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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Westinghouse Hanford Company Richland, Washington

Management and Operations Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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"Assuring Safe Interim Storage of Hanford High-Level Tank Wastes,"
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INTRODUCTION

The federal government established the Hanford Site in South-Eastern Washington near the City of Richland in 1943 to produce plutonium for national defense purposes. The Hanford Site occupies approximately 1,450 square kilometers (560 square miles) of land North of the City of Richland. The production mission ended in 1988, transforming the Hanford Site mission to waste management, environmental restoration, and waste disposal. Thus the primary site mission has shifted from production to the management and disposal of radioactive, hazardous, and mixed waste that exist at the Hanford Site.

This paper describes the focus and challenges facing the Tank Waste Remediation System (TWRS) Program related to the dual and parallel missions of interim safe storage and disposal of the tank associated waste. These wastes are presently stored in 2.08E+05 liters (55,000) to 4.16E+06 liters (1,100,000) gallon low-carbon steel tanks. There are 149 single- and 28 double-shell radioactive underground storage tanks, as well as approximately 40 inactive miscellaneous underground storage tanks. In addition, the TWRS mission includes the storage and disposal of the inventory of 1,929 cesium and strontium capsules created as part of waste management efforts.

Tank waste was a by-product of producing plutonium and other defense related materials. From 1944 through 1990, four (4) different major chemical processing facilities at the Hanford Site processed irradiated (spent) fuel from defense reactors to separate and recover plutonium for weapons production. As new and improved processes were developed over the last 50 years, the processing efficiency improved and the waste compositions sent to the tanks for storage changed both chemically and radiologically. The earliest separation processes (e.g., bismuth phosphate coprecipitation) carried out in T Plant (1944-1956) and

B Plant (1945-1952) recovered only plutonium. All remaining dissolved fuel elements, including enriched uranium, were sent to the tanks as alkaline waste. Later processes, such as the Reduction Oxidation Plant Process (REDOX) and Plutonium Uranium Extraction (PUREX) flowsheets were developed to also recover uranium which was then recycled back into making reactor fuel. The process of purification of both plutonium (Z Plant) and uranium (B Plant) also lead to the creation of waste streams which, after neutralization to a pH ≥ 10, were added to the tanks.

Most processes associated with plutonium recovery from spent fuel involved dissolving the material in nitric acid. After extensive acid side chemical separations to recover plutonium, uranium, and often neptunium, the waste streams were made alkaline by addition of sodium hydroxide and/or calcium carbonate prior to their transfer to the low-carbon steel waste tanks. Making waste alkaline produced large quantities of metal oxyhydroxides, which along with solids from the bismuth phosphate process formed the sludge found in the bottom of the tanks. The waste composition in tanks was complicated further by the recovery of uranium by sluicing during 1952-1958. The waste was made alkaline to prevent corrosion of the low-carbon steel tanks, thereby introducing large volumes of sodium nitrate and other sodium salts into the waste tanks. Sodium nickel ferrocyanide was added to 20 of the tanks during the 1950s in order to precipitate solids and create additional space in the tanks.

To increase useful storage capacity, volume reduction methods (e.g., in-tank and external evaporation), and recovery of heat producing cesium and strontium in B Plant (1968-1985) were carried out. The concentration of the originally soluble sodium salt-rich waste led to the production of the saltcake, which is often found overlying the sludge waste in the tanks. Most of the hazardous chemicals and radionuclides are found in the sludge. Only radio-cesium, -iodine and -technetium are significantly soluble in alkaline salt solutions.

The single-shell tanks were taken out of active service in 1980, and no new waste has been added to these tanks since then. Sixty-seven (67) of these tanks are assumed or confirmed leakers. Removal of drainable liquid by saltwell pumping (interim stabilization), waste sampling in support of characterization, installation of new monitoring equipment, and/or any mitigation or remediation deemed necessary to assure interim safe storage of the waste are the only significant intrusive activities into these tanks. Drainable liquid removed from the single-shell tanks, as well as dilute waste resulting from decontamination of production facilities are added to the double-shell tanks after due consideration of waste compatibility concerns. There are approximately 2.12E+08 liters (55 million gallons) of waste in the TWRS single- and double-shell tank system.

THE TWRS MISSION

The TWRS Program is the largest environmental clean-up program in the United States. The purpose of the TWRS interim safe storage mission is to place all tanks in a safety envelope and prepare for long-term disposal of tank waste.

