corrected. Leakage from a pipe or above-ground hose-in-hose transfer line, however, indicates a more significant structural problem, such as corrosion or erosion-induced failure. The DSA should therefore not allow leakage from the primary piping or above-ground hose-in-hose transfer lines.

- No formal criteria exist to help the contractor identify whether a leak is drip-wise or a continuous stream or spray, and therefore whether credited waste transfer system components are in compliance with the requirement in the DSA to confine waste. WRPS should therefore develop and implement these criteria under a formal leakage inspection program. Doing so would also increase WRPS's understanding of system behavior.

System Maintenance and Testing. The TSRs require a leak test for primary piping system connections (e.g., jumper connections, Chemjoints). For newly installed components, hydrostatic leak testing in accordance with American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME) B31.3, *Process Piping*, fulfills this requirement. For connections that are beyond the scope of the design and construction codes, such as those that are unmade and remade during normal operations, the TSRs require an additional in-service leak test to confirm that leak tightness is being maintained. To perform this test, operators flush raw water or transfer waste through a transfer path that includes the desired connection. If the contractor is conducting the leak test as part of the initial waste transfer, they impose additional controls such as real time video monitoring of the connection to ensure that the transfer can be promptly terminated if a leak is detected. Any visually detected leakage must be corrected before the waste transfer can be started or resumed. The staff notes that in-service leak testing of mechanical connections is good engineering practice, particularly for applications involving hazardous fluids such as high-level waste. However, the contractor does not impose minimum test requirements to ensure that a sufficient and consistent qualification level for remade joints is achieved. To ensure the effectiveness of this TSR control, WRPS should derive and formally impose minimum test requirements, such as test pressure, hold time, test line-up, and test medium. The staff notes further that a proper in-service leak test, combined with a code-

compliant design and initial hydrostatic leak test, should reduce the potential for drip-wise leakage at mechanical joints during operations of the waste transfer system.

The TSRs do not require a leak test for the intermediate connections between hose-in-hose transfer lines. The TSRs do require a leak test for end fittings where hoses connect to primary piping systems, but the contractor does not impose minimum requirements for this test. It is unclear why intermediate connections, which perform the same safety function as end connections for hoses and primary piping system connections, receive unequal treatment in the safety basis. Further, the staff believes WRPS should derive and formally impose minimum requirements for leak testing end and intermediate connections for hose-in-hose transfer lines.

In addition, the contractor may extend the 3-year service life for a hose-in-hose transfer line on the basis of calculated or measured exposures to specific temperatures, pressures, radiation, and chemicals. The methodology for service life extension assumes that radiation-induced damage acts independently of thermal aging, but the published literature does not support this assumption.[1,2] The material lifetime under simultaneous elevated-temperature and high-radiation conditions could be shorter than the lifetimes estimated by considering each factor alone. Therefore, the contractor's service life extensions may not be based on conservative analysis. Post mortem inspections and destructive examination of expired hose-in-hose transfer lines would help mitigate these concerns and add confidence to the basis for service life extension.

Post mortem inspection and destructive examination could also improve the technical basis supporting other polymer components that have no service life restrictions. Of particular interest are jumper connection gaskets fabricated from Teflon®, a polymer known to degrade readily in the presence of ionizing radiation. Hanford-specific operating experience with Teflon® has not identified leaks or other problems that would accompany such degradation. WRPS analysts cite several possible reasons for this, including shielding provided by the jumper design, a captive geometry for the gasket, and the absence of continuous radiation exposure. While the staff does not object to the continued use of Teflon® in this specific application, WRPS could confirm the current assumption that the Tank Farms environment does not adversely impact Teflon® properties by performing post mortem inspections and destructive examination of Teflon® gaskets removed from service, or performing accelerated aging tests.

The contractor employs double valve isolation to define the boundaries of safety-significant waste transfer system piping. The DSA limits through-valve leakage for credited isolation valves to 0.1 gallon per minute. In response to a September 17, 2008, Board letter that identified issues concerning degradation of valve seats exposed to abrasive slurries, contractor personnel developed a formal test plan for performing additional life-cycle qualification testing

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[1] Gillen, K. T., and R. L. Clough, "Time-Temperature-Dose Rate Superposition: A Methodology for Extrapolating Accelerated Radiation Aging Data to Low Dose Rate Conditions," *Polymer Degradation and Stability*, 24:137-168, 1989

[2] Planes, E., L. Chazeau, and G. Vigier, "Role of Temperature During Ageing Under Gamma Irradiation of Filled EPDM: Consequences of Mechanical Properties," *Journal of Polymer Science: Part B: Polymer Physics*, 48:1319-1328, 2010.

for isolation valves using waste simulants. If funded, WRPS personnel plan to begin this testing in 2011. The staff plans to follow this effort. Until this testing is complete, WRPS is unable to demonstrate that safety-significant isolation valves will adequately perform their safety function.

Deficiencies of the DSA. The DSA relies on multiple layers of defense-in-depth and frequency arguments to prevent and/or mitigate some hazards that would otherwise warrant a safety-significant/TSR-level control. This practice is inconsistent with the methodology described in DOE Standard 3009, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses* for identification of safety-significant controls. The following are two examples:

- Section 3.3.2.4.4.2 of the DSA identifies the requirement for safety-significant controls to protect facility workers from a hydrogen deflagration in a waste transfer-associated structure (e.g., pump or valve pit). One potential initiator for this event is leakage through a pump shaft seal used for tank waste transfer. DSA Section 3.3.2.4.3.4.3, however, concludes that a sufficient number of defense-in-depth layers are available to preclude the need for a credited control. While the staff believes that the appropriate controls exist for this event, unless at least one of these controls is presented as safety-significant in the DSA they cannot be credited with preventing or mitigating the accident scenario.

- The DSA postulates a deflagration of hydrogen gas in waste transfer system piping and hose-in-hose transfer lines generated by radiolytic decomposition of residual waste following a transfer. The DSA concludes that the unmitigated consequences of this event to facility workers are significant, but that sufficient layers of defense-in-depth, combined with the low probability of the event, preclude the need for a safety-significant control. DOE Standard 3009 precludes the use of frequency arguments to screen operational hazards from consideration of credited controls; WRPS should elevate an available control to safety-significant to prevent or mitigate this event.

The staff also observed that the DSA does not identify safety-significant controls for a seismic-initiated waste transfer system leak, although the consequences reported in the hazard analysis for this event clearly indicate that a credited control is required. DOE Standard 3009 requires WRPS analysts to identify appropriate credited controls to prevent and/or mitigate this event (e.g., a seismic safety function for the waste transfer system piping, a pump shutdown system) or clearly document the basis for excluding such controls.