Mission Related Activities Include:

1. Continuation of the current program of tank monitoring and maintenance including any enhancements needed to assure interim safe waste storage (see the discussion of controlled, clean, and stable below);

2. Resolution of safety issues related to interim safe storage and/or disposal of the waste in the tanks;

3. Removal and transfer of pumpable liquids from single-shell tanks by saltwell pumping (interim stabilization);

4. Performing waste and tank characterization to the extent needed to either resolve tank safety issues or to support safe retrieval, transfer, processing (pretreatment) and disposal of the waste;

5. Continuation of receipt and storage of newly generated waste in double-shell tanks; and

6. Concentration of waste to the maximum extent safely practical in the 242-A Evaporator.

These activities form the basis for assuring that the tank contents and the farms themselves are maintained in a controlled, clean, and stable mode until the waste is retrieved and processed for disposal.

In addition, major resources are being expended on:

1. Development and application of systems engineering to assure integration of the overall TWRS mission activities;

2. Preparation for phased waste retrieval, treatment and waste vitrification efforts that form DOEs first major step in demonstrating waste disposal utilizing private sector resources (privatization); and

3. Achieving an integrated and responsive authorization basis to assure continued safe operation of the tank farms as the mission changes from storage to disposal.

4. Gaining knowledge of tank waste.

The remainder of this paper will highlight recent achievements in the areas of resolution of tank waste safety issues, progress toward putting the tank farms into a controlled - clean - stable mode, and transition to an operating mode in which privatization is a key operating factor.

TANK WASTE SAFETY ISSUES

All U.S. Department of Energy (DOE) facilities that store hazardous or radioactive materials have documented safety analyses, which establish a range of operating parameters (e.g., temperature, pressure, concentration) within which routine operations are conducted. These safety analyses also evaluate the effects of potential accidents, abnormal events, and natural disasters. The DOE has a formal program which requires identifying any known or suspected conditions that have not been analyzed or fall outside of the observed safety range as an Unreviewed Safety Question (USQ). Following identification of a USQ, a review takes place that may result in a change to the safety documentation or a change in operations. Following the review process, the USQ may be closed from an administrative standpoint when conditions surrounding the safety issue have been reviewed and their effects bounded. However, the safety issue may still exist and may require operational constraints, ongoing monitoring or mitigation. [In that fashion, safety issues, and USQs are related but not identical]

Concern over waste tanks having the potential for releasing high-level radioactive wastes to the environment resulted in the passing of Public Law 101-510, section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," also known as the Wyden Amendment. In response, DOE has developed a set of criteria to identify tanks with potential safety concerns as "watch list" tanks. There are currently 54 "watch list" tanks, with 10 tanks that are listed in more than one (1) of four (4) different categories based on the specific safety concerns described below.

Over 50 years of fuel reprocessing at Hanford has resulted in the accumulation of nearly 2.12E+08 liters (55 million gallons) of waste in the single- and double-shell tanks. Prior to the 1990s, it was generally believed that the stored wastes were chemically unreactive under both the present storage conditions and plausible accident scenarios, as well as being chemically stable. This paradigm was proven wrong when detailed evaluation of tank contents and behavior discovered that:

1. Twenty-five (25) of the stored single- and double-shell tanks waste tanks were generating, storing, and releasing hydrogen in quantities that might lead to flammable gas concentrations above the safety margin of 25% of their lower flammability safety limit (The Flammable Gas Issue). Recent measurements have shown that changes in atmospheric pressure may cause changes in liquid levels in some of these and other waste tanks. This may indicate a greater amount of gas stored in the waste than previously believed, and 25 additional tanks may be added to the flammable gas watch list until this issue is resolved. Screening of all waste tanks for potential flammable gas accumulation has been initiated.

2. Twenty (20) single-shell tanks contain organic materials in the presence of excess sodium nitrate and sodium nitrite oxidizing agents that could lead to a potential propagating reaction, and ensuing release of radioactive and hazardous materials to the environment, if the waste was dried and heated to threshold temperatures above 200 °C. (The Organic Safety Issue)

3. Eighteen (18) single-shell tanks contained sodium nickel ferrocyanide which could similarly pose a threat of a propagating reaction, if dried and heated to above 250°C. Ferrocyanide based deflagration represents the bounding "worse case" accident scenario previously identified in the Hanford Environmental Impact Statement. (The Ferrocyanide Safety Issue)

4. A single-shell tank (241-C-106) contains sufficient heat producing radio-strontium that it requires addition of cooling water to prevent tank failure from structural damage, if its temperature is allowed to fall outside of safe operating criteria. (The High Heat Issue)

The Waste Tank Safety Program was chartered in 1990 to address the four (4) safety issues discussed above. If risks were high, relative to interim safe storage of the wastes until they could be retrieved and permanently disposed, then the safety program assured that either adequate controls were in place to prevent the condition of risk from occurring, or if that were not possible, mitigation or remediation of the condition was initiated to actively remove the cause at the tank farms. Until such data were collected and interpreted to assure continued safety, the tanks associated with safety concerns were placed under stringent operating controls.

Extensive work and increased knowledge over the last few years has led to the demonstration and documentation of a significantly lower-risk condition with the tank waste. This will allow us to close some of the safety issues discussed above. For example, laboratory studies with simulants and analyses of actual waste samples have bounded the energetics of the fuel-rich materials added to the tanks. In addition, storage of the wastes over the last 30 to 40 years resulted in degradation of the organics and ferrocyanide significantly reducing the potential for explosive reactions.

Key Understandings Leading to Safety Issue Resolution Include the Following:

- Demonstration that radiolytically or chemically induced waste aging processes have destroyed or significantly lowered the energy content of a vast majority of organic materials added to the tanks. Therefore, conditions exist which can no longer have the potential for a propagating reaction in even a dry tank. Furthermore, the exploration of waste species energetics, waste species solubility, and waste tank chemistry demonstrate that the organic rich tanks contain a sufficient amount of moisture to preclude a risk from propagation under even the bounding "worse case" accident scenario. A combination of experimental work and waste characterization is continuing to provide data to substantiate these findings of waste safety.

- Results of extensive tank monitoring and surveillance show that most of the tanks on the Flammable Gas Safety Watch List pose little potential for exceeding 25% of the lower flammability limits for generated gases, or if such gas accumulation potential exists, it can be mitigated by installing a low-flow ventilation system on the tank.

PROGRESS TOWARD PLACING THE SINGLE-SHELL TANK FARMS INTO A CONTROLLED - CLEAN - STABLE MODE

An essential element of the strategy for meeting the TWRS mission is achieving a Controlled, Clean, and Stable condition in the Tank Farms. This strategy is essential in achieving an interim, safe, low-cost status until retrieval and disposal operations commence in the tanks.

The definition of controlled, clean, and stable is as follows:

1. Controlled

   a) All necessary (as determined by safety analysis) active and passive safety systems are in place.

   b) Resolution of any safety issues related to interim safe storage and/or disposal of the waste stored in watch list tanks.

   c) All controls necessary to provide assurance of meeting risk acceptance criteria for current operations associated with these USQs are in place. Continuous, remote, on-line monitoring of key parameters, such as waste volume and temperature is in place to adequately control the Hanford Site high-level waste tanks. This includes continuation of the current program of remote tank monitoring and maintenance, including any enhancements needed to assure interim safe waste storage.

2. Clean

   a) Surface contamination areas are cleaned and reduced to radiological control areas or even less controls.

   b) Unused contaminated equipment is removed from the tank farm.

   c) Reusable equipment is stored, if not in use.

3. Stable

   a) Removal and transfer of pumpable liquids from single-shell tanks by saltwell pumping (interim stabilization);

   b) All penetrations where liquids could intrude into the tanks are sealed.

Controlled, Clean, and Stable Strategy

The controlled, clean, and stable strategy has the following four (4) elements, which are discussed below: 1) reduce the mortgage; 2) provide safe storage; 3) reduce worker exposure to hazards; and 4) maintain compliance with regulatory requirements.

1. Reduce the Tank Farm "mortgage." - The "mortgage" is the current operational costs to monitor the tanks and their waste. This task is currently a high labor-intensive effort that includes a large number of tank farms and tank entries. The procedures for single-shell tank farm entries will be modified to:

a) Require tank farm entry only on a non-routine basis.

b) Provide remote monitoring of all essential parameters.

c) Allow access for waste sampling and characterization, if required.

2. Provide safe storage prior to retrieval. - This task includes updates to safety analyses as well as specification of necessary engineering design features, and operational and administrative controls. It also includes any equipment modifications and development of procedures and training for the equipment.

3. Reduce worker exposure to hazards. - Every time a worker enters a tank farm, or operates equipment in or near a tank, there is some level of potential exposure to radiological and chemical hazards. The reduction of the areas specified as either radiological controlled areas (RCAs) or surface contamination areas (SCAs) reduces worker exposure to these hazards.

4. Maintain compliance with regulatory requirements. - The Hanford Site Tank Farms' are regulated as a Treatment Storage and Disposal Facility with associated permits and closure agreements in compliance with regulatory requirements. All interim storage activities must be performed in a manner to assure current and continued future compliance with regulatory requirements.

Planned Upgrades in Support of Controlled - Clean - Stable

Focused tank farm upgrades are planned to improve the reliability of safety-related systems, minimize on-site health and safety hazards, improve the regulatory compliance of tank farm support systems, and put the tank farms into a controlled, stable work environment until disposal is completed. The following upgrades are planned:

- Instrumentation such as automatic tank data gathering, management control systems, and closed circuit television monitoring will be upgraded or added to minimize personnel exposure and to provide more accurate data for tank status assessment.

- Tank ventilation systems will be upgraded to replace outdated ventilation systems.

- Electrical systems will be upgraded to meet capacity needs for both routine monitoring and to support retrieval, as well as to comply with current electrical codes; and

- Piping systems will be upgraded to enable transfer of liquid or waste slurries from the decontamination and decommissioning of other selected Hanford Site facilities to the tank waste system.

CHARACTERIZATION OF TANK WASTES

Another essential element of the strategy to achieve the TWRS mission is the characterization of tanks wastes. "Characterization" is understanding the Hanford Tank Waste chemical, physical, and radiological properties to the extent necessary to ensure safe storage, interim operation, and ultimate disposition of the waste. Due to the many processes that have been used at the Hanford Site and the varied waste resulting from them, coupled with ongoing reactions in the waste storage tanks, there is a great deal of uncertainty about the exact waste inventory in many of the tanks. Knowledge of the waste in the tanks is essential to define the extent of existing safety issues, to resolve the safety issues, and to support retrieval, treatment, and disposal system designs.

There are currently five (5) sampling methods used to gather information on tank wastes.

1. Grab sampling of supernatant liquids for laboratory analysis. (Use of a bottle to "grab" liquid at the tank waste surface)

2. Vapor sampling for both on-line and laboratory analysis.

3. Core sampling of solid wastes using core sampling systems designed to drill or push into the waste to retrieve segments that are about 2.5 cm (1-inch) in meter by 50 cm (19 inches) long. These segments are then transported to on-Site laboratories for extrusion and analysis.

4. Auger sampling of the top 40 cm of waste in the tanks.

5. In-situ measurement of the void volumes in the waste and the viscosity of the waste.

To address the challenge of safely characterizing the waste tanks and to bring focus to the program, the TWRS Tank Characterization Project was formed in February 1995. This led to the following accomplishments during the year:

- Two (2) new rotary core sampling trucks were delivered and accepted in July 1995. Field testing was completed in September 1995, and operational production commenced in October 1995.

- Key improvements were made to the drilling equipment and the drill bits to make them more compatible with the type of waste being drilled and to improve sample recovery. This resulted in sample recoveries increasing from an average of 20% to over 90%. Sampling equipment improvements included:

  - developed equipment for sampling different types of waste (dry or wet salt cake, sludge, liquid) which are highly radioactive and/or toxic as well as potentially flammable.

  - developed shielding equipment for protecting personnel from potentially high radiation exposure and contamination.

  - developed a complete core sampling system including the sampler, sample truck, nitrogen purge supply, exhauster, x-ray imager, and a cask truck for transportation of the waste samples.

  - secured radiation hardened video cameras for in-tank color photography.

- New x-ray imaging system was added to sampling truck to determine the amount of sample recovery in the field immediately following sample removal from the tank.

- The Tank Waste Characterization Basis document was completed for the safety program in June 1995, and upgraded to include the disposal program in August 1995. This document:

  - established a prioritization basis for sampling which integrates known safety and disposal programmatic needs.

  - defined the key waste tanks to be sampled based on grouping tanks into similar categories and selecting tanks to answer specific safety questions.

- Four (4) core sampling crews were trained and certified.

- Data quality objectives were issued for the five (5) primary sampling needs: safety program; retrieval, pretreatment, and disposal program; waste compatibility; historical model evaluation; and privatization waste characterization.

- Analytical laboratories were upgraded, and the goal throughput of five (5) analytical equivalent units was achieved in October 1995 for the first time.

These changes resulted in a ten-fold increase in the number of samples taken during CY 1995 compared to CY 1994. This was particularly important for the full-length core samples where 49 core samples were obtained compared to five (5) core samples during CY 1994. Sample loads through the analytical laboratory more than doubled. Finally, by the end of CY 1995, 116 of the 177 underground storage tanks had been sampled using one (1) of the five (5) sampling methods listed above.

Improvements in characterization capabilities planned for this year include:

1. Deployment of a core sampling system capable of retaining gas in the core samples and then analyzing those samples for the gases that are trapped in the waste.

2. Deployment of a cone penetrometer system for in-situ measurements of rheological properties of the waste and moisture content (using a neutron moisture probe). The cone penetrometer includes a Raman spectroscopy system capable of in-place speciation.

3. Deployment of Surface Moisture Measurement System capable of measuring the moisture content of surface wastes within the tanks up to 6 feet off-center below the 4-inch tank risers into the tank vapor space.

4. Deployment of a Light Duty Utility Arm capable of robotic operations over 10 feet off-center in the vapor space below 12-inch risers into the tanks. This system will provide significant flexibility for operations within the tanks including: inspection, sampling, gripping, and cutting operations.

5. Redesign of some of the core sampling equipment to allow rotary sampling (necessary to retrieve samples from very hard wastes) from tanks that could potentially contain explosive mixtures of gases within the waste.

SUPPORT OF DOE PRIVATIZATION EFFORTS

In September 1995, DOE announced its intent to "privatize" the disposal part of the tank waste remediation program. The idea was to turn clean-up of Hanford's tank waste over to a private company that would do the design work and pay construction costs without Federal appropriations. The company would then be paid for the glass waste logs it produced. The privatization would be done in two (2) phases: 1) design and construction of waste treatment, and immobilization facilities for a small fraction of the waste (6-13%), followed by; 2) design and construction of waste retrieval, treatment, and immobilization facilities for the bulk of the waste. Characteristics of the two (2) phases are summarized in Table 1 (Page 11). During Phase I, waste retrieval would be performed by the existing Site contractor.

A draft Request for Proposal (RFP) was issued for comment in November 1995, and a final RFP is expected to be released in March 1995 for the first phase. In August 1996, up to three (3) companies will be selected for more in-depth design work. Each company will design a prototype vitrification plant to immobilize the low-level radioactive wastes. Bidders will also have the option of adding a prototype plant to glassify high-level radioactive waste. In February 1998, DOE will pick the best two (2) of the three (3) bidders proposals to build the low-level waste plants with hot operations to begin by December 2002. It is possible that a third plant to vitrify high-level wastes will be authorized for the same time period.

DOE's goal is for the two (2) prototype plants to process 13,200 (~3%) of waste in the first 2 1/2 years and another 24,200 tons (~5-6%) in the second 2 1/2 years. As the first phase nears completion, DOE will put out an RFP to build two (2) larger low-level waste vitrification plants, plus a full-scale high-level waste vitrification plant. The second phase bidding process will be open to any company interested, not to just the successful Phase I bidders. Construction of the larger second-phase low-level waste plants is scheduled to begin in 2008. The second-phase high-level waste plant is to begin operating in 2010, and the low-level waste plants are to start in 2011. All of Hanford's liquid radioactive wastes are to be immobilized by 2028.

SUMMARY

To date, 8 tanks have been "characterized"; that is, present requirements for the tank waste information for those tanks have been met. Several tank farms have been designated controlled, clean, and stable. 1995 was a year in which giant steps were taken on the path of real progress in closure of safety issues and ultimate disposal of tank waste.

PRIVATIZATION APPROACH

Phase I:	Phase II:
Waste Treatment and Immobilization Demonstration, ~6 - 13% of Waste	Waste Retrieval, Treatment, and Immobilization Production, ~87 - 94% of Waste
- Low-level waste fraction plus option for high-level waste fraction	- All remaining tank waste plus potentially cesium and strontium capsules
- Three preliminary design contracts; two vendors selected to design, construct, and operate two competitive facilities	- Two vendors selected to design, construct, and operate two competitive facilities
- Schedule - Select two vendors 1998 - Hot Start-up 2002 - Complete demo phase 2011 - Complete D&D/RCRA Closure 2013	- Schedule: - Select two vendors 2005 - Hot start-up 2011 - Complete SST retrieval 2018 - Complete immobilization 2028